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College of Law and Management Studies

**Macro-prudential tools, banking sector resilience and economic growth in
Tanzania**

By

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This dissertation is submitted in fulfilment of the requirements of Doctor of Philosophy in
Finance.

July 2023

Declaration

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Dedication

To my husband Mzee Muhsin Mzee, my daughter Hanifa, and two sons, Tahmid and Muhsin, for bearing with me during the course of my program. To my father Mr. Jumanne Kishimba Kibela, and my mum Mectilda Constantine Saanane, for the encouragement and strength in unlocking the impossible.

Acknowledgement

“So which of the favours of our Lord do we deny?”

Quran Surah Ar-Rahman, 55:13

My greatest gratitude goes to the Almighty God, who has enabled me to accomplish a lot of my life dreams and career growth up to the step of accomplishing my PhD thesis. Highly favoured of all, He blessed me with a loving family, gifting me with a husband, daughter, and two sons who are my greatest inspirations.

Having reached the end of my doctoral studies, I find myself indebted to many people who have enabled me to complete this tireless journey with much ease and support. To begin with, I would like to sincerely appreciate the devotion, support and encouragement provided to me by my supervisor, Prof. Joseph Akande, and by my co-supervisor, Prof. Paul-Francois Muzindutsi. They made me feel that they were entirely part of my journey, and were always available to offer solutions and guidance whenever required.

Special thanks to the University of KwaZulu-Natal, the College of Law and Management Science, and the School of Accounting, Economics and Finance for providing financial support throughout my PhD journey.

A very special thank you goes to my colleagues at the Bank of Tanzania, for their consistent team work, frequent consultations, and encouragement. More specifically, special thanks go to Dr. Nguling'wa Balele for several sessions held with him related to concept, data, and methodology, from the beginning of my journey to the end, despite his busy schedule.

A PhD journey is very hectic, especially being a wife and a mother of three children; I really appreciate the support from my family and friends throughout this long-running journey. My greatest acknowledgement goes to my family: my husband Mzee, daughter, and two sons. Throughout this tough journey, my husband has always been by my side, however tough the journey was, always being a great pillar that has believed in me enormously. Hanifa, Tahmid, and Muhsin, the moment you needed mummy the most was the time I embarked on this journey; throughout this time, you taught me acceptance and

unconditional love, that mum is a student like us and she needs time, so thank you. Mzee, you always filled the space that I left in my children's presence, and continually made me keep focus by saying "Whatever started will end by the grace of Almighty God, so stay focused and I will take care of the rest, don't worry". I am eternally grateful for having you in my life: you made my journey smoother even during the rough times, as you always created time to hear my challenges and provided encouragement at all times.

Finally, I have immense gratitude to my mother-in-law, mother, and my nieces for constantly looking after my kids during my absence, as I embarked on my journey. I thank my father for always encouraging me to keep moving forward.

Abstract

This study assessed the relationship between macro credit risk stress tests, economic growth, and countercyclical buffers in Tanzania. The financial sector in Tanzania is predominantly dominated by banks with growing development in agent banking, digital platforms, and deposit mobilization. Credit risk is observed as the most significant risk in the banking sector, where various studies show that financial instability originates from exposure to this risk. Hence, in this growing interaction and integration between domestic and global activities, studies have shown that the potential risk of transmission may affect the domestic economy at large. This has called for a significant adoption of macro-prudential policy tools that interact with other segments of the financial sector, due to the growing global integrations. The study aimed to establish the interlinkages between macro-prudential tools and economic growth from a balance sheet to a prudential perspective, to support policy objectives related to credit and capital in Tanzania.

The study was implemented using three objectives, of which the first one was to assess the impact of the macro-credit risk stress test on banking sector resilience in Tanzania, using the Global Vector Autoregressive (GVAR) model and the Generalised Method of Moments (GMM) estimations. The second objective assessed the effect of bank credit risk to real economic growth by sector in Tanzania, using both a linear and non-linear Autoregressive Distributed Lag (ARDL) model. The third objective analysed the implication of the stress test results in influencing macro-prudential policy decisions in Tanzania, using the Hodrick Prescott (HP) filter to compute the credit-to-GDP gap indicator that represents a countercyclical buffer. The study covered a 15-year period from 2006 to 2020, with data from six major trading partners (USA, EU, India, China, South Africa, Kenya, and UAE), banking sector indicators from 15 banks, and credit composition data for six major economic sectors.

The study revealed that foreign and global transmissions have an impact to the banking sector in addition to domestic factors. More specifically, the increase in the crude oil price index and domestic inflation rate, revealed a significant effect on the aggregate credit portfolio compared to the other macro-shocks applied in the study. Regarding individual

bank analysis, banks are the most exposed to domestic GDP shocks, though generally the banking sector in Tanzania is still resilient and above the regulatory capital threshold. The study further revealed that there is a long-run and short-run effect of credit risk on the economic growth of most sectors; thus when this is amplified, the effect differs across various sectors of the economy. This study also drew findings that contribute to the existing literature by introducing a macro-credit risk stress testing work to Tanzania's framework, and assessing the transmission with its major trading partners. Further, this study also contributed to the integration of banking sector specific factors, in addition to macro-economic variables, when assessing the exposure to credit risk. Therefore, this assessment broadens the literature on assessing the impact of credit risk on sectoral economic growth and sector impact. This study revealed a crucial finding, that even during the financial global crisis of 2007/2009 the Tanzanian economy was not very vulnerable to the potential of having negative recessions, as reflected by the magnitude of credit exposure in the country.

The study recommends enhancing Tanzania's banking sector's resilience assessment and providing mitigation measures in advance, to contain the anticipated exposure to macroeconomic factors, both domestic and global, to ensure financial stability. The study also recommends that the Tanzanian economy adopt the countercyclical buffer, which can be relevant to cushion against potential credit risks in case they materialise. Further, the study recommends the need for policymakers to conduct sector-wise assessments rather than aggregate exposure, to come up with specific policies targeted to particular sectors, instead of generic policies.

Keywords: Tanzania, credit risk, economic sectors, economic growth, countercyclical buffer, stress testing, macro-prudential tools, GVAR.

List of Publications

Published Articles:

- Kishimba, K. J., Akande, J. O., & Muzindutsi, P.-F. (2022). Financial Sector Reforms and the Significance to Banking Sector in Tanzania. In *Corporate Finance and Financial Development* (pp. 103-128). Springer.
- Kishimba, K. J., Akande, J. O., & Muzindutsi, P.-F. (in press). Macro Credit Risk Stress Testing in Tanzanian Banking Sector: A Global Vector Autoregressive (GVAR) Approach. Accepted by the *Journal of African Business*.

List of Abbreviations

| Acronym | Meaning |
|--------------|--|
| ARDL | Autoregressive Distributed Lag |
| BCBS | Basel Committee for Banking Supervision |
| BIS | Bank for International Settlements |
| BOT | Bank of Tanzania |
| CAR | Capital Adequacy Ratio |
| CMSA | Capital Markets Securities Authority |
| DSE | Dar es salaam Stock Exchange |
| EAC | East Africa Community |
| EGM | Enterprise Growth Markets |
| FSAP | Financial Sector Assessment Programme |
| FSR | Financial Stability Report |
| GDP | Gross Domestic Product |
| GMM | Generalised Method of Moment |
| GVAR | Global Vector Autoregressive |
| ICCAP | Internal Capital Adequacy Assessment Program |
| IMF | International Monetary Fund |
| IPO | Initial Public Offers |
| LAPF | Local Authorities Pension Fund |
| NARDL | Non-linear auto regressive distributive lag |
| NHIF | National Health Insurance Fund |
| NPL | Non-Performing Loans |
| NSSF | National Social Security Fund |
| OECD | Organisation for Economic Co-operation and Development |
| PPF | Parastatal Pension Fund |
| PSPF | Public Service Pensions Fund |
| URT | United Republic of Tanzania |
| TAN-RE | Tanzania Reinsurance Company Limited |

| | |
|-------|---|
| TIRA | Tanzania Insurance Regulatory Authority |
| SSRA | Social Security Regulatory Authority |
| URT | United Republic of Tanzania |
| ROA | Return on Assets |
| ROCE | Return of Capital Employed |
| ROE | Return on Equity |
| SADC | Southern Africa Development Community |
| TDFL | Tanzania Development Finance Limited |
| VAR | Vector Autoregressive |
| VECMs | Vector Error-Correction Models |
| WCF | Worker's Compensation Fund |

Table of Contents

| | |
|--|-----------|
| Declaration | ii |
| Dedication..... | iii |
| Acknowledgement | iv |
| Abstract | vi |
| List of Publications..... | viii |
| List of Abbreviations | ix |
| Table of Contents | xi |
| List of Tables | xvii |
| List of Figures..... | xvii |
| 1 1 CHAPTER 1: INTRODUCTION | 1 |
| 1.1 Introduction..... | 1 |
| 1.1.1 Background of the study | 2 |
| 1.1.2 Statement of the problem..... | 8 |
| 1.1.3 Research Aim and objectives of the study | 9 |
| 1.1.4 Specific objectives | 9 |
| 1.1.5 Research questions | 10 |
| 1.1.6 Research hypothesis | 10 |
| 1.1.7 Scope/ Delimitation of the study | 11 |
| 1.1.8 Significance of the study..... | 12 |
| 1.2 Brief description of the study concepts | 12 |
| 1.2.1 Macro-prudential tools | 12 |
| 1.2.2 Stress testing | 13 |
| 1.2.3 Stress testing in Tanzania..... | 20 |
| 1.2.4 Banking sector resilience | 21 |
| 1.2.5 Economic growth | 22 |
| 1.2.6 Credit risk..... | 22 |
| 1.2.7 Countercyclical capital buffer | 23 |
| 1.3 Structure of the thesis..... | 24 |
| 1.3.1 Conceptual framework | 25 |
| 1.4 Research Contributions | 26 |

| | |
|--|-----------|
| 1.5 Summary | 27 |
| 2 2 CHAPTER 2: FINANCIAL SECTOR AND THE BANKING SUB-SECTOR IN TANZANIA..... | 28 |
| 2.1 Introduction..... | 28 |
| 2.2 The Tanzanian Financial Sector | 28 |
| 2.2.1 Overview of the financial sector | 28 |
| 2.2.2 Financial sector reforms..... | 29 |
| 2.2.3 Structure and composition of the Tanzanian financial sector..... | 31 |
| 2.2.3.1 Banking sub-sector | 31 |
| 2.2.3.2 Microfinance sub-sector | 32 |
| 2.2.3.3 Insurance sub-sector | 33 |
| 2.2.3.4 Social security schemes | 35 |
| 2.2.3.5 Capital markets | 37 |
| 2.2.4 Overview of the Tanzanian economy..... | 39 |
| 2.2.5 Financial sector assets and GDP | 41 |
| 2.3 The Tanzanian Banking Sector | 43 |
| 2.3.1 Evolution of the banking sector | 44 |
| 2.3.2 Regulatory environment of the banking sector..... | 48 |
| 2.3.3 Types of banks in the banking sector of Tanzania..... | 52 |
| 2.3.4 Tanzanian bank ownership structure | 55 |
| 2.3.5 Tanzanian banking sector asset composition | 55 |
| 2.3.6 Tanzanian banking sector performance..... | 56 |
| 2.3.6.1 Capital adequacy in Tanzanian banks | 57 |
| 2.3.6.2 Liquidity in Tanzanian banks | 59 |
| 2.3.6.3 Profitability in Tanzanian banks | 61 |
| 2.3.6.4 Asset quality in the Tanzanian banking sector | 63 |
| 2.3.6.5 Tanzanian banking sector's sensitivity to market risk | 65 |
| 2.3.7 Chapter Summary..... | 66 |
| 3 3 CHAPTER 3: MACRO-CREDIT RISK STRESS TEST IN TANZANIA | 68 |
| 3.1 Introduction..... | 68 |
| 3.2 Review of literature on macro credit risk stress testing..... | 70 |
| 3.2.1 Theoretical literature review on macro credit risk stress testing..... | 70 |

| | | |
|------------|---|------------|
| 3.2.2 | Empirical literature review on macro credit risk stress testing..... | 74 |
| 3.2.3 | Summary and gap in the literature for macro credit risk stress testing ... | 77 |
| 3.3 | Methodology | 78 |
| 3.3.1 | Model specification | 80 |
| 3.3.2 | Discussion of variables and sources..... | 82 |
| 3.3.3 | Trade and aggregate weights | 88 |
| 3.3.4 | GVAR estimation techniques | 89 |
| 3.3.5 | Descriptive statistics | 90 |
| 3.3.6 | Unit root test | 90 |
| 3.3.7 | Choice criteria for selecting the order of the VARX* | 91 |
| 3.3.8 | Cointegration of test results | 92 |
| 3.3.9 | Testing for weak exogeneity in GVAR | 92 |
| 3.3.10 | Structural stability test..... | 94 |
| 3.3.11 | Contemporaneous effects..... | 95 |
| 3.3.12 | Pair-wise cross-section correlations..... | 96 |
| 3.3.13 | Dynamic (impulse response) analysis..... | 97 |
| 3.4 | GVAR empirical results | 99 |
| 3.4.1 | Impact of domestic macroeconomic shocks on NPLs..... | 99 |
| 3.4.2 | Impact of global shocks on NPLs..... | 103 |
| 3.4.3 | Impact of foreign countries' shocks on NPLs | 106 |
| 3.4.4 | Impact of foreign countries' real GDP shocks on NPLs | 107 |
| 3.4.5 | Interest rate exposure from foreign countries | 112 |
| 3.4.6 | Exchange rate exposure from foreign countries | 118 |
| 3.4.7 | Inflation rate exposure from foreign countries..... | 122 |
| 3.5 | Chapter Summary | 127 |
| 4 | CHAPTER 4: STRESS TESTING AND BANKING SECTOR RESILIENCE | 130 |
| 4.1 | Introduction..... | 130 |
| 4.2 | Literature review on stress testing and banking sector resilience..... | 133 |
| 4.2.1 | Theoretical literature review on stress testing and bank resilience | 133 |
| 4.2.2 | Empirical literature review on stress testing and banking sector resilience | 136 |
| 4.3 | Methodology for stress testing and bank resilience | 141 |

| | | |
|------------|---|------------|
| 4.3.1 | Specifications for GMM models | 142 |
| 4.3.2 | Panel model..... | 143 |
| 4.3.3 | Stress testing and banking sector resilience..... | 145 |
| 4.3.4 | Data description and sources | 146 |
| 4.4 | Estimated results | 152 |
| 4.4.1 | Descriptive statistics | 153 |
| 4.4.2 | Panel unit root test..... | 155 |
| 4.4.3 | Diagnostic test | 159 |
| 4.4.3.1 | Instrument validity test | 159 |
| 4.4.3.2 | Autocorrelation test..... | 159 |
| 4.5 | Empirical results and discussions..... | 160 |
| 4.5.1 | Results of the dynamic panel model | 160 |
| 4.5.2 | Reaction of credit risk indicators to scenarios of macroeconomic shocks 163 | |
| 4.5.1 | Impact of credit risk on bank's capital position | 168 |
| 4.6 | Chapter Summary | 175 |
| 5 | 5 CHAPTER 5: EFFECT OF CREDIT RISK TO REAL ECONOMIC GROWTH IN TANZANIA | 177 |
| 5.1 | Introduction..... | 177 |
| 5.2 | Review of the literature on the effect of credit risk to real economic growth in Tanzania | 180 |
| 5.3 | Theoretical literature review on the effect of credit risk on real economic growth in Tanzania | 181 |
| 5.3.1 | Empirical literature review on the effect between credit risk and real economic growth in Tanzania | 183 |
| 5.4 | Methodology..... | 188 |
| 5.4.1 | Data variables and specification..... | 189 |
| 5.4.2 | Model specification..... | 190 |
| 5.5 | Empirical results and discussion..... | 196 |
| 5.5.1 | Descriptive Statistics..... | 197 |
| 5.5.2 | Unit root test | 198 |
| 5.5.3 | Model selection and optimal lag length..... | 199 |
| 5.5.4 | Long run ARDL and NARDL analysis | 200 |

| | | |
|------------|--|------------|
| 5.5.4.1 | Bounds test for cointegration | 200 |
| 5.5.5 | Wald test..... | 201 |
| 5.5.6 | Short ARDL and NARDL error correction models | 204 |
| 5.5.7 | Diagnostic tests..... | 207 |
| 5.6 | Chapter Summary | 212 |
| 6 | CHAPTER 6: MACRO CREDIT STRESS TESTS AND MACRO-PRUDENTIAL POLICY | 213 |
| 6.1 | Introduction..... | 213 |
| 6.2 | Literature review on macro credit stress tests and macro-prudential policy ... | 215 |
| 6.2.1 | Theoretical literature review on macro credit stress tests and macro-prudential policy | 216 |
| 6.2.2 | Empirical literature review on macro credit stress tests and macro-prudential policy | 220 |
| 6.3 | Methodology | 223 |
| 6.3.1 | Model specification for macro credit stress tests and macro-prudential policy..... | 224 |
| 6.3.2 | Data description..... | 225 |
| 6.4 | Interpretation of results..... | 226 |
| 6.4.1 | Setting the countercyclical buffer | 226 |
| 6.4.2 | Stress test results in comparison to releasing the CCyB | 227 |
| 6.5 | Chapter Summary | 228 |
| | CHAPTER 7: SUMMARY, CONCLUSION AND RECOMMENDATIONS..... | 229 |
| 7.1 | Introduction..... | 229 |
| 7.2 | Summary of the findings..... | 230 |
| 7.3 | Objective, achievement and key conclusions | 232 |
| 7.4 | Recommendations..... | 235 |
| 7.5 | Limitation of the study..... | 236 |
| 7.6 | Areas for further research..... | 236 |
| | Appendices | 238 |
| | Diagnostic Test..... | 238 |
| | Appendix 1: Descriptive statistics for domestic variables..... | 238 |
| | Appendix 2: Descriptive statistics for foreign variables | 241 |
| | Appendix 3: Descriptive statistics for global variables..... | 243 |

| | |
|---|------------|
| Appendix 4: Unit root tests for the foreign variables at the 5 percent significance level | 244 |
| Appendix 5: Unit root tests for the domestic variables at the 5 percent significance level | 247 |
| Appendix 6:Unit root test for the global variables at the 5 percent significant level 250 | |
| Appendix 7: Choice criteria for selecting the order of the VARX* models together with corresponding residual serial correlation F-Statistics | 251 |
| Appendix 8: Choice criteria for selecting the order of the weak exogeneity regressions together with corresponding residual serial correlation F-statistics ... | 252 |
| Appendix 9: Average pairwise cross-section correlations: Variables and residuals 254 | |
| Appendix 10: Descriptive statistics for ln_GDP by sector | 255 |
| Appendix 11: Descriptive statistics for NPLs by sector | 256 |
| Appendix 12: Descriptive statistics for control variables by sector | 257 |
| Appendix 13: Unit root test for ln_GDP by sector..... | 258 |
| Appendix 14: Unit root test for NPLs by sector | 259 |
| Appendix 15:Unit root test for control variables by sector | 260 |
| Appendix 16: Unit root test for NARDL for ln_GDP by sector | 261 |
| Appendix 17: Unit root test for NARDL for ln_GDP by sector | 262 |
| Appendix 17: NARDL-Unit root test for control variables by sector..... | 263 |
| Appendix 189:Unit root test for banking sector variables | 264 |
| Appendix 20:Unit root test for macroeconomic variables | 265 |
| Ethical Clearance Letter | 266 |
| Turnitin report summary | 267 |
| References | 268 |

List of Tables

| | |
|--|-----|
| Table 2.1: Contribution of the Financial Sector to GDP (percentage) | 42 |
| Table 2.2: Market share of the banking sub-sector from 2010 to 2020 | 54 |
| Table 3.1: A summary of variables and sources | 86 |
| Table 3.2: Trade weights based on the direction of trade statistics | 89 |
| Table 3.3: F-Statistics for testing Weak Exogeneity at the 5% significance level | 93 |
| Table 3.4: Structural Stability Tests: Break Dates for QLR Tests | 94 |
| Table 3.5: Contemporaneous Effects of Foreign Variables on Domestic Counterparts .. | 96 |
| Table 4.1: A summary of the variables | 151 |
| Table 4.2: Summary statistics | 155 |
| Table 4.3: Unit root test results for banking related indicators | 157 |
| Table 4.4: Unit root tests results for macroeconomic variables | 158 |
| Table 4.5: Autocorrelation/serial correlation test | 160 |
| Table 4.6: Results of the estimation of dynamic panel model with fixed effects | 163 |
| Table 4.7: Change of NPLs after macroeconomic scenarios | 167 |
| Table 4.8: The computation of the stressed CAR for each bank | 169 |
| Table 4.9: The computation of the assumption for RWA | 169 |
| Table 4.10: Impact of macro-economic shocks on CAR ratios | 174 |
| Table 5.1: Summary description of data variables | 190 |
| Table 5.2: NARDL model selection | 200 |
| Table 5.3: Bound test for ARDL estimates | 200 |
| Table 5.4: Bound test for NARDL estimates | 201 |
| Table 5.5: Wald test results | 202 |
| Table 5.6: Long-run ARDL model estimates | 203 |
| Table 5.7: Long-run NARDL model estimates | 204 |
| Table 5.8: Short-run ARDL model estimates | 205 |
| Table 5.9: Short-run NARDL model estimates | 206 |
| Table 5.10: Results for ARDL and NARDL model for validity tests | 208 |
| Table 5.11: Results for NARDL model for validity tests | 209 |

List of Figures

| | |
|---|-----|
| Figure 1.1: Conceptual framework for the proposed credit risk stress test methodology in Tanzania | 26 |
| Figure 2.1: Financial Sector Composition from 2010 to 2020 | 39 |
| Figure 2.2: Capital adequacy ratios from 2010 to 2020 | 59 |
| Figure 2.3: Liquidity ratio 2010 to 2020 | 61 |
| Figure 2.4: Profitability ratios from 2010 to 2020 | 63 |
| Figure 2.5: Asset Quality (Non-Performing Loans ratio) 2010 to 2020 | 65 |
| Figure 3.1: Generalised Impulse responses of selected domestic-macro economic variables shock and impact on NPLs | 101 |
| Figure 3.2: Generalised Impulse responses of selected domestic-macro financial variables shock and impact on NPLs | 103 |

| | |
|--|-----|
| Figure 3.3: Generalised Impulse responses of oil price shock and impact on NPLs ... | 104 |
| Figure 3.4: Generalised Impulse responses of raw materials price shock and impact on NPLs..... | 105 |
| Figure 3.5: Generalised Impulse responses of metals price shock and impact on NPLs | 106 |
| Figure 3.6: Generalised Impulse responses of foreign countries negative GDP shock and impact on Tanzania's NPLs | 112 |
| Figure 3.7: Generalised Impulse responses of foreign countries positive nominal interest rate shock and impact on Tanzania's NPLs..... | 117 |
| Figure 3.8: Generalised Impulse responses of foreign countries positive exchange rate shock and impact on Tanzania's NPLs..... | 122 |
| Figure 3.9: Generalised Impulse responses of foreign countries positive exchange rate shock and impact on Tanzania's NPLs..... | 127 |
| Figure 4.1: Average of banking sector variables from Q2-2006 to Q4-2020 for the 15 banks..... | 148 |
| Figure 5.1: Sector wise analysis of Credit risk (NPLs ratio) and GDP (percent) | 180 |
| Figure 5.2: Results for CUSUM test for ARDL model estimates..... | 210 |
| Figure 5.3: Results for CUSUM test for NARDL model estimates | 211 |
| Figure 6.1: Credit to GDP gap and the buffer guide | 227 |

CHAPTER 1: INTRODUCTION

1.1 Introduction

Macro-prudential tools, banking sector resilience, and economic growth are significant components in the assessment of the financial stability of an economy. The financial sector is considered the economy's engine in stimulating growth and reducing poverty (Bank, 2019). In addition, increasing access to financial sector services and products remains an essential aspect for poverty reduction and economic growth, and hence enhancing the stability of the sector is equally important (Bank, 2019). The financial sector has contributed significantly to the economic growth of countries, through financial development, reform implications as well as growth rate comparability (Beck & Maimbo, 2012; Burgess, 2011; Cecchetti & Kharroubi, 2015a).

The Tanzanian banking sector has experienced tremendous growth in financial services and products as well as assets, while being a major facilitator for economic growth in terms of financial sector players. Therefore, an effective and efficient regulatory environment ensures the stability of the financial sector. **The banking sector in most African countries, in particular Tanzania, Kenya Uganda and Rwanda, accounts for more than 50 percent of the country's financial sector operations (BOT, 2021).** There is a need to have macro-prudential regulations in place to extensively look at the banking sector not in isolation but holistically, to assimilate the systemic risks associated with exogenous factors beyond the banking sector's operations. Further, there is a need to develop prudential regulations targeting individual banks, assuming the impact of one bank is exogenous of the interaction among banks, and as such macro-prudential regulations assess the systemic risk of the financial system as a whole (Arnold et al., 2012).

Global macroeconomic and financial distortions affect domestic economies, and these transmissions are beyond the control of open economies that undertake trade beyond **boarders**. Hence these expose the financial sector of such economies to global impacts, as was the case during the global financial crisis of 2007-09 (Berezina et al., 2019). Macro-prudential analysis integrates various tools including countercyclical buffer, stress testing, as well other banking sector mitigation tools, with the motive of enhancing financial stability after the impact of the said global financial crisis.

Central Banks across the globe as well as the International Monetary Fund (IMF) and the Bank for International Settlements (BIS), have done enormous work in developing and proposing macro-prudential frameworks to complement micro-prudential assessments.

Balancing the exercising of macro-prudential tools like stress testing and countercyclical buffer, are very important in an economy. This creates a cushion in good times of the credit cycle that will be utilized in case crises occur, to minimize losses in the financial system as well as the economy at large. However, this mitigation may conflict with lending, since more capital buffers are required to be retained while the economy requires growth in credit. Stress testing also helps to assess the resilience of banks in advance to prepare for additional capital required, and evaluate the potential areas that may affect the banking sector. Therefore, the attempt to integrate global transmission, macro-prudential tools of stress testing to assess banking sector resilience, as well as viewing the significance of economic growth in determining countercyclical buffers, is important for developing countries like Tanzania, given the increasing global interactions.

This rest of this chapter presents the background to this study, illustrates the study's problem statement, the research aim and objectives, the research questions, the research hypothesis, the scope/delimitation, the significance of the study, a brief description of the study, the structure of the thesis, the conceptual framework, and a summary.

1.1.1 Background of the study

Following the 2007-09 global financial crisis, transmission between macro-prudential oversight and banking sector resilience has been an area of interest, with the urge to enhance financial stability, economic growth, and guide policy initiatives (Claessens, 2015). In recent years, a number of studies (Berezina et al., 2019; Buncic & Melecky, 2013; Çakmak, 2014; Constâncio, 2016b; Henry et al., 2013; Onder et al., 2016; Pérez Montes & Trucharte Artigas, 2013) have reported the need to complement micro-prudential with macro-prudential oversight. These aim at ensuring the resilience of the financial sector through a systemic risk assessment in order to support economic growth (Bonfim & Monteiro, 2013; Burra et al., 2015; Stojkov, 2020), as well as guide macro-prudential policy decisions for this sector (Górnicka et al., 2020; Selialia et al., 2010). On one hand, micro-prudential oversight is broadly known as an assessment of the resilience of an individual bank to shocks, without considering the interlinkages with the other banks and sectors within the economy (Basto, 2013; Claessens, 2015).

On the other hand, macro-prudential oversight is the assessment of the resilience and soundness of the financial system to systemic risk exposures, to ensure the stability of the financial system (Schou-Zibell et al., 2010). Macro-prudential oversight supports banking sector resilience assessment and ultimately economic growth, by effectively understanding the major risks that are directly related to growth and policy decisions from banking sector operations (Onder et al., 2016).

Studies by Basto (2013), Berezina et al. (2019), and Górnicka et al. (2020), narrate that macro-prudential oversight is conducted using a range of tools related to any of the categories including: capital (countercyclical buffer, conservation buffer), borrower-based (loan-to-value ratio, debt-service-to-income ratio, debt-to-income ratio), and balance sheet tools (macro-stress testing). Macro-prudential oversight is conducted using these tools with the aim of strengthening the resilience of the financial sector through credit-related risks and system-wide risks, including through stabilizing the impact of vulnerabilities originating from credit cycles (Amel, 2018; Buncic & Melecky, 2013; Foglia, 2018; Grundke et al., 2019; Havrylchyk, 2010; Messai & Gallali, 2018; Patra & Padhi, 2020b; Rakotonirainy et al., 2020; Vu et al., 2018; Youssef, 2018).

Conversely, different studies have adopted macro-prudential tools like macro stress tests in as a **standalone tool, for assessing** the resilience and systemic impact on the banking sector, instead of assessing financial stability using multiple tools together (Çakmak, 2014; Dua & Kapur, 2018; Onder et al., 2016; Pérez Montes & Trucharte Artigas, 2013). In another view of macro-prudential oversight through the use of macro credit stress test, studies noted the impact of credit risk on the capital position of banks, arising from macroeconomic scenarios (Havrylchyk, 2010; Patra & Padhi, 2020b; Rakotonirainy et al., 2020; Vazquez et al., 2012; Vu et al., 2018). Meanwhile, findings show that different regulatory authorities adopted borrower-based macro-prudential tools, including loan-to-value ratio, debt-service-to-income (DSTIs) ratio, debt-to-income (DTIs) ratio, and capital tools (Claessens, 2015; Kang et al., 2017; Selialia et al., 2010). These additional factors will also complement other macro-prudential tools (Constâncio, 2016b; Dees & Henry, 2017; Górnicka et al., 2020).

However, a gap is noted in the interaction between the capital and balance sheet macro-prudential tools for risk assessment, as well as transmission to the economy, which this study aims to fill. Therefore, this study draws on how macro-prudential tools, macro stress tests (balance sheet tool), and countercyclical buffer (capital tool) can transmit among each other, impact economic growth through credit risk, as well as support policy decisions. Banking sector resilience in Tanzania is assessed using capital adequacy ratios of core and total ratios, with regulatory capital requirements being 10 and 12 percent, respectively. As of 2021, the core and total capital ratios in Tanzania stood at 19.5 percent and 20.2 percent (BOT, 2021).

The Tanzanian banking sector is structured of large, medium, and small banks, of which commercial banks fall within the large and medium banks (Tanzania, 2019). In recent years, macro stress tests have been conducted by the Central Bank of Tanzania on a quarterly basis, as well as the International Monetary Fund (IMF)/World Bank under the Financial Sector Assessment Programs (FSAP) conducted in 2018. The aim was to assess the resilience of the banking sector in Tanzania to different risks, and the implications of the interconnectedness of the financial sector to identified systemic impacts (Fund, 2018; Tanzania, 2019). The FSAP results revealed that, in the worst case scenario (severe) stress test, 22 banks accounting for 32.0 percent of banking assets would be under-capitalized, hence leading the core capital ratio to decline from 18.9 percent to 13.7 percent over the review period (Fund, 2018).

The extent of exposure of the Tanzanian financial system to external shocks (arising from macroeconomic challenges from neighboring/international economies) as well as exposure to countercyclical risks. This will help you to lay a better premise to argue for a macro-prudential regulation in the country.

In 2018, stress test results in Tanzania denoted that core capital declined to 11.59 percent due to the impact of sectoral credit risk (Tanzania, 2018). However, these results do not provide a policy direction or impact for decision-makers in the country in a disaggregated

manner, since credit accounts for more than 50 percent of the bank's income with different sectors' contributing to this. Hence, there is a need to assess the interaction between credit risk by sector and real economic growth, as macro-prudential policy is inevitable over a period of time, to gauge the relevance of stress testing the results of policy decisions. Further, the existing stress tests in Tanzania do not capture the specific impact of economic activity from credit risk to real economic growth. This study attempts to model an appropriate countercyclical buffer, including the appropriate timing of the usage of the buffer, for developing countries like Tanzania, given the credit cycles observed from q1 2006 to q3 2020.

On the one hand, to address the interaction challenges, several studies have attempted to assess macro-prudential policies from different dimensions, like Górnicka et al. (2020) and Henry et al. (2013), who viewed how credit risk relates to economic growth using stress testing. On the other hand, Bonfim and Monteiro (2013), Burra et al. (2015), and Stojkov (2020) assessed macro-prudential impact in isolation of the transmission between banking sector resilience and interaction among macro-prudential tools. However, several studies like Budnik et al. (2019), Buncic and Melecky (2013), Havrlychyk (2010), Henry et al. (2013), Rakotonirainy et al. (2020), and Youssef (2018) observed the limitation of the usage of credit risk stress tests in translating these to other macro-prudential tools.

Nevertheless, one of the lessons from the 2007/09 financial crisis was the observation that credit risk was a major source of systemic risk, hence warranting in-depth analysis and simulation to identify potential threats originating from credit (Buncic & Melecky, 2013; Çakmak, 2014; Onder et al., 2016). In Tanzania, credit is a major function of the banking business, accounting for more than 50 percent of a bank's assets as well as source of income, hence the impact of credit risk to the real economy and banking sector resilience is significant (BOT, 2019). As of 2019, the banking sector intermediation in Tanzania, as depicted by credit as a percentage of GDP, was 23.5 percent (BOT, 2019), and this proportion calls for the need to assess the impact of banking sector resilience on the economic growth of the country (Budnik et al., 2019). In view of this, the direct link

between credit and GDP growth calls for the need to re-think stress testing (Górnicka et al., 2020).

The key feature of the Tanzanian economy is a small open economy that are highly influenced by external shocks, due to free market activity with a dependency essential for justifying your choice of the countries mentioned above and the GVAR model of analysis (Rakotonirainy et al., 2020).

Meanwhile, the average industry level of the non-performing loans (NPLs) ratio in Tanzania, over 10 years, stood at 8.78 percent, above the acceptable limit of 5.0 percent, signaling heightened credit risk. The scenario plays out with the average industry core capital ratio, that stood at 17.2 percent, being significantly above the regulatory limit of 10.0 percent, (Tanzania, 2019). Despite several measures being undertaken by the Tanzanian Government to contain the growing NPLs, credit risk challenges still remain mainly due to poor loan appraisal processes and limited usage of credit reference system (BOT, 2021). The need to disintegrate and further assess the causes of credit risk in relation to global, foreign, domestic, and banking sector related variables is paramount, as well as the need to link individual banks with the economic growth implication by sector, rather than by aggregated level. Additionally, there is the need to view credit beyond its effect on the balance sheet, and assessing the domestic, foreign, and global variables is inevitable, as the structure of NPLs is still a burden.

The financial sector¹ in Tanzania is mainly dominated by banks, which account for 70.1 percent of the total of the financial sector's assets (Tanzania, 2019). The banking sector continues to grow in line with the development in agent banking, digital platforms, and deposit mobilization. The remaining portion of the financial sector which is not banking sector related in Tanzania, constitutes of social security, insurance, and collective schemes, accounting for 27.1 percent, 2.1 percent and 0.7 percent, respectively (Tanzania, 2019).

¹ Financial sector in Tanzania includes banks, social security sector, insurance sector and collective schemes.

The Tanzanian banking sector is dominated by credit accounting representing over 50.0 percent of the total assets as of December 2019, of which more than 90.0 percent is provided by commercial banks. Out of the 47 banks operating in Tanzania, the commercial banks (36), development financial institutions (2), community banks (6), and microfinance banks (3) account for 95.2 percent, 3.6 percent, 0.6 percent, and 0.3 percent of the total assets, respectively. Banking sector credit in Tanzania is classified into 23 activities (sectors), while GDP by sector is classified into 18 sectors; however, 10 of these sectors are aligned to the specification in the banking sector, taking up more than 70.0 percent of the banks' credit (Tanzania, 2019).

The Central Bank of Tanzania in its efforts undertook several measures to continue stimulating credit growth in the country, from the reduction of the Minimum Statutory Requirement (SMR) from 9.0 percent to 7.0 percent, to the removal of 10.0 percent of provisioning on current loans (Tanzania, 2019). However, credit risk as depicted by non-performing loans (NPLs), continues to be high above the 5.0 percent threshold for the past ten years, standing at 9.8 percent as of December 2019 (Tanzania, 2019). This has been noted to be the major source of risk that can impair the capital position of the banks (Tanzania, 2018, 2019). Further, it has been noted that most of the challenges witnessed in the Tanzanian banking sector from 2015 to 2019 originated from credit, that led to the closure of six banks and the buyout of one of the top ten banks (Tanzania, 2018, 2019). Bank performance is assessed using capital adequacy and profitability ratios.

The study **focuses on Tanzania** as one of the developing countries which has yet to establish a countercyclical buffer in order to support countries with the same banking structure and dependency on credit as their major function. **Another aim is** to identify the magnitude of impact that credit risk would have on the real economy, and the usage of the proposed countercyclical buffer. In addition, the study looks at the need to monitor credit cycles to ascertain the resilience of individual banks and usage of the countercyclical buffer. This **study uses** commercial banks to represent all the banks, given their high proportion of holding and significance in the market (Tanzania, 2019).

1.1.2 Statement of the problem

Inadequate credit risk assessment threatens the resilience of the banking sector, which is crucial in the economy and functioning of the country. The International Monetary Fund (IMF) through the Financial System Stability Assessment (FSSAP) has adopted macro solvency stress testing as part of macro-prudential tools, in assessing the resilience of the banking sector (Fund, 2018). Likewise, Central Banks have continued to develop macro-prudential tools for country-specific systemic risk assessment, as well as to improve risk management tools including macro stress test models, with a major focus on solvency and liquidity stress tests (Başarır & Toraman, 2014; Buncic & Melecky, 2013; Çakmak, 2014; Dees & Henry, 2017). Despite the various micro prudential approaches adopted in Tanzania of individual bank assessment, findings showed that it will be difficult to detect system wide exposure since they looked at individual banks, hence a shift from micro-prudential to macro-prudential regulation in Tanzania (BOT, 2017). Further, small open economies like Tanzania are highly influenced by external shocks, due to free market activity and limited control measures from external shocks(Rakotonirainy et al., 2020).

Similarly, the Central Bank of Tanzania adopted the use of solvency stress testing as part of its macro-prudential policy tools for mitigating the impact of future crises on banks, by ensuring that banks have adequate capital buffers through enhanced supervision and additional regulatory requirements (Tanzania, 2019). Despite the Bank of Tanzania's efforts to discharge its mandate, the applicability of the stress test to filter macro-prudential policy measures and its implication to the real economy remain a challenge (Tanzania, 2019). This was due to the complexity of the stress testing as well as challenges in disseminating information due to the capital implication to banks (Askari et al., 2021b). The IMF through the 2018 FSSAP conducted an assessment in Tanzania using solvency stress testing as one of the macro-prudential tools (Tanzania, 2019); however, a gap was noted as the framework did not provide macro-prudential policy directives or show the magnitude of the impact caused by banks, given their size compared to real economic growth.

Given the significance of credit risk as the major source of risk in the banking sector, several studies model credit risk in isolation of the other risk factors including liquidity, contagion, interest, and foreign exchange risk, in order to effectively assess its implication on the banking sector's performance (Amel, 2018; Rakotonirainy et al., 2020; Vu et al., 2018). Existing literature on the transmission of macro-prudential tools using macro stress tests, has added knowledge on the development and application of the stress testing model, scenario development, and feedback loops from the real economy. However, several limitations exist, including the impact of credit risk macro stress test assessments for individual banks as well as for aggregated banks, in order to identify the systemic impact on the banking sector (Amel, 2018). Likewise, there is another limitation regarding the connection between the real economy and the effectiveness of countercyclical buffers as capital-related macro-prudential policy tools, which calls for further research (Budnik et al., 2019). This study fills the gap by integrating individual banks by sector classification and aggregated bank macro-credit stress testing, with economic growth and macro-prudential tools. Hence, the banking sector is vulnerable to global and domestic transmission shocks where the buffer is unsecured with the dire economic consequences, necessitating the study.

1.1.3 Research Aim and objectives of the study

The main aim of this research is to assess how the application of macro-credit risk stress testing impact a bank's resilience, real economic growth, and macro-prudential tools. This will be attained by using three specific objectives leading to three research papers.

1.1.4 Specific objectives

The specific objectives for this study are to:

1. Assess the impact of macro-credit risk stress testing on banking sector resilience in Tanzania;
2. Evaluate the effect of bank credit risk to real economic growth by sector in Tanzania; and
3. Analyze the implication of the stress test results in influencing macro-prudential policy decisions in Tanzania.

1.1.5 Research questions

From the above objectives, this study expects to answer the following research questions:

1. What is the impact of credit risk stress testing on commercial banks' resilience?
2. What are the effects of banks' credit risk on real economic growth by sector in Tanzania?
3. To what extent do macro-credit risk stress tests support macro-prudential policy decisions?

1.1.6 Research hypothesis

From the above research questions, it is necessary to test the study using the following hypotheses (null hypothesis, H_0 and alternative hypothesis, H_1) to attain the intended objectives.

1. **Hypothesis One:** Given that credit holds more than 50 percent of the total composition of banks' assets in Tanzania, which is a large contribution to the banking sector, we therefore expect the impact of credit risk shocks to have a negative effect on commercial banks' resilience.

H₀: Macro-credit risk stress test does not significantly affect the performance of commercial banks' resilience.

H₁: Macro-credit risk stress test significantly affects the performance of commercial banks' resilience.

2. **Hypothesis Two:** Several studies assessed the impact of economic growth on credit risk. However, the reverse causality effect of the credit risk affecting economic growth, has a significant impact on economies that are highly dependent on the banking sector to finance economic activities. Credit intermediation has increased significantly in the past ten years as shown by credit to private sector growth in Tanzania, although the depth in relation to contribution to economic growth is still small. However, there is the expectation of an impact of credit risk to economic growth in Tanzania, given its role.

H₀₂: There is no significant relationship between credit risk and economic growth by sector in Tanzania.

H₁₂: There is a significant relationship between credit risk and economic growth by sector in Tanzania.

3. **Hypothesis Three:** The main objective of conducting stress testing is to assist in macro-prudential policy decisions, and ultimately identify early warning signals for the purpose of financial stability. The existing credit-related macro-prudential policies are expected to be influenced by the macro-credit risk stress test's impact on the banking sector's performance.

H₀₃: There is no significant implication of the stress test results on macro-prudential policy decisions.

H₁₃: There is a significant implication of the stress test results on macro-prudential policy decisions.

The outcomes of these tests are expected to proffer solutions to the above questions, and ultimately attain the aim with regards to the specified objectives of this study.

1.1.7 Scope/ Delimitation of the study

The focus of the study is on macro-prudential analysis, economic growth, and banking sector resilience in Tanzania. The study period is 14 years, from 2006 to 2020. The choice to begin from 2006 is largely influenced by data availability for most of the commercial banks in Tanzania, given the entry, merging, acquisition, as well as closure of banks in the country. In addition, the stated period took note of granularity and consistency, as provided by the Central Bank of Tanzania. The data collected concentrated on aggregate banks as in chapter 5, as well as individual banks in chapter 6, due to the profiles that allow for inconsistencies and comparison between different banks in Tanzania. The study focused on 19 of the 46 banks in Tanzania, accounting for more than 80 percent of the banking sector's assets, as described in section 5.3.2, **with both domestic and foreign owned commercial banks.** Further details can then be provided in the methodology section.

1.1.8 Significance of the study

The role of macro credit risk stress testing in the banking sector has continued to gain momentum, due to the contribution of credit risk in affecting the performance of banks. In Tanzania, macro stress testing is used for providing early warning indicators to assess the resilience of the banking sector (BOT, 2019). Despite the increased usage of macro stress testing as part of risk assessment, there is a growing need to enhance stress testing for systemic risk assessment since not only benefits policy makers rather banks since they will be able to secure buffers to be able to contain in case they occur.

The 2018 FSSAP conducted a macro stress test assessment in Tanzania linking all the risk factors implicated in the banking sector (IMF, 2018). However, no empirical study has been done extending this implication to real economic growth by sector. Therefore, this study will contribute to the existing knowledge and literature on macro credit risk, by working on the disaggregated data of individual banks and by individual sector, in addition to the aggregate data for systemic risk assessment through credit risk. Further, the study will assess the effectiveness of macro-prudential tools using the macro stress test and countercyclical buffer, concentrating on the credit in the banking sector and real economy. This aims at assisting policymakers to extend concentration of the financial stability of the financial system rather than just on the normal supervisory and compliance tool of risk management. The arising evidence in solving the systemic risk exposure of the Tanzanian banking industry is important to avoid a spillover effect from the functioning of the banking sector to the economy through interdependency in terms of income generating activities operations (Andersen et al., 2019).

1.2 Brief description of the study concepts

1.2.1 Macro-prudential tools

The role of macro-prudential analysis gained momentum after the global financial crisis of 2008/09, with the intention to enhance the assessment of financial stability. Central Banks including the Reserve Bank of Australia, Bank of England, Reserve Bank of South Africa, European Central Bank, IMF, and BIS, among others, have done enormous work in developing and proposing macro-prudential frameworks to complement the micro-prudential assessments. While prudential regulations target individual banks, assuming

the impact of one bank is exogenous of the interaction among banks, macro-prudential regulations on the other hand assess the systemic risk of the financial system as a whole (Alpanda et al., 2014, 2018; Claessens, 2015; Selialia et al., 2010). Macro-prudential assessments for the banking and non-banking sectors in relation to the real sectors of the economy, require the usage of policy measures or tools, which are either capital or balance sheet-related, to evaluate the health and soundness of the financial system (Alpanda et al., 2014; Claessens, 2015; Jayaram & Gadanez, 2016).

More specifically, bank-related macro-prudential tools can either be quantitative or qualitative, with the data for the former submitted by banks and the latter obtained from sentiment surveys. The choice of macro-prudential tool depends on the type of shocks and imbalances, some of these financial originating domestically and others to mitigate vulnerabilities from global factors assessed (Belkhir et al., 2020; Jayaram & Gadanez, 2016; Selialia et al., 2010; Upper, 2017), hence creating relevance for the suitability of indicators.

The interaction between macro-prudential policy tools and other segments of the assessment of the financial sector, has become a significant area of research in recent years, due to growing global integrations (Cantú et al., 2020; Górnicka et al., 2020; Grace et al., 2015). Macro-prudential analysis is not a standalone tool, as it requires the assessment of the interaction of impacts to obtain a desired output and to justify the relevance of its existence. A study by Budnik et al. (2019) assessed the interaction and enhancement of Financial Soundness Indicators (FSIs) as a balance sheet macro-prudential tool with stress testing, in a situation where there was a non-availability and low frequency of datasets. (Constâncio, 2016b; Górnicka et al., 2020; Jayaram & Gadanez, 2016) explored approaches of how stress testing is used as a macro-prudential policy tool by Central Banks, and developed a model for an integrated assessment and rating of banks, based on the stress tests results, to cover the losses and ensure financial stability.

1.2.2 Stress testing

Stress testing is a tool that is utilized in various disciplines, such as construction, software development, civil engineering, component manufacturing, and cardiac health care,

involving placing a severe amount of pressure on an object or system, to test its resilience under extreme conditions (Dent et al., 2016). In the case of finance, stress tests have been applied in away to the banking sector, to find out how they may contain hypothetical adverse scenarios and identify risky institutions (Baudino et al., 2018). Studies done including one by the BCBS (2009), define stress tests as one of the significant risk management tool that supplements other risk management tools, used by banks and regulatory authorities to detect early warning signals in the event of the occurrence of adverse unexpected outcomes, and to determine how much capital is required to restore the situation and mitigate exposure to these.

Berger et al. (2020) also define stress tests as a simulation exercise made to assess how a particular individual, institution, or system may react in the event of an unusual, stressful situation. Further, the same authors emphasized that bank stress tests showed the ability of banks to cushion and have business continuity in the event of a hypothetical, adverse scenario, which could lead to potential financial turmoil or crisis. Predominantly, the type of stress test used is chosen by different authorities, studies, and international standard bodies based on the objective, participant, methodology used, approach, as well as the impact (Adrian et al., 2020; Baudino et al., 2018). For this particular study, the stress test chosen was based on the objective, implying either micro-prudential or macro-prudential stress tests. On the one hand, micro-prudential stress tests are conducted at bank level or by supervisors, focusing on an assessment of the resilience of an individual bank to withstand macro-financial shocks, and an assessment of the adequacy of individual banks' capital or liquidity, linked to their risks (Acharya et al., 2014; Adrian et al., 2020; Baudino et al., 2018). On the other hand, macro-prudential stress tests are conducted at regulatory authority level, and are aimed at assessing system-wide resilience, with individual interactions taken into account, to withstand adverse effects to financial and economic shocks (Baudino et al., 2018).

A literature review of macro stress testing can be consolidated based on the classifications of Sorge (2004) and (Foglia, 2008). The Sorge approach provides a systematic review of the undertaking of macro stress testing, by clearly defining the scope

in terms of whether the assessment is based on aggregate institutions, or large or small banks, and whether foreign only or domestic. (Sorge, 2004). In doing so, the schematic classification of macro stress test methodologies assessed by Sorge (2004), are done through a piecewise approach using reduced and structural models, and an integrated approach, mainly by using Wilson’s and Merton’s models.

The Foglia approach focuses on how to link macro-economic drivers of stress with bank-specific measures of credit risk, forming part of the early detection of vulnerabilities and assessment of macro-financial linkages, as well as macro-economic and macro-prudential oversight. Different approaches include structural economic, vector autoregressive models, pure statistical, and judgement approaches. Several studies by Çakmak (2014), Havrlychuk (2010), Jakubik and Hermanek (2007), Onder et al. (2016), and Papadopoulos et al. (2016) developed a macroeconomic credit risk model for stress testing specific banking sectors, based on assessing the interlinkage between macroeconomic shocks and banking sector performance on aggregate and by sector.

In 2008/09, the impact of the global financial crisis accelerated the utilization of stress testing as a tool for assessing the best method that simulates the probability of occurrence of a crisis, given certain assumptions, to reduce uncertainty over bank health and decide what to do about vulnerable institutions (Baudino et al., 2018; Kanas & Molyneux, 2018). Further, following the crisis that severely affected large banks in several countries, leaving financial institutions in financial distress, authorities focused on identifying the weaknesses of individual banks, providing mitigation measures to ensure the health of the financial system, and disclosing the results to the public to boost confidence in the financial system (Čihák et al., 2019).

Table 1 : Key developments undertaken in bank stress tests

| Sno. | Year | Event | Practitioners |
|------|-------------|--|---------------------------|
| 1. | Early 1990s | Small-scale stress tests were conducted on the trading books by banks, aiming at complementing other statistical techniques used to evaluate risks on their trading books. | Large international banks |

| | | | |
|----|-------------|---|---|
| 2. | 1996 | The Basel Accord of 1988 was amended in 1996 in order to use stress tests to evaluate trading portfolios, so as to incorporate market risk in the computation of capital requirement, therefore using internal models for quantifying market risk, as well as for implementing bank-wide stress testing for market risk. | Basel Committee for Banking Supervision (BCBS) for banks in the G-10 to implement from 1998. |
| 3. | 1999 | IMF and World Bank established the Financial Sector Assessment Program (FSAP) in 1999, probed by the Asian financial crisis, aimed at assessing the resilience of the financial sectors, the quality of regulatory and supervisory frameworks, and the ability to contain financial crisis in case they occur. | World Bank (WB) and International Monetary Fund (IMF). IMF uses this for advanced economies, while the IMF/WB adopted this for emerging economies. |
| 4. | Early 2000s | <p>✓ The adoption of the Internal Rating-Based Approach for capital requirements for credit risk called for the need to conduct stress tests for compliance.</p> <p>✓ As banks increasingly adopted the use of stress tests, in the early 2000s, central banks on the other hand sought to also start undertaking stress tests for quantifying risks, assessing banking sector resilience, as well as ensuring financial stability.</p> | <p>✓ Basel Committee on Banking Supervision - Bank for International Settlements, 2001.</p> <p>✓ Euro area countries including Ireland (2000), Finland (2001), Luxembourg (2002), and Germany (2003).</p> |

| | | | |
|----|------------|--|--|
| 5. | 2004 | <p>✓ The revised Basel II framework was endorsed focusing on the banking book, of which the requirement for credit risk stress testing by banks was introduced.</p> <p>✓ In addition to the continued implementation of FSAPs, of which stress testing was one of the assessment tools.</p> | <p>✓ Basel Committee on Banking Supervision - Bank for International Settlements, 2004.</p> <p>✓ Netherlands (2004), Austria (2004).</p> |
| 6. | 2007 | <p>The application of a stress testing working paper was endorsed to facilitate the development of stress test models by Martin Cihack of the IMF. The working paper explains the stress testing framework, and fosters transparency in presenting stress testing assumptions, and assessing the robustness of results to the assumptions.</p> | <p>Central banks that are conducting FSAPs through IMF/WB.</p> |
| 7. | April 2009 | <p>The Supervisory Capital Assessment Program (SCAP) is a mandatory stress test that was adopted for 19 major U.S. bank holding companies (BHCs), backed by government capital, that was introduced to ensure that banks had adequate capital buffers to withstand losses, and meet the credit needs of their customers in a more severe recession than anticipated.</p> | <p>Federal Reserve Bank of the US (2009).</p> |
| 8. | May 2009 | <p>✓ Stress testing principles were published to address key weaknesses in stress testing practices that were highlighted by the global</p> | <p>Basel Committee on Bank Supervision.</p> |

| | | | |
|-----|-----------|--|---|
| | | <p>financial crisis. The principles involve key principles for stress testing for both banks and supervisors to ensure their effective conduct.</p> <p>✓ Committee of European Banking Supervisors (CEBS) begins inaugural EU-wide stress test.</p> | Banks and supervisors. |
| 9. | July 2009 | Tanzania adopted the Cihack stress test model customized by the IMF Technical Assistance Team, aimed at assessing the resilience of the banking sector in the country. | Bank of Tanzania. |
| 10. | 2010 | In the EU, the stress-test exercise was coordinated by the Committee of European Banking Supervisors (CEBS) and developed in close cooperation with the ECB and the European Commission. This aimed at assessing the resilience of the European banking system. | Committee on European Banking Supervision (CEBS). |
| 11. | 2011 | The Dodd-Frank Act Stress Test is a complement to the Comprehensive Capital Analysis and Review (CCAR) program, which was introduced with a forward-looking view, to assess the impact on capital levels that would result from immediate financial shocks and nine quarters of adverse economic conditions. | Board of Federal Reserve. System. |
| 12. | 2014 | ✓ Solvency system-wide stress tests that examine individual banks' levels of capital adequacy, were introduced for banks that under the direct supervision of the ECB, primarily to support supervisory and micro-prudential objectives. | European Central Banks (ECB). |

| | | | |
|-----|------|--|---|
| | | <ul style="list-style-type: none"> ✓ The Bank of England (BOE) introduced the first concurrent stress test building on the existing EBA exercise. This was done mainly by focusing on combining both global macro-economic and market shocks, which were used for EBA system-wide stress testing and UK macro-economic elements developed by the BOE. | Bank of England. |
| 13. | 2018 | <ul style="list-style-type: none"> ✓ The IMF/World Bank Financial Sector Stability Assessment Program (FSSAP) 2018 was conducted in Tanzania, of which macro stress testing formed part of the risk assessment. ✓ Stress testing principles were revised to take into account the evolution of stress testing in recent years; these guidelines focus on the key elements for developing frameworks for both bottom-up as well as top-down stress testing conduct. | <ul style="list-style-type: none"> ✓ IMF/World Bank. ✓ Basel Committee on Bank Supervision. ✓ Banks and supervisors. |
| 14. | 2019 | <p>Disclosure of the concurrent stress test results by the Bank of England.</p> <p>A scan of the status of stress testing in the African region by IMF was conducted.</p> | Bank of England. |
| 15. | 2020 | <p>Stress testing of banks during the Covid-19 pandemic took a different perspective, leading to banks moving away from the traditional approach of designing scenarios, and</p> | <p>Bank of International Settlements.</p> <p>Regulatory authorities among</p> |

| | | | |
|--|--|---|--|
| | | embedding more flexible assumptions and higher shocks than anticipated cases. | others, Bank of England and European Central Bank (ECB). |
|--|--|---|--|

Source: adopted from (Adrian et al., 2020; Baudino, 2020; Committee, 2009; Dent et al., 2016; Leika et al., 2020; Pliszka, 2021; Ryznar et al., 2015)

1.2.3 Stress testing in Tanzania

Stress testing, which forms part of risk management, is done using both a bottom-up and top-down approach in Tanzania (Tanzania, 2018). Tanzania adopted the sensitivity analysis, single period stress testing approach using a customized IMF Cihak stress testing model of 2009, for undertaking top-down stress testing of the banking sector (Tanzania, 2018). However, the stress test framework concentrates on assessing all the individual risk factors using macro-economic variables, and tests impact to banking sector liquidity and capital position on individual and aggregate terms. The model provides one timeframe change of the stress test scenario, and is hence a single period and single factor model.

The stress testing process in Tanzania involves the development of scenarios and is later transferred to the main CIHAK model, for assessing the impact to capital position on aggregate and individual banks. For the development of scenarios, the vector autoregressive model is adopted for determining the magnitude of shocks originating from macro-economic factors. Both qualitative and quantitative factors are used for defining the magnitude of shocks, to take into account the qualitative aspect of the banking sector in terms of operations (IMF, 2018b). The stress test model is Excel-based with separate sheets for individual risks; once shocks are applied, the impact on capital originating from each risk up, right up to the end, is obtained. Particularly for credit risk, the usage of commodity and fuel prices is used to design the scenarios (BOT, 2019a). In addition, the aggregate NPL shock is derived from the watch loan (a specially mentioned category of NPLs) ratio, which is added to the existing NPLs with the assumption that all the Especially Special Mentioned (ESM) loans will turn to being non-performing (BOT, 2019a).

1.2.4 Banking sector resilience

Crises affecting the banking sector have a long history, from the Asian crisis to the global financial crisis 2007/09 to the recent COVID-19 pandemic. These first two crises originated from the financial sector itself, while the pandemic originated from health issues. The 2007/09 crisis created food for thought for financial sector regulators, to consider more risk-based supervision in addition to a macro-prudential analysis.

Similarly, banking sector resilience literally refers to the ability of the banking sector or individual banks to remain within the required capital limits and continue operations without any challenges. This is amplified by the Basel Committee introducing capital buffers including conservation, countercyclical and Domestic Systemically Important Banks (D-SIB) buffers to gauge the magnitude of cushioning that banks require to remain resilient in case shocks materialize (Basten & Koch, 2017; Belkhir et al., 2020).

Resilience is about the system's ability to continue to serve the economy well, by identifying the triggers for crises that unfold unexpectedly from within an institution, or emerging strains including climate change (Papadimitriou et al., 2020). Drawing from an academic and policy literature review, banking sector resilience is linked to the ability to have enough capital buffers to withstand adverse shocks; however, in addition to capital buffers, several factors including diversity, interconnectedness, financial system size, asset and liability composition, complexity and transparency, and leverage are taken into account. All these together are used for a macro-prudential assessment to ensure that the resilience of the financial sector is positive (Nidhiprabha, 2011).

The aftermath of the global financial crisis of 2008/09 led to banks and regulatory authorities to implement buffers, whose significance was substantially reviewed during the period of the COVID-19 pandemic, where banks were resilient enough to withstand the shocks (Papadimitriou et al., 2020). In addition, banks were able to utilize the buffers as intended in a time of stress. Therefore, capital positions are a significant factor in assessing the resilience of the banking sector, notwithstanding the fact that risks posed to this sector ultimately end up depleting capital positions. In this regard, much emphasis

is placed by international standard bodies on ensuring additional buffers are maintained in accordance with the magnitude of exposure (Slovik, 2012).

1.2.5 Economic growth

The term economic growth is defined as the process whereby a country's real national and per capita income increases over a long period of time, with features that signal an improvement in living standards as well as output of goods and services (Lewis, 2013). Over a long period, an increase in national and per capita income should be sustained, thus increasing sustainable production capacity through use of technology or expansion.

Economic growth is usually reflected by Gross Domestic Product (GDP), a significant indicator that is normally used to control the economic cycle of a country. GDP is approximated by annual growth of real GDP in percentage. Studies show that during the expansion phase of an economy, borrowers need sufficient funds to support their repayments, and during a recession their ability to service debt declines (Chaibi & Fiti, 2015).

Economic growth provides an interlinkage of source as well as a feedback effect on the functioning of the banking sector. Credit is a stimulant of economic growth as well as a result of it, as there is a tight connection between the two. (Banu, 2013) assessed the impact of credit on economic growth using GDP as an indicator of economic growth, and revealed that credit to households makes a major contribution to GDP compared to credit provided for public administration.

1.2.6 Credit risk

Credit risk is defined as the potential that a bank borrower or counterparty will fail to meet their obligations in accordance with agreed terms (Ejoh et al., 2014). According to Al-Smadi and Ahmad (2009), credit risk is the situation where the promised cash flows held by financial institutions may not be paid in full, either through lending or investing in securities. The major business of banks is to provide lending services, therefore they have a potential exposure to credit risk, although risk management of credit risk is very

complex, owing to the causes that are beyond a bank's control, including the macro-economic environment (Garr, 2013).

Credit risk has several components categorized as default, downgrade, concentration, and spread risks (Zamore et al., 2018). Default risk is the common definition of credit risk that occurs when borrowers are unable to make contractual payments as they become due. (Zamore et al., 2018) defined downgrade risk as risk related to the ratings of issuers, while concentration risk is when too much exposure is placed in one area (product, sector, or investor).

The same authors further point out that another credit risk is spread risk, which is caused by the changeability between interest rates and the risk-free return rate (Zamore et al., 2018).

Significantly, credit risk is viewed as the risk of default, whereby non-performing loans are used as a proxy for it (Abdolshah et al., 2021; Ganbaatar & Selenge, 2012; Messai & Gallali, 2018; Patra & Padhi, 2020a; Rakotonirainy et al., 2020; Razafindravonona, 2021), or loan loss provisions (Amel, 2018; Havrylchuk, 2010; Kattai, 2010; Vuković, 2014). Non-performing loans are preferred due to the availability of data and the flexibility to assess the economic information for both sectors, namely individual banks as well as aggregate ones (Rakotonirainy et al., 2020).

1.2.7 Countercyclical capital buffer

The Basel III countercyclical capital buffer is calculated as the weighted average of the buffers in effect in the jurisdictions in which banks have a credit exposure (Edgea & Liangb, 2022). This is a mechanism to build up additional capital during periods of excessive credit growth when risks of system-wide stress are observed to be growing (BCBS, 2017). The Countercyclical capital buffer (CCyB) is one of the macro-prudential policy tools introduced as part of the adoption of Basel III, following the financial crisis 2007-09, adding to the existing buffers to enhance the resilience of the banking system in times of financial crisis (Vasylyeva et al., 2014). Studies have revealed that countercyclical buffers were developed to address the challenges of pro-cyclicality in financial markets' regulatory and supervisory framework, by building buffers during good

times that could also be utilized during challenging times (Behn et al., 2013). From a practical point of view, the proximity of countercyclical buffers calls for banks to hold more capital as assets grow rapidly, in order to ensure that a substantial amount of buffer is retained to cushion assets at times of insolvency and financial downturns (Behn et al., 2013). Therefore, this promotes a sustainable provision of credit to the economy by making the banking system more resilient and less pro-cyclical (Detken et al., 2014; Drehmann & Gambacorta, 2012). The need to relate the growth of credit with capital retention is very important for developing economies to analyse the financial sector, which cushions against potential risks from the pro-cyclicality of the economy and business cycles.

The indicator for determining the pro-cyclicality and business cycles, in order to establish a useful common reference point for taking buffer decisions, is the assessment of the behavior of credit-to-GDP (Drehmann & Tsatsaronis, 2014). The credit-to-GDP gap has been identified as a leading indicator that signals financial distress, and is defined as the difference between the credit-to-GDP ratio and its long-term trend (Repullo & Saurina Salas, 2011). With the growing usage of the credit-to-GDP gap as an indicator of financial vulnerabilities, studies have identified challenges in finding a suitable guide for setting a buffer for CCyB (Auer et al., 2022). Further, other studies show that the credit-to-GDP gap is not the best early warning indicator for banking crises, especially in the case of emerging market economies, while also having some measurement problems (Detken et al., 2014). Despite these challenges, the credit-to-GDP gap still remains the most suitable indicator given the data availability for developing countries like Tanzania.

1.3 Structure of the thesis

There are seven chapters in this thesis. Chapter 1 focused on the introduction, motivation, and statement of the problem of the study. This chapter further explained the objectives, contributions, and conceptual framework for the study. Chapter 2 reviewed the financial sector and banking sub-sector in Tanzania, mainly focusing on providing an overview of the Tanzanian financial sector including reforms, its structure and, composition, as well as the Tanzanian economy in relation to GDP. For the Tanzanian banking sector, the

study was able to review the evolution, regulatory environment, types of banks, and ownership, as well as banking sector performance.

For chapters 3, 4, 5, and 6 have their own independent literature reviews, methodologies, and empirical analysis. Chapters 3 and 4 aim at attaining the first objective of the study, namely assessing the impact of macro credit risk stress test on the resilience of the banking sector in Tanzania. Chapter 3 developed a macro credit risk stress test using global and foreign transmissions, in addition to the variables of the domestic banking sector. Chapter 4 assessed the banking sector's resilience for individual banks to assess their ability to cushion against shocks. Chapter 5 analyzed the effect of credit risk to real economic growth in Tanzania. Chapter 6 designed a countercyclical capital buffer and assessed the implication of the stress test results obtained in Chapter 4, how they deviate from the buffer, at what time the buffer would be required, and by which specific bank in Tanzania. Chapter 7 contains the summary, key findings and conclusions, recommendations, limitation of the study, and areas for further research.

1.3.1 Conceptual framework

The overall research gap is illustrated by the following conceptual framework, which summarizes the methodology for the proposed credit risk stress test in Tanzania. Figure 1 provides a sketch of the thesis, from the development of stress scenarios to associating them with the macro-economic variables, both foreign and domestic, as stipulated in Chapter 3. Further, the stress scenarios are also linked through the banking sector variables in addition to the domestic variables, as detailed in Chapter 4. The impact of the stress scenarios is assessed through the aggregate banking sector's credit risk using NPLs in Chapter 3, while Chapter 4 extended the impact of the stress scenario to a bank's capital position for the selected individual banks. The study extended the analysis to assess the link between credit risk and economic growth in Chapter 5, and how it translates in the financial system. Lastly, the study intends to assess the link between the impact of stress testing and macro-prudential policy tools for enhancing policymakers' decisions, as detailed in Chapter 6.

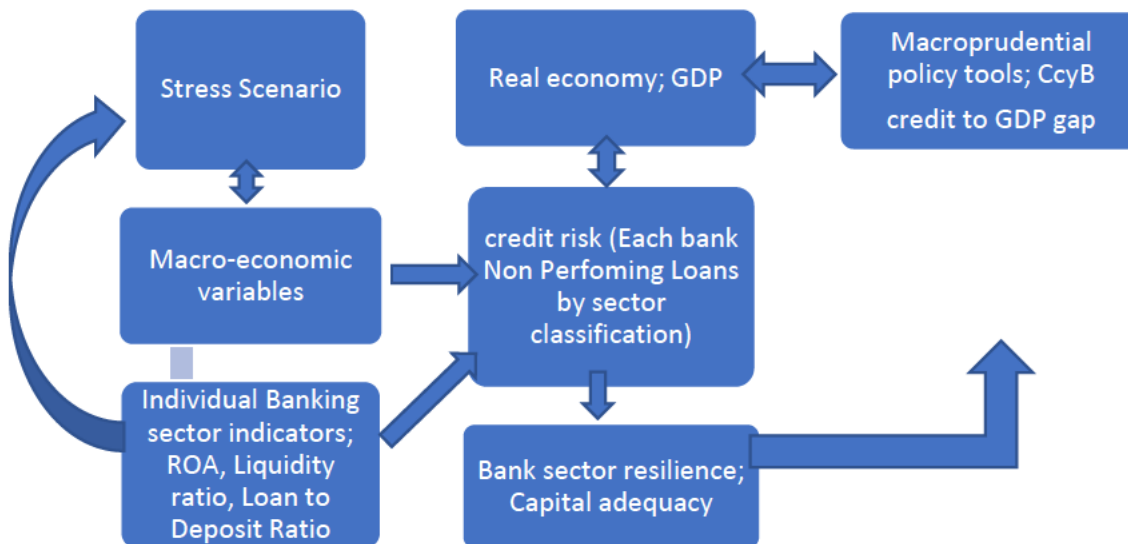


Figure 1.1: Conceptual framework for the proposed credit risk stress test methodology in Tanzania.

1.4 Research Contributions

This study is an attempt to empirically test the need for Tanzania to design a macroprudential policy that will enhance banking sector assessment of risk with a view of securing enough capital buffers in case a potential crisis occurs. Tanzania is one of the small open economies that is vulnerable to global shocks due to the free market economy practice and high dependency on global trade to influence the economic its economic activities, hence it became the focus for this study.

This study contributes to the body of knowledge in several ways. Firstly, this study contributes to the existing knowledge by adopting a Global Vector Autoregressive (GVAR) model to assess credit risk with developing macro shocks of a combination of banking sector factors, as well as global and domestic macroeconomic variables on an individual bank's perspective. This is first to be done in the Tanzanian banking sector.

Secondly, this study contributes to the literature on macro credit risk stress testing in Africa, as well as the rest of the world by adding countries like Kenya and the UAE in the GVAR model, which were previously not featured.

Thirdly, this study expands on the existing literature on stress testing by linking with global, domestic, and banking sector impacts to assess the banking sector resilience in Tanzania, where the GMM and dynamic panel model approaches were adopted.

Fourthly, this study expands on the assessment of the effects of the relationship between credit risk and economic growth, using the data from six major sectors in Tanzania using the linear and non-linear autoregressive distributed lag (ARDL) approaches.

Lastly, this study fills the gap on the ex-tante literature for establish a countercyclical capital buffer (CcyB) and assessing the linkage between credit and GDP using a CcyB, with Tanzania representing developing economies. This further adopted the use of countercyclical buffers using Basel III, to mitigate the pro-cyclicality of bank capital and gauge the effectiveness of macro-prudential policies in decision-making, by using the case of Tanzania.

1.5 Summary

This chapter provided the background for the study, focusing on an assessment of the interaction between the capital and balance sheet macro-prudential tools for risk assessment, as well as transmission to the economy - a gap which is expected to be filled by this study. In this chapter, an overview of the banking sector, which is predominately dominated by credit extension provided by commercial banks, was also assessed. Further, the chapter expanded on the aim and both general and specific objectives, from which were derived the research questions and hypothesis for undertaking the study. Furthermore, the scope and delimitation of the study, as well as a brief description of the key study concepts, were also reviewed including macro-prudential tools, stress testing, banking sector resilience, economic growth, and credit risk. The chapter provided the structure of the thesis as well as a graphical representation of the conceptual framework for the entire study. The next chapter is to address the financial sector and the banking sub-sector in Tanzania, with a view of assessing their evolution, reforms, and relationship with the Tanzanian economy.

CHAPTER 2: FINANCIAL SECTOR AND THE BANKING SUB-SECTOR IN TANZANIA

2.1 Introduction

The preceding chapter identified a gap in the interlinkage between credit risk, economic growth, and countercyclical buffers in supporting policymakers (Asamoah, 2008; Bansal, 2015; Eta & Anabori, 2015; Yadav, 2016). Empirical studies have shown that macro-prudential tools can either work as standalone or complementary tools for assessing the resilience of the banking sector, taking into account the dimensions of severity that may deter the functioning of this sector (Belkhir et al., 2020; Berezina et al., 2019; Upper, 2017). This study aims to bridge the abovementioned gap using Tanzania as a case study, to assess the interaction between macro-prudential tools using a balance sheet tool (macro credit risk stress tests) and capital-related tool (countercyclical buffer), and their impact on economic growth. In doing so, this chapter provides an overview of the financial sector and domestic economy in Tanzania. Further, the overview of the financial sector focuses on the banking sector, in particular its evolution and regulatory framework, as well as the types of banks, ownership structure, asset composition, performance, and credit distribution by sector classification. This chapter lays out why the study focused on the Tanzanian banking sector to assess the interlinkage between credit risk exposure and the economy, given its contribution to both the financial sector and the economy at large. This chapter also assessed the performance of the banking sector in Tanzania, with the exposition in an article that assessed the financial sector reforms and through descriptive analysis (Kishimba et al., 2022a).

2.2 The Tanzanian Financial Sector

2.2.1 Overview of the financial sector

This section reviews the financial sector's reforms, structure, and composition, as well as the domestic economy, and the financial sector's contribution to Gross Domestic Product (GDP). According to Ouanes and Thakur (1997), the financial sector is the composition of entities that provide financial intermediation services for the economy, including banks and other financial institutions such as mutual funds, credit unions, pension funds, and insurance companies. In addition, according to a study by Alexander and Baden (2000), the OECD defines the financial sector as "the set of institutions, instruments, and the

regulatory framework that permit transactions to be made by incurring and settling debts; that is, by extending credit”.

Generally, the financial sector's significant functions are as a value exchange, intermediation services, risk transfer, as well as liquidity, which support the functioning of other industries, hence stimulating economic growth and poverty reduction (Australia, 2014; Fethi & Katircioglu, 2015; Herring & Santomero, 1995; Svilokos et al., 2019). Moreover, individuals can provide these functions, but having structured institutions, considering informational asymmetries that arise in financial transactions, therefore requires particular supportive abilities to enable the financial sector to operate smoothly.

Tanzania has a blended financial sector, undergoing expansion in asset growth, and entry of new entities into the market, contributing to the economy (Kishimba et al., 2022a). Therefore, an effective and efficient regulatory environment ensures the stability of the sector. The Tanzania Masterplan, as stated by (URT, 2020), notes that the Tanzanian financial sector comprises banking and non-banking sub-sectors, including social security schemes, microfinance, insurance, and capital markets (represented by collective schemes). Before reviewing the different sub-sectors of the Tanzanian financial sector, there is a need to assess the reforms undertaken in the financial sector.

2.2.2 Financial sector reforms

Financial sector reforms have an amplified impact on the economy, as markets widen and interlink, creating a supportive environment for economic development. Khan and Sundararajan (1991) state that financial sector reforms are policy measures designed to deregulate the financial system, and transform its structure into a liberalized market-oriented system within an appropriate regulatory framework. In addition, a study by Okeke (2007) also states that reforms are deliberate actions by the government to fast track a process to achieve the desired objective, and establish a movement towards a friendlier, market-oriented economy that will be all-inclusive. **Financial sector reforms refers to steps taken to reform the sectors of the financial sector including banking sector, capital market, foreign exchange market and government debt market etc (Ogujiuba & Obiechina, 2011).**

Financial sector reforms have facilitated the existence of an enhanced role on credit allocation, increased development of the capital markets, and independence of the commercial banks. Most of the financial sector's reforms consider that the sector as being significant in its contribution to economic growth, and in increasing coverage, access, and flexibility to support trade in respective economies using banking systems, given its significance in developing economies' markets (Asamoah, 2008; Bansal, 2015; Eta & Anabori, 2015; Yadav, 2016). These efforts which were undertaken in the reforms were to fill the gap in: the lack of prudent regulations and supervision; nascent financial markets; informal financing; access to funding; and allocation of credit to various activities and economic sectors.

In that context, the Tanzanian economy has undergone several reforms since early 1991, including the first generation reforms, that focused on the legal and regulatory environment (Ndalichako, 2016). The reforms targeted the banks and capital market participation, which allowed foreign participation to stimulate competition and economic activities (Nguling'wa Balele, 2018; URT, 2020). Despite the benefits reaped in the first generation reform, access to finance remained a challenge.

Therefore, in 2006, the second generation reform aimed to complement the first generation ones, by concentrating on inclusive growth and services, including the banking, social security, insurance, and capital markets (Gray & Khan, 2010). In light of this, several policies were recommended for review that led to an increase in the entry of financial players, which stimulated the economy's growth (URT, 2020). According to Nguling'wa Balele (2018) and URT (2020), these developments have been transformative to the financial sector, have encouraged inclusive growth, and have increased access to finance, which has fostered the development of innovative products in the market. The reforms undertaken in Tanzania over three decades, supported by a favourable macroeconomic environment, have resulted in the emergence of robust and efficient payment systems, as well as an inclusive banking sector, capital market, insurance, and social security schemes (Fund, 2018; URT, 2020).

2.2.3 Structure and composition of the Tanzanian financial sector

This sub-section reviews the composition of the financial sector in Tanzania as outlined in the approved Tanzania Financial Sector Masterplan 2020. The financial sector is considered the economy's engine in stimulating economic growth and reducing poverty (Bank, 2019). In addition, access to the financial sector's services enhances the stability of the sector, by reducing the traditional concentration of financial services to a few individuals and other sectors (Bank, 2019). The Tanzanian financial sector is composed of the sub-sectors of banks, pension funds, microfinance, insurance companies, and capital markets. However, the financial sector in this country is mainly dominated by the banking sector, which accounts for about 65 percent, followed by 20 percent, 10 percent, 5 percent, and 5 percent, for the next four sectors mentioned, respectively.

2.2.3.1 Banking sub-sector

The banking sector in Tanzania is the largest financial sub-sector, accounting for about 70 percent of total financial assets, hence offering a significant intermediation function to the economy (BOT, 2021). According to Babu (2015), a bank is a financial institution and a financial intermediary that accepts deposits and channels these into lending activities, either directly or through capital markets. Prabhavathi K (2018) views a bank as an establishment where individuals safely make advances as required, and to whom they entrust their money when they do not need to use it. According to BOT (Act, 2006), a bank is defined as an entity engaged in the banking business, which receives funds from the general public through the placement of bonds, certificates, notes, or other securities, and uses such funds, in whole or in part, for loans or investments at the account of and risk of the person doing such business.

Like many developing countries, the Tanzanian banking sub-sector dominates the financial sector, accounting for more than 70 percent of its total assets (AnnualBOT-FSR, 2020a), and making a significant contribution to the economic growth of Tanzania. The Banking sector is competitiveness enough and concentrated to five banks in the banking industry in Tanzania with credit concentration of more than 50 percent thus relating to macro-prudential policy (BOT, 2021). The existence of several acts, including the BOT Act of 2006, Banking and Financial Institutions Act, Cap.342, Foreign Exchange Act of

1992, and National Payment System Act of 2015, provides powers to the Bank of Tanzania to supervise and regulate the banking business, payment systems, and foreign exchange business. In Tanzania, the banking sector has a total of 46 banks, which includes 35 commercial banks, four microfinance banks, five community banks, and two development financial institutions (AnnualBOT-FSR, 2020a). This reflects that the Tanzanian banking sector is dominated by commercial banks, which account for about 95 percent of the total banking assets, followed by development banks that account for about 3.9 percent (BOT, 2021). Each banking sub-group will be discussed in detail in the following sub-sections.

2.2.3.2 Microfinance sub-sector

The financing gap for individuals who lack collateral guarantees has failed to be fulfilled by commercial banks; therefore, the existence of the microfinance sub-sector in developing economies has been very significant in supporting economic growth through extending credit (Gutierrez-Nieto et al., 2007; Zohir & Matin, 2004). The inception of microfinance goes back to the Grameen Bank of Bangladesh in the 1980s, which focused on assisting the poor to access financial services, through the provision of loans, savings, and other essential financial services, so as to reduce poverty and create a socioeconomic welfare impact (Kinde, 2012; Zohir & Matin, 2004). Microfinance is a financial intermediary that provides small loans to a marginalized category of borrowers with little or no collateral assets.

The microfinance sub-sector has been a supportive engine for economic growth and financial inclusion initiatives, by accessing individual borrowers who are not in the banking sub-sector (Gutierrez-Nieto et al., 2007). The microfinance sub-sector in Tanzania started operations with both regulated and unregulated institutions. Before 2019, regulated microfinance institutions in Tanzania were those that take deposits from customers; as of 2020, four banks were licensed to carry out that role (AnnualBOT-FSR, 2020a).

The existence of the Microfinance Act, 2018 led to the issuance of regulations, including: the Microfinance (Non Deposit Taking Microfinance Service Providers) Regulations, 2019; the Microfinance (Savings and Credit Cooperative Societies) Regulations, 2019; and the Microfinance (Community Microfinance Groups) Regulations, 2019 (BOT, 2019b-

c). Further, in the same year, the Bank of Tanzania delegated its powers and functions to other authorities such as the Tanzania Cooperative Development Commission (Tier 3) and local government authorities (Tier 4), for effective supervision (BOT, 2019b-c). The existence of the regulatory sphere aims to formalize the existing microfinance sub-sector, in order to improve the provision of proper business conduct, financial inclusion, and consumer protection initiatives. The microfinance sub-sector comprised of microfinance banks accounted for 0.6 percent of the banking sub-sector's total assets, therefore making up a tiny proportion of the banking sector; as such, additional banks are needed to offer microfinance services (BOT, 2021a-b).

2.2.3.3 Insurance sub-sector

The insurance sub-sector in Tanzania is the third largest in the financial sector, behind the social security schemes and the banking sub-sectors, accounting for about 10 percent of the total assets of the financial sector (BOT, 2019). Insurance is a legal contract between an insurance company and an individual, which is used to hedge against the risk of uncertain losses that may be assumed (Davies et al., 2003; Madura, 2014). Usually, insurance companies provide financial benefits to the insured through risk-sharing and transfer contracts (IMF, 2019a). TIRA (2009) states that the Insurance Act in Tanzania defines the insurance business as the “business of assuming the obligation of an insurer in any class of insurance, whether defined in the Act or not, which is not declared to be exempt from the provisions of the Act in terms of Section 2 and includes assurance, re-insurance and reinsurance”. The classification of the insurance industry in Tanzania falls into life, general, and re-insurance, which is in line with the (IMF, 2019a), in the development of financial soundness indicators for the sector.

Since the insurance sector intends to reduce uncertainty and the impact of losses, this sub-sector can encourage new investments, competition, and innovation, therefore playing a significant role, both directly and indirectly, in the economic growth and development of a country (Feyen et al., 2013). URT (2020) notes that the first (1991) and second (2006) financial sector reforms, led to a transition of the sub-sector in terms of regulations, growth, as well as entry of private sector players into the market. This led to

an increase in insurance companies from two to 31, as of December 2018. The sub-sector is regulated by the Tanzania Insurance Regulatory Authority, which is mandated by the Act, 2009, contributing to 2.38 percent of the total assets of the financial sector (AnnualBOT-FSR, 2020a). The insurance industry is categorized into life, non-life and re-insurance, of which non-life can be termed as general insurance in other jurisdictions (IMF, 2019a).

Life insurance is a contract between an insurer and a policyholder, which guarantees that the insurer will pay a sum of money to named beneficiaries upon the death of the insured party, in exchange for a premium paid over a set period by the policyholder during their lifetime. In Tanzania, life insurance is categorized into group, individual, and other life, of which the market share is 80.52 percent, 17.85 percent, and 1.62 percent, respectively. The number of operating life insurance companies was five, accounting for 26.64 percent of the sub-sector's total assets and 16.66 percent of the total premiums received (TIRA, 2020).

Meanwhile non-life insurance, also considered as general insurance, comprises of products covering a wide range of risks, including motor, health, marine, aviation, liability, travel, commercial, fire, and property insurance. In 2020, motor, fire and, health constituted more than 70 percent of the market share, with 33.02 percent, 22.72 percent, and 19.63 percent weightings, respectively (AnnualBOT-FSR, 2020a; TIRA, 2020). The number of operating insurers in general business is 25, accounting for 73.36 percent of total assets and 83.34 percent of total premiums received (TIRA, 2020).

Re-insurance is also another service provided in the insurance business, which is defined as the transfer of a portion of risk by insurers to another company (TIRA, 2020). Out of the 32 insurers in Tanzania, there is only one re-insurer known as TAN-RE (TIRA, 2020). However, in 2019, bancassurance was allowed, with a total of 14 banks registering for the business, after the issuance of the Bancassurance Guidelines, 2019 (AnnualBOT-FSR, 2020a). In addition, the insurance sector continued to enhance the performance of the sub-sector, by licensing three actuarial firms in 2020. All these developments aim at stimulating the operations of the insurance markets as well as to increase access, efficiency, and reliability. The insurance penetration ratio as a percentage of Gross

Domestic Product was approximately 1.55 percent as of 2020, while in the same year, this sub-sector contributed 15.7 percent to the financial sector in terms of gross premium written. Hence there is still a low penetration level of insurance, therefore more insurance products and services are needed as well as greater outreach.

2.2.3.4 Social security schemes

Social security schemes in Tanzania contribute significantly to the functioning of the economy, as well as being a major contributor in the financial system in terms of deposits and capital market participation (BOT, 2021). This sub-sector is the second largest after the banking sector in Tanzania, accounting for 26.13 percent of total financial assets (AnnualBOT-FSR, 2020a). A study by Servais (2012) defined social security as the protection that a society provides to individuals and households, to ensure access to health care and to guarantee income security, particularly in cases of old age, unemployment, sickness, invalidity, work injury, maternity, or loss of a bread-earner. The aim of social security schemes is to provide people with access to health care facilities, as well as for them to obtain minimum income security in proportion to the level of income contributed (ILO, 2001).

Ahmed and Ndyali (2018) and Dau (2003) in their studies noted that social security schemes are divided into three pillars: social assistance, mandatory, and voluntary schemes. Pillar one, social assistance, is defined as those schemes that constitute social aspects among others, such as water, health, and education, and is usually financed by the government, non-government initiatives, and donor financing. The second pillar, mandatory schemes, is considered to be compulsory and contributory schemes financed by both employer and employee during their working lives, for both terminal and short-term benefits. The third pillar, voluntary/supplementary schemes, has led to an increase of coverage for social protection, also caters for the informal sector, and is usually managed by employers, professional bodies, community-based organizations, and other private sector actors. These schemes which fall under the third pillar category range from cooperative and credit societies, personal savings, occupational pension, and private-schemes, among others.

There have been various reforms in the social security schemes sub-sector in developing economies, focusing on improving coverage of social protection (Van Ginneken, 2003). Further, these reforms have supported social protection in the case of the East African region, referring to Kenya, Uganda, and Tanzania, since the era of the colonial government and even after independence (Dau, 2003). Focusing on Tanzania in particular, the history of social security schemes goes back to the colonial era, where there were informal and traditional protection schemes at the family and community level (Msalangi, 1998). Formal social protection was devised by the colonial rulers for meeting their needs, as well as those of Tanzanians working for the colonial government (Eckert, 2004) .

Among the first generation reforms in 1991, there was the transition of the National Provident Fund to the National Social Security Fund (NSSF) in 1997, which became operational in 1998 (Dau, 2003). Despite efforts undertaken in the reforms, the coverage of social protection in Tanzania was less than 6.5 percent of the labour work force, due to structural challenges, unappealing benefits, and the majority of the work force not being part of the formal economy (Ackson, 2007; Sakthivel & Joddar, 2006). Some developments after the 1991 reform include the issuance of the Social Security Policy of 2003, which focused on expanding the coverage of social security to the informal sector, as well as harmonising the existing funds to improvise on rationalizing contributions and benefit structures (Ackson, 2007).

In 2008, the social security function was undertaken by the Prime Minister's Office - Labour Youth and Disabilities, which was established to regulate, supervise, and monitor the performance of social security activities in the country under the Social Security (Regulatory Authority) Act, 2008 (SSRA, 2008). In 2012, the regulatory authority became fully fledged as the Social Security Regulatory Authority (SSRA), with its major focus being to develop a parametric formula for rationalizing the funds disbursed, as well as creating efficient supervision of the social security schemes sub-sector in Tanzania.

In 2018, the social security schemes sub-sector had six institutions operating in the country, including the Government Employees Provident Fund (GEPF), Local Authorities Pension Fund (LAPF), Parastatal Pension Fund (PPF), the Public Service Pensions Fund

(PSPF), the National Social Security Fund (NSSF), the National Health Insurance Fund (NHIF), and Worker's Compensation Fund (WCF). In the same year, 2018, the four funds (GEPF, LAPF, PPF, and PSPF) were merged, forming the Public Service Social Security Fund (PSSSF), which was to cater for public sector employees, while the National Social Security Fund (NSSF) would cater for private sector employees and self-employed persons (URT, 2020). The reform initiatives mainly focused on improving the operational efficiency and sustainability of the funds (Mwakisisile & Larsson, 2021).

In 2019, the SSRA was dissolved by the government and the responsibilities were transferred to the Prime Minister's Office - Labor, Youth and People with Disability (PMO-LYED), of which the current regulatory authority is responsible for regulating the four funds, while the Bank of Tanzania is a dual regulator mandated to oversee all financial matters as per the Act (URT, 2020).

2.2.3.5 Capital markets

A capital market is a market for the efficient delivery of long-term funds, undertaken by parties such as individuals and institutions, which are traded in the form of debt and equity capital, where buyers and sellers have explicit and implicit claims to capital (Getachew, 2017; Kawode, 2015). Capital markets form part of the financial sector, which is the use of appropriate mechanisms for companies and governments, to mobilize, allocate, manage, and distribute long-term funds for financing developmental projects, for the efficient functioning of the economy (Aobdia et al., 2015). The capital market operates in either the primary or secondary markets, where the primary markets are where newly-issued securities are traded for the first time. On the other hand, secondary markets are where the securities which were previously issued in the primary market are traded, while providing an exit mechanism for investors (CMSA, 2018a). Capital markets have continued to play an important role in developing and developed economies as a source of alternative funding, given the depth, efficiency, and robustness of their stock exchanges (Widia Astuty et al., 2015).

In Tanzania, the capital market is one of the 1991 financial sector reform initiatives, which resulted in the establishment of the regulatory authority in 1995 to effectively manage capital market-related issues. The Capital Markets and Securities Authority (CMSA) was

established by the Capital Markets and Securities Act, 2002, with the aim of promoting and developing efficient and sustainable capital markets, formulating guiding principles for the industry, licensing and regulating capital market players, market development, as well as advising the government on policies and all matters related to the securities industry (CMSA, 2015).

The Dar es Salaam Stock Exchange (DSE) is a non-profit-making body incorporated in 1996, which began trading operations in 1998. The DSE was set up to facilitate the government's implementation of the financial sector reforms, and later to widen the share ownership of individuals in companies in Tanzania (Munisi, 2019). In 1998, the first company to list shares with the DSE was Tanzania Oxygen Limited (TOL), which later changed its name to Tanzania Gas Limited, followed by Tanzania Breweries Ltd. (Norman, 2013).

The CMSA (2018b) reports that the exchange has witnessed significant developments, with the number of listed companies growing from six in 2005 to 28 in 2018, of which eight of the listed companies were banks. In 2019, Acacia Mining PLC (ACA) was delisted from the exchange owing to its delisting from its primary listing on the London Stock Exchange Group (CMSA, 2019). The CMSA (2018b) reported the introduction of an alternative market, the Enterprise Growth Markets (EGM), which aimed at providing an opportunity for small companies, in this particular case community banks, to be able to issue Initial Public Offers (IPOs) and raise capital at the Dar es Salaam Stock exchange (DSE).

As for the bond market, in 1997, the Tanzanian government issued a two-year bond, then five- and seven-year bonds in 2002, for lengthening the maturity profile of government debt (Massele et al., 2015). Further advancements were made in the exchange in 2003 as part of its liberalization; in particular, restrictions on cross listings were lifted to allow companies based in the EAC region to cross list. Kenya Airways was the first firm to cross list on the exchange in the following year (Munisi, 2019).

A study by Munisi (2019) shows that investors are concentrated in the market, participating on both the buying and selling sides, as well as in the market capitalization of cross listed companies. The stock exchange is still dominated by foreign participation

in terms of trading on both the buying and selling sides, due to Tanzanian citizens lacking awareness of the benefits of the exchange, as well as the low efficiency of the market (CMSA, 2019).

Figure 2 shows the share of the sub-sectors in terms of the financial sector’s assets, representing the banking sector as the dominant sub-sector for the ten-year period under review. The banking and insurance sub-sectors have increased their share of assets, while the social security sub-sector has declined, as attested by the report by BOT (2019b-a).

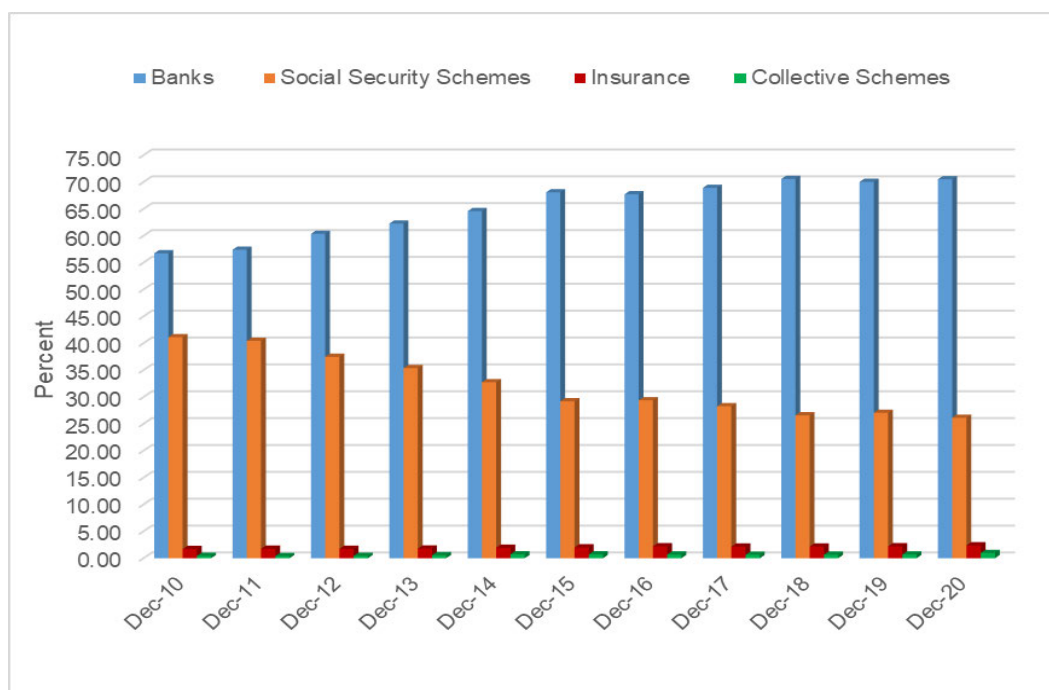


Figure 2.1: Financial Sector Composition from 2010 to 2020
 Source: Annual Reports from Bank of Tanzania

2.2.4 Overview of the Tanzanian economy

The Tanzanian economic policy originates from post-independence (1961-1966), when the country adopted the socialism economy model, after being under British colonial rule, with agriculture being the main contributing sector to the economy, representing approximately 59.0 percent (Mandalu et al., 2018). Nyerere (1977) argued during the time of the implementation of the Arusha declaration, which mainly focused on rural development with the main means of production being owned by the peasants and

workers under the control of government and cooperatives, that agriculture would be the future of Tanzania. However, a study by Gabagambi (2013) identified the challenges witnessed in the socialist approach in the 1980s, that led to a failure to deliver on the aspired economic development. The challenges highlighted were poor performance of parastatals failing to meet people's demands, as well as the country abandoning agriculture in favour of private sector-led industrialization.

The aftermath of the economic crisis in Tanzania, witnessed in the 1980s, resulted in the government taking measures to liberalize the economy, by embarking on adjustment program policies that aimed to reduce the budget deficit and improve monetary policy (Liviga, 2011). In doing so, the government's 1996 Economic Recovery Program sought to revive the export sector, by reducing cost price distortions and introducing import liberalization measures (Kanaan, 2000). Through these efforts, Tanzania witnessed an improvement in the economy; when comparing the years 1980 and 2000, real economic growth increased from 3.3 percent to 4.9 percent, the inflation rate dropped to 6.0 percent from 30.2 percent, and GDP per capita went up from USD 592 to USD 1.228, which signalled improved macro-economic stability (WorldBank, 2021).

Tanzania's population expanded from 10.30 million in 1961 to 59.73 million in 2020, an increase of 4.9 times, with a labour force of 28.03 million, representing 49.4 percent of the population (WorldBank, 2021). Despite the episode of economic reforms in Tanzania (1967-1991), the share of the labour force in comparison to the population is the highest compared to EAC regional peers Uganda and Kenya, where this ratio is 44.1 percent and 36.1 percent, respectively (WorldBank, 2021). Besides, Tanzania covers an area of 945,087 square kilometres, the largest area compared to its EAC regional peers, where Kenya and Uganda cover 580,367 square kilometres and 241,037 square kilometres, respectively (WorldBank, 2021).

In addition to two decades of sustained growth, in July 2020, Tanzania's status changed to becoming a lower-middle-income country from the low-income country category, way earlier than the planned year of 2025 (WorldBank, 2020). This owed to economic reforms, peace, and tranquillity, as well as investment in infrastructure projects, which led to sustained macroeconomic stability, supporting this growth (WorldBank, 2020). This

change in status makes Tanzania the second country after Kenya in the EAC region to join the middle-income category, and among the eight Africa countries in that category (WorldBank, 2020). Tanzania's Gross Domestic Product was USD 62.4 billion in 2020, with the main contribution to this being made by construction, transport and storage, and agriculture (WorldBank, 2020). Tanzania's GDP rate was 4.9 percent, the highest growth rate witnessed in the region for 10 years leading to 2020 (AnnualBOT-FSR, 2020a). Moreover, macroeconomic factors like inflation have been relatively low and well managed. The inflation rate of 3.2 percent was within the agreed target of 3-5 percent in 2020/21 and within regional (EAC and SADC) convergence benchmarks²; meanwhile, the annual average exchange rate was TZS/USD 2,288.6, with major exports being agricultural produce including coffee, cotton, and cashew nuts (BOT, 2020c). Henceforth, the Tanzanian economy has undergone tremendous milestones of growth in terms of demographics, labour, as well as economic variables. The next section assesses the contribution of the financial sector to the economy.

2.2.5 Financial sector assets and GDP

In terms of financial stability, it is important to be able to measure the contribution of the financial sector to the economy. Therefore, having an indicator for measuring economic growth is vital, with GDP being the most significant indicator used to measure economic activity; GDP is defined as the value of the goods and services produced by a nation's economy minus the value of the goods and services used up in production (Dyran & Sheiner, 2018). Studies have viewed the relationship between the financial sector and GDP through the lenses of development, reform implications, as well as growth rate comparability (Beck & Maimbo, 2012; Burgess, 2011; Cecchetti & Kharroubi, 2015b). In order to assess financial development, the WorldBank (2019) proposed indicators including the private sector credit to GDP ratio, financial institutions' assets to GDP ratio, the broad money supply (M2) to GDP ratio, and deposits to GDP ratio. However, this study looks at the depth of the Tanzanian financial sector, by investigating the penetration of each individual sub-sector's contribution to GDP, as well as the financial sector's contribution as a whole. Depth in this particular case means the size, relating to whether

² The EAC and SADC targets are a maximum of 8.0 percent with a range of 3-7 percent, respectively.

the country is a bank-based or financial market-reliant economy. Assets value in the Tanzanian stock market is being represented by using collective schemes assets value, given the availability of data in the sub sector (BOT, 2019).

Over the past ten years, the financial sector's contribution to GDP has remained above 30 percent, however, with a decreasing trend owing to the increase in GDP growth being higher than the financial sector's assets (AnnualBOT-FSR, 2020a). Table 2 shows the trend in the contribution of individual sub-sectors' assets to GDP, as well as the financial sector's assets to GDP, with the banking sector being the main contributor. As the economy expands, the financial sector continued to contribute to GDP by about 33.29 percent by 2020, where banks accounted for 23.48 percent of that contribution, followed by social security schemes with 8.70 percent. This can be attributed to the proportional growth of the sub-sectors, and the role played by intermediation as well as the financial sector at large. The decline of the financial sector's contribution from 46.73 percent witnessed in 2010 to 33.29 in 2020, reflects that, as the economy is expanding, the source of financing is from the informal sector and not from formal financial services; hence, this calls for the need to enhance policies to encourage the usage of formal services to obtain financing.

Table 2.1: Contribution of the Financial Sector to GDP (percentage)

| Sn | Particulars (Assets) | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|----|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | Banks | 26.52 | 25.17 | 25.22 | 24.63 | 24.83 | 26.11 | 23.19 | 23.11 | 23.55 | 23.64 | 23.48 |
| 2 | Social Security Schemes | 19.22 | 17.74 | 15.66 | 13.98 | 12.59 | 11.29 | 10.06 | 9.48 | 8.87 | 9.13 | 8.70 |
| 3 | Insurance | 0.8 | 0.77 | 0.72 | 0.71 | 0.75 | 0.77 | 0.76 | 0.73 | 0.73 | 0.75 | 0.79 |
| 4 | Collective Schemes | 0.2 | 0.17 | 0.18 | 0.22 | 0.27 | 0.27 | 0.23 | 0.22 | 0.22 | 0.24 | 0.32 |
| 5 | Total Financial Assets | 46.73 | 43.85 | 41.78 | 39.51 | 38.35 | 38.35 | 34.25 | 33.53 | 33.36 | 33.75 | 33.29 |

Source: Annual Reports of Bank of Tanzania (2020)

2.3 The Tanzanian Banking Sector

The previous section provided an overview of the Tanzanian financial sector, particularly focusing on its reforms and structure. This section brings into view the status of operations of the banking sector, which was fostered by the developments undertaken in the financial sector at large in 1991. Moreover, this section concentrates on the banking sector in terms of composition, selected indicators that denote performance, regulatory environment, credit distribution, as well as contribution to GDP. According to (URT, 2020), the banking sector's contribution to GDP growth was 26.5 percent, signalling an increase in the penetration of credit and access in terms of intermediation, through the credit channel in the economy.

2.3.1 Evolution of the banking sector

The history of banking goes way back to trade and commerce, where people exchanged goods for other goods and later transformed this to creating a value for money (Gajdhane, 2012). As trade grew, the person sitting at a bench offering the service of money was known as a banker, and after that came the move from the coin to the paper form; eventually, the increased interactions between individuals, groups, as well as companies led to the need to have a banking system (Gajdhane, 2012).

In a study by Oluduro (2015), banking is defined as the business activity of accepting and safeguarding money owned by other individuals and entities, and then lending out this money for making profit or simply covering operating expenses, to stimulate economic activities through the multiplier effect. The Tanzania Banking and Financial Institutions Act (2006, p6) defines the banking business as “the business of receiving funds from the general public through the acceptance of deposits payable upon demand or after a fixed period or after notice, or any similar operation through the frequent sale or placement of bonds, certificates, notes or other securities, and to use such funds, in whole or in part, for loans or investments for the account of and at the risk of the person doing such business” (BOT, 2006b).

The evolution of the banking sector differs from country to country. In China and Russia, the institutional matrix is noted to have a hybrid system of state-controlled banks performing hybrid functions of regular commercial banks and policy banks (Kirdina & Vernikov, 2013). In the case of emerging economies, India’s banking history relates of the use of temples as a safe custody centre during the times of the Hindustani kings, to banks mainly owned and controlled by the state in more recent times (Gajdhane, 2012). In Nigeria, the banking sector has existed for more than a century and for almost a half a century in the economic spheres (Oluduro, 2015). In the same study, Oluduro (2015) classified the eras of the evolution of the banking sector in this country: between 1892 and 1954, there was an era of free and monoculture banking; between 1952 and 1985, there were liberalization efforts among others, putting regulations in place; and between 1986 to the present, there have been efforts on structural adjustments, reforms, and consolidation to enhance the viability and confidence in the system.

The history of banking in Tanzania goes back to the colonial era in the early 1900s. The colonial era in Tanzania was made up of two episodes: one of German rule and the other of British rule (Lwiza & Nwankwo, 2002a) . During German rule, the banking sector was established mainly to serve the colonial rulers and a few businesses, with two banks, namely Ostafrikanische Bank and Handelsbank fur Ostafrika, being established in 1905 and 1919, respectively, to operate in Tanganyika (Lwiza & Nwankwo, 2002b). The entry of British rule in 1919 after World War I, led to the establishment of three dominant commercial banks: National and Grindlays Bank, Standard Bank, and Barclays Bank DCO, which replaced the banks that existed during the German era (Kimei, 1987).

In the 1950s, other banks, including banks originating in India such as the Bank of India and the Bank of Baroda, opened branches to facilitate services to businesses and their people residing in Tanganyika at that time(Ndalichako, 2016).In addition, Ottoman Bank, of Anglo-French origin, was also established during the same time to provide services in the areas of their business operations (BOT, 2011; V. L. Ndalichako, 2016). It was observed that during the colonial era, the banking sector mainly aimed to serve the colonial economy; it was characterized by the dominance of foreign-owned commercial banks, no central bank to regulate and supervise the institutions, a lack of financial access to productive sectors of the economy, as well as a geographical concentration of banks in urban areas (Kimei, 1987; Lwiza & Nwankwo, 2002b).

By the time of independence in 1961, the country's banking industry comprised of eight banks, including Standard Bank of South Africa, National and Grindlays Bank, Barclays Bank DCO, Ottoman Bank, the Bank of India, the Bank of Baroda, the Commercial Bank of Africa, and The National Bank of Pakistan (BOT, 2011; Kimei, 1987). Apart from the banking sub-sector, during the same time, studies (Kimei, 1987; Lwiza & Nwankwo, 2002b) noted the existence of four non-financial institutions, including the Post Office Savings Bank, the Land Bank, the Local Development Loan Fund, and the African Productivity Loan Fund (BOT, 2011).

After gaining independence from British rule, some banks were established by the Tanzanian Government, including: the Tanzania Bank of Commerce (TBC), in 1965; the National Development and Cooperative Bank, in 1964; and the People's Bank of

Zanzibar, in 1966 (Lwiza & Nwankwo, 2002b). In 1967, the Arusha declaration was introduced mainly to advocate for socialism and self-reliance, and to move away from capitalism after the colonial era (Mlozi, 2002; Nyerere, 1977). The post-Arusha Declaration era was characterised by the merging of all the private commercial banks to form the National Bank of Commerce (Ndalichako, 2016), while also focusing on the nationalization of the financial sector to cater for different purposes (Lwiza & Nwankwo, 2002b). This nationalization led to the establishment of non-bank development financial institutions, including the Tanzania Investment Bank (1970) and the Tanzania Rural Development Bank (1972), which is currently known as the Cooperative and Rural Development Bank. The former institution focused on providing development finance to the country's productive sectors on a large scale, while the latter provided finance to the rural sectors (Lwiza & Nwankwo, 2002b; Ndalichako, 2016). In addition, through the Arusha Declaration's agenda of nationalization, the financial sector expanded resulting in the establishment of the Tanzania Housing Bank (1972), which mainly focused on supporting the financing of rural and urban residential, office, and commercial buildings. Further, other non-bank financial institutions which were established included The National Insurance Corporation and The Postal Office Savings Bank. Notwithstanding, during this era, all banks and financial institutions were owned by the Tanzanian Government, except for Tanzania Development Finance Limited (TDFL) and Diamond Jubilee Trust Fund (Lwiza & Nwankwo, 2002b; Ndalichako, 2016).

The challenges witnessed in the government-owned banks established during the socialist era, included among others, poor service delivery, the existence of high on-performing assets (NPA), an increase in the subsidies to the banks, as well as non-dividend declarations; this resulted in the formation of a Presidential Commission in 1988, that aimed to review the banking sector's operations (Simpasa, 2011). One of the recommendations of the Commission was to develop a strong legal, regulatory, and supervisory framework, which resulted in the enactment of the Banking and Financial Institutions Act (BFIA) in 1991 (Lwiza & Nwankwo, 2002b; Ndalichako, 2016; Simpasa, 2011). The Act provided the Bank of Tanzania powers to license, regulate, and supervise banks and financial institutions (BOT, 2011). Lwiza and Nwankwo (2002b) noted that the

reforms further led to the entry of foreign and domestic private banks into the market, of which some of the early banks were Meridian Biao Bank Tanzania Limited (1992) - which was later taken over by Stanbic Bank Tanzania Limited (1995), Standard Chartered Bank Tanzania Limited (1993), Eurafrican Bank Tanzania Limited (1994), and Citibank Tanzania Limited (1995).

In 1997, The National Bank of Commerce (NBC), was restructured into three separate entities, namely NBC (1997) Limited, the National Microfinance Bank Limited, and Consolidated Holdings Corporation. Further, in 1996, the Cooperative and Rural Development Bank was also restructured into a private bank and renamed CRDB Bank Limited (CRDB Bank PLC). Since the entry of foreign banks into the market and the enactment of the BFIA, the banking sector in Tanzania has experienced the closure of more than six banks and financial institutions, mainly caused by the failure of their parent banks (BOT, 2011). In the same study, (BOT, 2011) it was noted that the banks that had faced challenges included: Tanzania Housing Bank (1995), Meridian Biao Bank (1995), Trust Bank Tanzania Limited (1998), Greenland Bank Tanzania Limited (1999), Delphis Bank Tanzania Limited (2003), and First Adili Bancorp (2000). However, these failures did not lead to the loss of depositors' money (Mlozi, 2002). Nevertheless, Greenland Bank and Tanzania Housing Bank were liquidated, while the remaining banks were taken over by other banks; however, all depositors were able to recover their money (BOT, 2011b).

In 2006, the legal and regulatory environment was enhanced whereby, the Bank of Tanzania Act, 1995 and the Banking and Financial Institutions Act, 1991 were revoked, and replaced by the Bank of Tanzania Act, 2006 and the Banking and Financial Institutions Act, 2006, which became effective in July 2006 (BOT, 2006b-a). In the same study, BOT (2006b-a) narrated that the changes were made to take into account market developments, as well as to support the privatization and restructuring process of banks like Tanzania Postal Bank (TPB) and People's Bank of Zanzibar Limited, with Tanzania Investment Bank (TIB) being a development institution.

This enactment resulted in the government making efforts to encourage the formulation of regional/community banks and financial institutions in various parts of the country; this led to the number of regional community banks operating in Tanzania to reach 12, which

were: Mbinga, Njombe, Tandahimba, Mwanga, Covenant, Efata, Maendeleo, Meru, Kilimanjaro, Mufindi, Uchumi, and Kagera Farmers (BOT, 2006b-b). The study by BOT (2019b-b) showed that in 2016, due to impaired capital levels and liquidity problems owing to a growing number of non-performing loans, poor governance, and limited economies of scale, six banks (Mbinga, Njombe, Covenant, Efata, Meru, and Kagera Farmers) failed to regain their capital positions; hence, as per compliance, they were placed under liquidation. In 2019, mergers and acquisitions took place in the Tanzanian banking sector, including: Mwanga Community Bank, EFC microfinance, and Hakika Microfinance Bank which came to form Mwanga Hakika Microfinance Bank Plc; Exim Bank Plc taking over UBL commercial bank; and Tanzania Postal Bank taking over TIB Corporate bank (BOT, 2019b-c). In order to maximize on economies of scale and manage operational costs for regional banks, merging was seen as an appropriate action to take to maintain a continuity of services to people in their different geographical distributions (BOT, 2016b, 2017).

2.3.2 Regulatory environment of the banking sector

Changes in the structure of the banking sector, in terms of outreach as well as products and services offered, led to the need to have an effective regulatory environment to mitigate exposures that may arise due to these developments in the sector. Regulations form the cornerstone of the banking sector that aid in the reduction in the possibility of a bank's failure, or on a macro level may result in a financial crisis (Čihák et al., 2012). As countries take up efforts to continue liberalizing the financial sector, the need to strengthen the regulatory and supervisory environment is paramount, given the increase in the magnitude of exposure, and therefore, focus on securing consumer protection and financial stability (Botha & Makina, 2011).

Bank regulations mainly focus on implementing the key principles of licensing and supervision, minimum requirements, and market discipline, with a focus on protecting investors, preventing systemic risks, and enhancing the efficiency of operations (Barth et al., 2013). In many countries, the Central Bank regulates the financial sector, more specifically the banking sub-sector, however, in countries like the US, UK, Japan, as well as South Africa, an independent body oversees the functioning of the financial sector (Barth et al., 2013). In the EAC region, only Rwanda oversees the functioning of the

banking, insurance, and social security schemes through the Central Bank, while in the other countries (Kenya, Uganda, Tanzania, Burundi, and South Sudan), independent regulatory authorities oversee the banking sub-sector and the rest of the financial sector.

The history of the regulatory framework in Tanzania has its own route, moving from the colonial era to the pre-Arusha Declaration period, when there was no Central Bank instituted to regulate the banking sub-sector (Lwiza & Nwankwo, 2002b). Despite Germany being the colonial power, the dominance of Indians in East Africa in terms of settlement and trade made the Indian rupee the major currency of trade (Mauri, 2007). However, the rise of British colonial rule in 1919 brought a turnaround in Tanzania, leading to the establishment of the East Africa Currency Board (Lomoro, 1964). Studies by Lomoro (1964) and (Mauri, 2007) showed that the establishment of the Board was to cater for the British colonial territories in the East Africa region, including Tanganyika, Uganda, and Kenya, as well as Zanzibar and Aden, which later joined in 1939. They argued that the aim of the Board was to replace the Indian rupee, which after the World War II had experienced currency fluctuations against the pound sterling, as well as to create a homogenous currency of exchange for the East Africa territories (Mwangi, 2001). Nevertheless, the enactment of the Tanganyika Banking Ordinance No.31 of 1960, which operated in conjunction with the Banking Rules, Cap 430, 1960, defined the banking business in Tanganyika during that era (Aloisi & Chijoriga, 2002). Studies (Aloisi & Chijoriga, 2002; BOT, 2011; Chitanda, 2013) have noted that the Ordinance defined the banking business as the business of receiving money on current accounts subject to withdrawal by cheque, allowing only a company or a cooperative society licensed by the registrar of companies to perform banking business, and requiring a minimum capital of 2 million Tanzanian shillings to be paid up. In addition, (BOT, 2011) stated that banks were required to invest 25 percent of their annual income in government stocks and bonds.

The growing trade of agricultural produce in the East African region in 1990s, made EAC very active, including providing a crop finance credit facility, monetary policy, as well as shifting the headquarters to Nairobi from London to smooth the operations (BOT, 2011). However, (Mauri, 2007) demonstrated that the Board experienced challenges, given no

control or any supervisory authority over commercial banks and other financial institutions, therefore leading to its dissolution in 1965 and the formation of individual central banks for each East African region country (Kenya, Tanzania, and Uganda).

In the post-independence period of Tanganyika (after 1961), under the Arusha Declaration's agenda, all existing banks and financial institutions were state owned and established by independent acts of parliament, with the objectives and powers defined in their respective statutes (Lwiza & Nwankwo, 2002b; V. L. Ndalichako, 2016). (Lwiza & Nwankwo, 2002b) further elaborated on the acts at that time, which were: The National Bank of Commerce (NBC) Act, 1967; The Tanzania Investment Bank (TIB) Act, 1971; The Tanzania and Rural Development Bank (TRDB) Act, 1971; The Tanzania Housing Bank (THB) Act, 1972; and The National Insurance Corporation (NIC) Act of 1967. A study by (BOT, 2011) noted that the supervisory function under the Bank of Tanzania, which started in 1978, had no legal powers to issue regulations or supervise banks and other deposit-taking institutions. In line with these multiple legislations, which lacked an apex supervisory body, the regulatory reforms fostered by the recommendations drawn from the Nyirabu Presidential Commission in 1988, aimed at addressing these shortcomings and restoring the financial sector, following the challenges observed in the performance of the by then state-owned banks (Lwiza & Nwankwo, 2002b; Mlozi, 2002).

Among the actions of the 1991 financial sector reforms, was the enactment of the Banking and Financial Institutions Act, 1991, that gave the Central Bank a mandate to supervise and regulate the banking sector, to ensure the orderly and effective conduct of the banking business (V. L. Ndalichako, 2016; Simpasa, 2011). In the 2006 second generation financial sector reforms, the Banking and Financial Institutions Act was revised, taking into account the developments in the market at that time, and defining permissible activities that banks could engage in (V. L. Ndalichako, 2016).

On the one hand, the Bank of Tanzania Act, 2006, identified that the principal functions of the Central Bank were to formulate, implement, and be responsible for monetary policy, including exchange rate policy. Furthermore, the Bank was responsible for: issuing currency, regulating and supervising banks and financial institutions, including mortgage, development, lease, licensing, and revocation of licenses; and to deal, hold, and manage

the gold and foreign exchange reserves of Tanzania (BOT, 2006a). On the other hand, the Foreign Exchange Act, 1992, aimed at making better provisions for a more efficient administration and management of dealings and other acts, in relation to gold, foreign currency, securities, payments, debts, import, export, transfer or settlement of property, and for purposes incidental to and connected to those (URT, 1992).

In 2005, regulations were issued for: banks' and financial institutions' internal control and internal audits; microfinance companies and microcredit activities; and financial cooperative societies (BOT, 2005). In 2008, various regulations, guidelines, and circulars for banks and financial institutions were issued varying from: licensing, capital adequacy requirements, management of risk assets, credit concentration and other exposure limits, publication of financial statements, foreign exchange exposure limits, liquidity management, physical security measures, prompt corrective action, independent auditors, financial leasing, mortgage finance, and credit reference bureau (BOT, 2011).

By 2013, to strengthen the supervision role and enhance financial inclusion, the Bank of Tanzania had issued: the Risk Management Guidelines, 2010; Outsourcing Guidelines for Banks and Financial Institutions, 2008; Guidelines for Board of Directors of Banks and Financial Institutions, 2008; and Guidelines for Agent Banking, 2013 (BOT, 2013). In 2014, the Bank of Tanzania issued one prudential regulation on consolidated supervision, and undertook revision of the existing twelve regulations, aiming at taking into account developments in the market (BOT, 2014b-a).

The Bank of Tanzania has adopted supervisory methods, including onsite and offsite surveillance, to ensure the soundness and stability of banks, by targeting at minimum six major risks that should be effectively identified, monitored, and measured. The supervisory tools are complemented by regulatory tools including guidelines, circulars, regulations, as well as the BOT Act. The major reforms in terms of regulations, guidelines, and circulars ensure effective supervision of licensed banks, as banks adopt and align with the core Basel accords.

The central bank has a set of regulations that affect the banking sector operations from monetary to micro ad macro prudential policies. Monetary policy regulations are a set of

actions put in place by a central bank to manage economic fluctuations and achieve price stability, by ensuring inflation is low and stable (Collard et al., 2017; Ngambou Djatche, 2022). Monetary policy regulations are limited to achieve sustainable economic growth thus individual bank proactive measures for securing capital buffers are not considered thus macro-prudential regulations take that on board (Spencer, 2014). Among the macro prudential regulations attempt in Tanzania is the requirement for banks is having a conservation buffer in addition to the normal capital ratios of core and regulatory capital (BOT, 2021).

2.3.3 Types of banks in the banking sector of Tanzania

The introduction of a regulatory and supervisory framework created an enabling environment that spurred the growth of the banking sector in Tanzania, which expanded to a total of 46 banks in 2020 from merely three banks during the reforms of the 1990s. The Tanzanian banking sector is composed of commercial banks, development institutions, community banks, and microfinance institutions. As of the end of 2020, out of the 46 banks operating in Tanzania, 35 were commercial banks, two were development financial institutions, five were community banks, and four were microfinance banks, accounting for 95.2 percent, 3.6 percent, 0.6 percent, and 0.3 percent of the total assets, respectively (BOT, 2021). Therefore, commercial banks continued to dominate the banking sector in terms of asset size, between 2010 and 2020.

Meanwhile, the ownership structure of the banking sector, as prescribed by the Bank of Tanzania stress testing model (AnnualBOT-FSR, 2020a) according to asset classification in Tanzania, comprising of domestic, foreign, EAC³, and government, was 50.8 percent, 29.5 percent, 10.5 percent, and 9.1 percent, respectively (BOT, 2021b-b). In developing countries like Tanzania, banks continue to dominate the financial sector, as the capital markets are still at a nascent stage of growth, highlighting the significance of banks in financial development as well as their intermediation role in stimulating economic growth.

³ EAC refers to the banks that originate from any of the East African region states including Kenya, Uganda, Rwanda, Burundi, Tanzania and South Sudan.

The ownership structure as per the Bank of Tanzania Act 2006, means having either local or foreign ownership of more than 50.0 percent of shares (BOT, Act, 2006).

According to (Daiff & Daiff, 1995), commercial banks refer to financial institutions based on trade funds, that act as intermediaries between capital and investments, while seeking access to private capital with the investments. Basically, commercial banks accept cash deposits and advance loans for investment with the aim of earning a profit. When monitoring the composition in terms of types, commercial banks continue to dominate the market, with a notable decline in community banks' assets observed in 2017, due to the closure of six of the banks in that category (Tanzania, 2019). Therefore, this study will use commercial banks to represent all banks, given their high proportion of assets held as well as their providing more than 90 percent of credit in the market (Tanzania, 2019). (Além & Madeira, 2015; Kingombe et al., 2011) consider development financial institutions as institutions usually linked to national governments that invest in sustainable private sector projects, thus aiding to bridge the gap between the public and private sectors; their target is to maximize impacts on development, remain financially viable in the long term, and mobilize private sector capital. In Tanzania, there are two development financial institutions which are Tanzania Agricultural Development Bank Limited and TIB Development Bank Limited; both are owned by the government, and account for 4.8 percent of the banking sector's total assets (Tanzania, 2019).

The definitions of microfinance institutions proposed by some studies (Hartarska (2005); Labie and Mersland (2011); Olugbenga and Mashigo (2017)), are seemingly different from one another. However, the essence of the definitions is usually the same. These studies view microfinance institutions as the provision of small-scale financial services to low-income or unbanked people. BOT (2019b-b) defines microfinance institutions as "a bank or financial institution which undertakes banking business mainly with individuals, groups and micro and small enterprises in rural or urban areas". Since 2019, the composition of microfinance institutions in Tanzania has been made up of both deposit-taking as well as non-deposit-taking microfinance institutions, following the new Microfinance Regulation 2019, which mandated the Bank of Tanzania to regulate all microfinance in the country (URT, 2018, 2019). However, banking sector deposits, where only microfinance was

involved, accounted for 0.3 percent of deposits by the end of 2020 (Annual BOT-FSR, 2020a).

Community banks are usually defined by the basic services that they provide, and are limited to a specific geographical location; however, others may have outlets or branches in operation elsewhere (DeFatta, 2015; Lux & Greene, 2015). Like-wise, Mataba and Aikaeli (2016), in concurrence with BOT (2014), view community banks as banks that serve a defined geographical area with restricted services, from the acceptance of deposits and lending to any other service specified by the Central Bank. Community banks in Tanzania have paved the way since the 1991 reforms, which spearheaded the enactment of the Banking and Financial Institutions Act, 2006 (URT, 2020). Since 2020, there are four community banks in Tanzania, which are Maendeleo Bank Plc, Uchumi Commercial Bank Ltd, MUCOBA Bank Plc, Tandahimba Community Bank Ltd, and Kilimanjaro Cooperative Bank Ltd (BOT, 2021).

Studies by Fund (2018) and Tanzania (2019) have shown the dominance of commercial banks in Tanzania holding more than 90 percent of market share, with community banks, microfinance banks, and development financial institutions holding the remaining portion. The same trend can be observed in Table 3 for the past ten years, depicting a high concentration risk on the performance of the commercial banks.

Table 2.2: Market share of the banking sub-sector from 2010 to 2020

| Types of Banks | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Commercial banks | 97.6 | 97.3 | 97.4 | 96.9 | 96.5 | 96 | 95.6 | 95.4 | 95.7 | 94.3 | 95.1 |
| Community banks | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.9 | 0.4 | 0.5 | 0.6 |
| Microfinance Institutions | 0 | 0 | 0 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.5 | 0.3 |
| Development Financial Institutions | 1.9 | 2.1 | 2.0 | 2.1 | 2.3 | 2.8 | 3.1 | 3.1 | 3.4 | 4.8 | 3.9 |

Source: Tanzania Financial Stability Reports (2020)

2.3.4 Tanzanian bank ownership structure

Ownership structure in the banking sector, which forms part of corporate governance and affects bank performance, means the proportion of majority shareholding to the total number of shares, and either can be measured using total assets, deposits, or capital base (Allen et al., 2017; Amidjaya & Widagdo, 2020; Arouri et al., 2011). Ownership in the banking sector defines the market dominance structure, control, and influence of the banking sector, as well as whether it is state, foreign, or domestically private driven (BOT, 2021). Most central banks view ownership structure of the types of banking sectors in Tanzania, namely commercial banks, development financial institutions, microfinance institutions, and community banks, as being either owned by foreign, domestic, or state interests⁴. Ownership in this context means having more than a 50 percent holding on domestic and foreign banks. This study focused on the type of bank, so as to concentrate on the major type which accounts for more than 90 percent of banking assets, and later viewed performance based on ownership, whether foreign, domestic-private, and government-owned.

2.3.5 Tanzanian banking sector asset composition

The Barth (2006)IASB (2006) framework defines assets as “resource controlled by an entity or probable future economic benefits obtained, as a result of a past events”. (Harrison, 2006) views an asset as a store of value of which an economic benefit can be derived in the future, when holding on to it for a particular period of time. In the context of this study, bank assets are both physical and financial properties owned by a bank. In most banks’ balance sheets, assets are classified into current and fixed assets, with major asset categories being composed of physical assets, loans, investment securities, and reserves.

Referring to the Tanzania (2019), asset composition of the banking sector comprises of loans⁵, investment in debt securities, and balances with the Bank of Tanzania and others⁶,

⁴ State in this context refers to bank ownership of more than 50 percent by the Government of the United Republic of Tanzania or The Revolutionary Government of Zanzibar.

⁵ Loans to proxy Loans, advances, and overdraft

with these accounting for 57.8 percent, 16.7 percent, 6.0 percent, and 19.5 percent, respectively. Loans have been dominating the asset composition of banks for the past decade, with commercial banks taking more than 90 percent of the share, signalling their significance in the market. Loans in the banking sector act as the catalyst for economic growth by providing financing support.

2.3.6 Tanzanian banking sector performance

Assessment of the performance of the banking sector is very important for developing economies like Tanzania, due to their high reliance on this sector to undertake the intermediation function, as well as to achieve sustainable economic growth. With the banking sector taking up more than 70 percent of financial assets, and a growing bank assets to GDP ratio of 25 percent, banks remain dominant due to having a nascent financial market, which provides alternative sources of financing for companies (BOT, 2019).

Therefore, this sub-section covers an assessment of the performance of the banking sector using Financial Soundness Indicators (FSIs). Financial soundness indicators were developed and used for financial stability analysis even before the global financial crisis of 2008/09, in addition to the other economic and financial analysis tools (Craig & Sundararajan, 2003; Fund, 2006; San Jose et al., 2008; Sundararajan et al., 2002). In light of the international financial turmoil of the late 1990s, the urge to enhance financial stability assessment through a broad search for tools and techniques to monitor vulnerabilities, improve risk assessment, ensure soundness of the financial sector, and prevent further financial crises, was prompted (Sundararajan et al., 2002).

FSIs are defined as indicators that depict the current financial health and soundness of the financial institutions in a country, and of their corporate and household counterparts (IMF, 2019b). FSIs include both aggregated information on financial institutions, as well as indicators that are representative of markets in which financial institutions operate. In addition, the role of FSIs gained momentum in light of the financial crisis, and as one of the recommendations of the G-20 Data Gaps Initiative.

Furthermore, the growing need of improving FSIs as early warning signals, has gained momentum owing to recent episodes of instability, including the COVID-19 pandemic that has further highlighted the importance of continuous monitoring of financial systems as a crisis prevention tool. In light of this, several studies (Navajas & Thegeya, 2013; Schou-Zibell et al., 2010; Yaaba & Adamu, 2015) have shown the relationship between financial soundness indicators with the macro-prudential framework, profitability, banking crises, and financial crises.

Therefore, this study adopted the financial soundness indicators that are used to measure the strength of the banking sector, based on the relationship between solvency and liquidity, while taking into account capital adequacy, liquidity, profitability, asset composition and quality, and sensitivity to market risk (AnnualBOT-FSR, 2020a). Moreover, this study assesses these indicators in line with the IMF compilation guide (IMF, 2019a).

2.3.6.1 Capital adequacy in Tanzanian banks

Capital adequacy ratios have been prominent in finance literature given their significance in ensuring the safety, efficiency, and stability of the banking sector (Bialas & Solek, 2010). Capital adequate ratios not only ensure solvency, but also operate as a shield against loss, which in turn ensure banks' sustainable economic operations with satisfactory returns.

The Basel Accord, an international standard for the calculation of the capital adequacy ratio, has been at the forefront of developing and enhancing the computation and requirements of capital. This aims at ensuring enough buffers are available to cushion against potential exposures in case they materialize, after drawing from past experiences of crises (Aspal & Nazneen, 2014; Bateni et al., 2014).

The Basel Accord ranges from Basel I to IV the indicators created have been enhancing the computation of capital adequacy (FSB, 2010; Kombo, 2014; Oyetade et al., 2020). Studies (Arnold et al., 2012; Bateni et al., 2014; Malimi, 2017; Oyetade et al., 2021; Pastory & Mutaju, 2013) have assessed the relationship between capital adequacy and other selected indicators, ranging from bank size and profitability, to asset quality

indicators. The findings denote that capital adequacy is more aligned to asset quality and profitability ratios. Therefore, the capital adequacy ratio is defined as the amount of core capital that banks must hold, commensurate to the amount of risk weighting that they carry on their balance sheet's assets, as defined by national authorities or aligned with the Basel Accord's computation (FSB, 2010; Rognes, 2020). The Basel Capital Accord distinguishes the core capital elements to obtain tier 1 capital, and for supplementary capital to obtain tier 2 capital (Aspal & Nazneen, 2014).

Tanzania is still fully compliant with the Basel I Accord that requires banks to maintain a minimum core capital of 8 percent of risk-weighted assets. However, Tanzania has partially adopted components of Basel II and III on capital computation, thus shifting the capital requirement to 12.5 percent of core capital and 14.5 percent of regulatory capital (BOT, 2014). At the EAC level, Rwanda has already adopted Basel III in the computation of capital, meaning that it has moved to using the common equity tier one capital rather than the core capital (BNR, 2021b; BOU, 2020; CBK, 2021).

Over the ten years leading up to 2020, the banking sub-sectors for all the EAC countries were resilient, and maintained high capital buffers above the minimum regulatory requirement of 10 percent and 12 percent. Figure 2.4 shows how Tanzania has lower capital adequacy ratios compared to her regional peers of Uganda and Rwanda, who have maintained substantially higher buffers after adoption of the conservation buffer, DSIBs buffer, and also considering the countercyclical buffer (Andersen et al., 2019). Nevertheless, the ratios are still within the prudential limits though they need to be closely monitored to ensure the resilience and stability of the financial system.

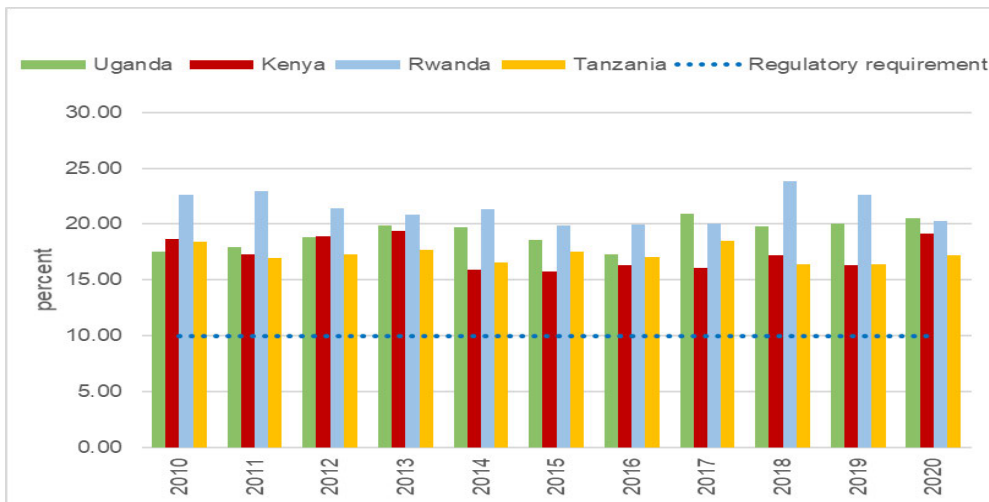


Figure 2.2: Capital adequacy ratios from 2010 to 2020

Source: EAC Financial Stability Central Banks (CBK, NBR, BOU and BOT)

2.3.6.2 Liquidity in Tanzanian banks

Liquidity constraints within a short period of time are one of the major hindrances in the banking sector's sustainability (Arif & Anees, 2012). During the 2008/09 global financial crisis, many banks ignored the impact of liquidity risk and had put less prudential regulations on management, which, therefore, resulted in a bottleneck during the crisis, triggering other risk factors in the long run (IMF, 2019a). The crisis changed how regulators viewed liquidity risk management, which led to more regulatory requirements and enhanced liquid asset criteria (Chen et al., 2018; FSB, 2010; Marozva, 2015). Liquidity resolution is one of the roles of central banks' as the lender of last resort to banks that may face challenges. (Basel, 2008) defines liquidity as the ability of a bank's assets to meet obligations as they become due, without incurring unacceptable losses.

Therefore, the inability of a bank to meet its obligations when they become due, without incurring unacceptable losses, is termed as liquidity risk, which may either be of funding or market-related risk. The 2008/09 crisis exhibited a funding liquidity risk impact that dried the interbank market, and central banks came to the rescue by pumping funds through the standby facilities, to save banks from the liquidity challenges (Dahir et al., 2018; Nikolaou & Drehmann, 2009). On the one hand, (Drehmann & Nikolaou, 2013) defined funding liquidity risk as the inability of a bank to meet obligations with immediacy, within a specific time horizon. On the other hand, market liquidity risk can be viewed from a cost

and liquidation perspective or challenge, due to inadequate market depth or disruption, therefore the cost of trading an asset relative to fair value cannot be realized (Vodova, 2011).

Further, some studies have viewed liquidity risk in isolation as a compliance and management issue (Kumar & Yadav, 2013; Préfontaine et al., 2010), while others have seen it as a form of impact assessment in terms of its relationship with the banking sector. Regarding the latter, several studies (Arif & Anees, 2012; Ariffin, 2012; Chen et al., 2018; Marozva, 2015; Tesfaye, 2012) assessed the relationship between liquidity risk and other banking sector performance indicators, and the results revealed that profitability was the most related form of exposure in case a liquidity challenge occurred.

In Tanzania, liquidity management is governed by the Banking and Financial Institutions (Liquidity Management) Regulations, 2014, which aim at ensuring that banks are able to meet all their obligations on time; these regulations also put in place liquidity management strategies to mitigate liquidity risk exposures, as well as maintain public confidence by meeting the liquidity standards stipulated in these management regulations, in addition to those in the Bank of Tanzania Act, 2006 (BOT, 2014b-b). In line with the IMF's compilation guide and the Central Bank of Tanzania's compilation of financial soundness indicators, liquidity is denoted by five major ratios: Foreign Exchange Liabilities to Total Liabilities, Liquid Assets to Demand Liabilities, Liquid Assets to Total Assets, Liquid Assets to Customer Deposits Liabilities and Total Loans to Customer Deposits. However, the early warning indicator for liquidity exposure is the Liquid Assets to Customer Deposits Liabilities ratio, which also has a regulatory requirement of not being less than 20.0 percent (AnnualBOT-FSR, 2020a).

For the past 10 years, Tanzania's banking sector has maintained a relatively stable liquidity ratio; however, the level is lower than other regional peers as can be attested in Figure 4. Rwanda was left out in liquidity assessment in terms of regional comparisons, as they have adopted the liquidity coverage ratio and disregarded the normal liquidity ratio; hence there is a challenge of data availability. Tanzania continued to have lower liquidity levels compared to her regional peers, signaling liquidity pressure that may pose a challenge in case of a major shock in the market. Hence, there is a need to devise

appropriate mechanisms to adopt and maintain high liquid assets, by adoption of Basel II and III, to ensure banks have a high quality of assets (BNR, 2021a).

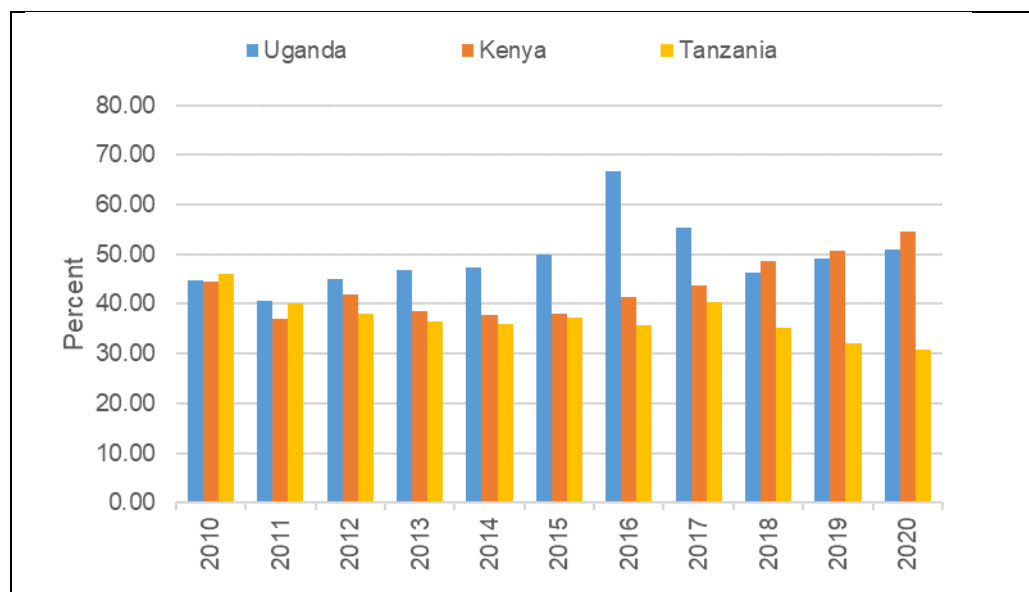


Figure 2.3: Liquidity ratio 2010 to 2020

Source: EAC Financial Stability Central Banks (CBK, NBR, BOU and BOT)

2.3.6.3 Profitability in Tanzanian banks

Profitability is a result of the functioning of a bank's operations through the efficient use of capital and available assets. Indicators that are predominantly used to represent profitability are return on assets (ROA), return on equity (ROE) and net interest margin (NIM) (Gul et al., 2011; IMF, 2019a). In addition, (Gul et al., 2011) considered return on capital employed (ROCE) as one of the profitability indicators. These indicators are usually considered to assess a business's ability to generate earnings relative to its revenue.

Bank profitability ratios can be determined by either internal factors that are manageable and controllable by a bank, including non-performing loans, deposits, liquidity, and investment in securities, or by external factors, which are beyond the bank's control, including inflation rates, exchange rates, interest rates, market share, as well as growth (Gyamerah & Amoah, 2015; Rasiyah, 2010). (Agbeja et al., 2015) viewed profitability as a dependent ratio which can be influenced by capital adequacy ratio, therefore maintaining

more equity has a positive impact on profitability. On the other hand, (Bikker & Vervliet, 2018) reviewed the undue influence that interest rates have on a bank's profitability, ultimately having an impact on financial stability in due course.

When assessing the performance of the banking sector and financial stability in Tanzania, profitability indicators are also considered as part of the financial soundness indicators with major concentration on return on assets (ROA), return on equity (ROE), and net interest margin (NIM) (Gul et al., 2011; IMF, 2019a).

Return on assets is a ratio that compares the annualized income to average assets (IMF, 2019a), and this ratio usually reflects how well a bank's management efficiently manages their assets to generate profits (Bikker & Vervliet, 2018; Gul et al., 2011). On the other hand, the (IMF, 2019a) defines return on equity (ROE) as a ratio that determines how efficient banks are in using their capital. The (IMF, 2019a) describes ROE as a ratio of the annualized profit after tax against the average capital (capital and reserves), which measures a bank's ability to generate capital through retained earnings as well as its efficiency in generating profits from shareholders' equity (Gul et al., 2011). Net interest margin is defined as the difference between interest income and interest expenses against gross income, and aims to evaluate the efficiency and effectiveness of banks (Khan & Jalil, 2020). From 2014 to 2019, Tanzania observed the lowest ratio of profitability among the four EAC countries shown in Figure 5. The low profitability levels witnessed in Tanzania are mainly due to high operating costs of running the banking business, as well as challenges witnessed in repayments of loans, hence resulting in write-offs (BOT, 2021). Therefore, there is need for the Tanzanian banking sector to reduce their costs of operations to enhance efficiency and effectiveness of the market.

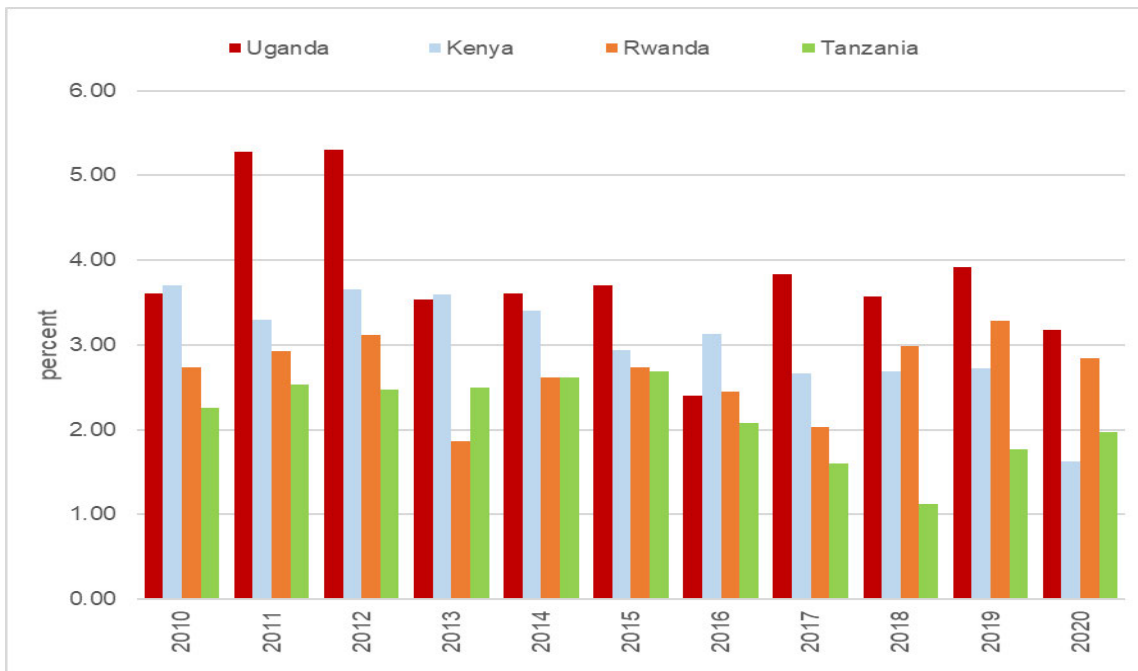


Figure 2.4: Profitability ratios from 2010 to 2020

Source: EAC Financial Stability Central Banks (CBK, NBR, BOU and BOT)

2.3.6.4 Asset quality in the Tanzanian banking sector

The aftermath of the global financial crisis of 2007/09 showed the significance of asset quality for the stability of the financial system. Further, the profitability, liquidity, as well as the capital adequacy of the banking sector are highly affected by the performance of the asset quality (Lucky & Nwosi, 2015; Pastory & Mutaju, 2013).

Asset quality is an essential part of a sound and stable banking sector that involves the evaluation of a bank's assets, in order to obtain the level and size of the credit risk related to the bank's operations (Kadioglu et al., 2017; Lucky & Nwosi, 2015; Swamy, 2015). Further, asset quality aims at assessing the credit risk of the banking sector, which is a very significant type of exposure, due to its high interconnectedness with profitability and economic growth (Ekinci, 2016). In most cases, asset quality in the banking sector is represented by non-performing loans (Oyetade et al., 2022; Raj et al., 2020).

There is no common definition of non-performing loans (NPLs), however, (Bholat et al., 2016; BOT, 2014c; IMF, 2019a) state that these are loans whose contractual obligation

for repayment has passed the due 90 days. In order to measure NPLs' behaviour, a ratio is computed. The NPL ratio is a lagging indicator that is obtained by dividing the gross non-performing loans by the gross loans, in a bank's portfolio. This ratio aims at identifying problems in the asset quality, with an increased ratio signalling more exposures and challenges in the portfolio (IMF, 2019a).

Different authorities assess credit risk using the NPL ratio, however, there is no prudential threshold for the ratio to determine the minimum requirement. Nevertheless, authorities tend to undertake comparisons among peer countries in addition to looking at the changing trends of the ratio (Bholat et al., 2016). In the case of Tanzania, an acceptable level of NPLs, which cannot be more than 5.0 percent, has been put in place (AnnualBOT-FSR, 2020a). For the past ten years, the banking sector in Tanzania has recorded NPL levels well above the acceptable level of 5.0 percent, signalling the impact of individual banks' performance raising the ratio to high levels (AnnualBOT-FSR, 2020a). As such, credit risk, as depicted by non-performing loans, stood at 9.8 percent, as of December 2019 (Tanzania, 2019). This has been noted to be the major source of risk that can impair banks' capital positions (Tanzania, 2018, 2019). It has been further noted that most of the challenges witnessed in the Tanzanian banking sector from 2015 to 2019, originated from credit, which led to the closure of six banks and the buyout of one of the top ten banks (Tanzania, 2018, 2019).

In addition to NPLs, asset quality is assessed using NPLs' net provisions to total capital, and is intended to gauge the potential impact of the portion of NPLs not covered by specific provisions on capital (BOT, 2021). The ratio of earning assets to total assets is the ability of banks to invest in assets that provide a return for the sustainability of their operations (IMF, 2019a).

Drawing from the graph in *figure 2.7* comparing countries in the EAC region, the non-performing loans ratio all lie above 5.0 percent, which is the acceptable level, except for Uganda. The NPLs ratios for Tanzania, Kenya, Uganda, and Rwanda are 9.76 percent, 14.14 percent, 4.50 percent and 5.27 percent, respectively as of the end of 2020. The reduction in NPLs is due to several measures taken by the EAC partner states, including

loan restructuring to prevent the insolvency of borrowers, an enhanced credit underwriting process, and loan recovery efforts.

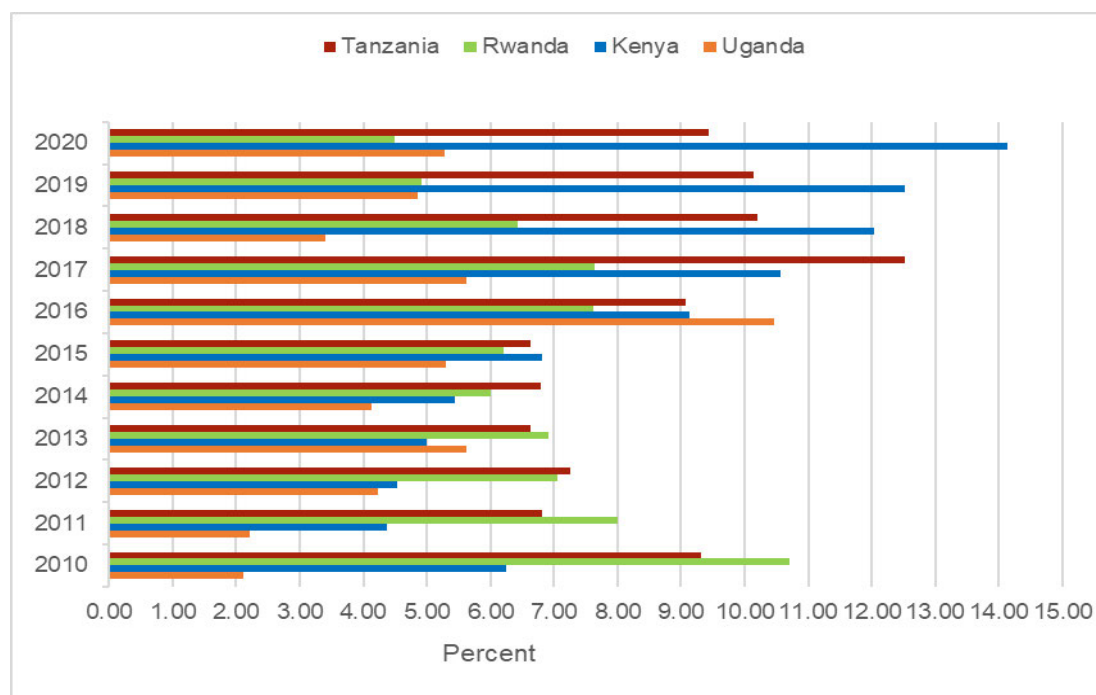


Figure 2.5: Asset Quality (Non-Performing Loans ratio) 2010 to 2020

Source: EAC Financial Stability Central Banks (CBK, NBR, BOU and BOT)

2.3.6.5 Tanzanian banking sector's sensitivity to market risk

Market risk is the risk of losses of financial instruments arising from the movements in market prices of interest rate, foreign exchange, commodity, and equity risks (Ekinci, 2016; IMF, 2019a). The major concentration of market risk in developing countries like Tanzania, is from interest rate and foreign exchange; however, for the compilation of financial soundness indicators, sensitivity to market risk is assessed using the net open position in foreign exchange to capital. This measures the mismatch between foreign currency assets and liability position, in order to assess the potential vulnerabilities of banks to foreign exchange movements (IMF, 2019a). The assessment of banks' vulnerability to foreign exchange rate exposure is paramount, due to the international interactions in business operations that expose banks to other currency-related risks.

In addition, the proportions of foreign exchange assets to total assets ratio, as well as foreign exchange liabilities to total liabilities, are also important to assess whether the banking sector is highly dominated by foreign currency exposure rather than domestic currency. Therefore, in case of a reversal, the implication to the domestic currency given a high dominance of foreign currency may be significant compared to a lower dominance of it.

2.3.7 Chapter Summary

This chapter provided an overview of the financial sector in Tanzania, with a major focus on the banking sub-sector that accounted for about 70 percent of this sector, followed by 15 percent for social security schemes. The chapter focused on reviewing financial sector reforms, understanding the contribution of each sector to GDP, as well as looking more deeply at the financial sector where notably the banking sector is the main contributor to economic growth. Further, the chapter reviewed the evolution of the banking sector, where this sub-sector has been the most prominent sector from the colonial era to date, and the major reforms which focused on its enhancement. The study also reviewed how the introduction of the regulatory and supervisory frameworks created an enabling environment for growth, as well as for the provision of various products and services in the market.

The composition of the banking sub-sector was assessed and noted to be dominated by commercial banks, which account for about 95.0 percent of the total banking sector's assets, followed by development institutions with 3.9 percent. The Tanzanian banking sector's performance was assessed from a trend analysis to a comparability view against its EAC regional peers, where Tanzania was noted to have adequate capital buffers as well as its liquidity ratios being within the minimum regulatory requirement. However, credit risk represented by the NPLs ratio was above the 5 percent acceptance level, hence warranting close monitoring of the market.

Notably, regulatory reforms have led to substantial growth in the financial sector and have contributed to Tanzania's economic prospects, supporting the financing of development

projects as well as other economic activities. This chapter noted that banks are still resilient, with high capital adequacy ratios above the regulatory requirement and maintaining liquidity ratios above the 20.0 percent minimum requirement. However, a concern remains on the quality of assets, as the non-performing loans ratio has remained above the acceptable level of 5.0 percent for the past ten years, hence warranting monitoring. The next chapter considers the impact of domestic, foreign, and global macroeconomic and financial variables to the banking sector in Tanzania, by proposing a macro credit risk stress testing framework.

CHAPTER 3: MACRO-CREDIT RISK STRESS TEST IN TANZANIA

3.1 Introduction

Risk management, which forms an integral part of financial stability assessment through micro-prudential and macro-prudential oversight, detects early warning indicators that inform policymakers on prompt actions to be taken. Chapter 1 detailed the motivation of the study, while concepts of the banking sector and stress testing were explained in *Chapter 2*. This chapter assesses the impact of credit risk and macroeconomic variables, both global and domestic, on Tanzania. This is the chapter with the extension of a journal article (Kishimba et al., 2023) and hence it contains the literature review, methodology, and analysis. Stress tests are used to measure the amount of unexpected losses that can be generated in case a potential risk event materializes, and which may have an impact on a bank's capital, and thus affect its financial stability and the economy at large. Stress tests of the banking sector are conducted from a solvency assessment to individual risk, mainly related to credit, liquidity, interest rate, and exchange rate. Credit risk is considered as one of the major factors that can affect the capital position of banks, hence endangering the resilience of the banking sector; as such, its monitoring is warranted (Pesaran & Schuermann, 2003; Taskinsoy, 2019). Credit risk uses stress testing to complement risk management tools, to support the assessment of banks' ability to withstand shock in case they materialize.

After the global financial crisis of 2008/09, stress testing gained momentum in countries like Tanzania, forming part of the early warning indicators identified to propose policy mitigation measures (BOT, 2019). Drawing from Chapter 1, where the concepts around stress tests were defined and their significance, limitations, and methodological approaches detailed, this chapter will focus on the conduct of stress testing, specifically for credit risk. This will be undertaken by critically reviewing credit risk modelling approaches, as the study focuses on credit risk, an empirical literature review, methodology, as well as the empirical results on the relationship between credit risk and macro variables.

Stress testing has attracted attention in assessing the effect on a bank's balance sheet of unexpected shocks that, once they occur, may have a significant impact on not only

individual bank, but rather the entire financial sector. On the one hand, several studies by Çakmak (2014), Havrlychik (2010), Jakubik and Hermanek (2007), Onder et al. (2016), and Papadopoulos et al. (2016) developed a macroeconomic credit risk model for stress testing specific banking sector factors, by linking macroeconomic shocks and banking sector performance. Further, other studies have sought the need to also include bank-specific variables as part of a credit risk assessment (Amel, 2018; Razafindravonona, 2021). The main focus of these studies was to support policymakers in assessing the number of unexpected losses from macroeconomic shocks. On the other hand, developed a credit risk stress model embedding banking sector factors, in addition to macroeconomic variables, to assess the impact of credit risk on banking sector capital.

For scenario development, econometric models have been significantly used, especially the Vector Autoregressive model for assessing the impact of macroeconomic variables on credit risk (Vu et al., 2018). Similarly, **Global Vector Autoregressive (GVAR) models** have grown in significance as the urge has arisen to assess the impact of global interactions and domestic variables on credit risk portfolios (Havrlychik, 2010; Pesaran & Schuermann, 2003; Rakotonirainy et al., 2020). Therefore, this study contributes to the existing knowledge like the studies by Havrlychik (2010), Rakotonirainy et al. (2020), and Youssef (2018), by adopting a GVAR model to assess credit risk. The study assessed the impact of banking sector variables, combined with global and domestic macroeconomic variables, on the credit risk of commercial banks by individual sector classification (NPLs). This was done to test the resilience of commercial banks to these shocks, using Tanzania as a case study.

Tanzania has been maintaining an aggregate high capital adequacy with high NPLs, despite several measures to contain the growing number of NPLs. Therefore, this study expands on the causality of NPLs' growth beyond the domestic economy, using Tanzania as a model for developing countries with open-ended economies. The chapter focuses on the assessment of the transmission and impact of the global economy to shocks, in addition to the existing bank-related and domestic operations, to ascertain the impact of credit risk. This objective was motivated by the lack of an existing study, to the best of the author's knowledge, that related the impact of both banking factors as well as global,

foreign, and domestic transmission on the banking sector, for developing countries like Tanzania.

The rest of the chapter is structured around a literature review of previous studies on how macro stress tests, specifically credit, were conducted, both theoretically and empirically (section 3.2). The methodology adopted in the study is covered in section 3.3, the data analysis is detailed in section 3.4, and a summary of the chapter is presented in section 3.5.

3.2 Review of literature on macro credit risk stress testing

Sound risk management, detection of early warning indicators, and spillover effects are very significant in the banking sector, for which stress testing supports these processes, thus ensuring the surveillance of financial stability (Adrian et al., 2020). There is, hence, the need to have a robust stress testing framework focusing on the major banking exposure, which is credit risk. Several factors have been identified as determinants of the impact of credit risk through conducting stress testing, including macroeconomic variables to global linkages and banking sector factors (Amel, 2018; Rakotonirainy et al., 2020; Razafindravonona, 2021). Therefore, through these various effects that can either be endogenous or exogenous, this study explores various theories that support the modeling of credit risk within the context of the impact of the variables. On one hand, there is the existence of different schools of thoughts that may deter from only concentrating on domestic variables in assessing the linkage of credit risk (Ganbaatar & Selenge, 2012; Messai & Gallali, 2018; Schechtman & Gaglianone, 2012). On the other hand, thinking beyond the domestic content, meaning global, as detailed by (Rakotonirainy et al., 2020), as well as banking-specific variables have a huge impact on credit risk (Ahmed et al., 2021). In this chapter, the underpinning theories and empirical evidence of conducting macro credit risk stress testing are reviewed, by assessing the linkages between credit risk and macroeconomic variables.

3.2.1 Theoretical literature review on macro credit risk stress testing

The fundamentals and composition of macro credit risk stress testing target the risk management of banks. Stress testing forms part of the risk management techniques used to evaluate the potential impact of plausible scenarios, like the negative impact of GDP

growth on credit risk (Adrian et al., 2020). With the increase in complexity of financial instruments, the need to adopt sophisticated tools for risk assessment is important. The choice of risk to be tested is an important element of stress testing. As earlier stated, credit risk is the major source of risk in the banking sector, thus measuring risk and impact is essential for financial stability (Pesaran et al., 2006).

Stress tests conducted by the IMF have mainly focused on solvency risk, and they have adopted credit risk modelling as part of their core analytical framework. Given the significance of credit risk in Tanzania, the study focuses on credit risk modelling to assess the linkage between credit risk and macroeconomic variables. Credit risk modelling is undertaken using two main approaches, namely the Merton model (1974) and Wilson model (1997). On this point, the theories behind the existence of these approaches include rational option pricing theory and arbitrage pricing theory, which provide a theoretical basis for this study in linking credit risk to macroeconomic variables in Tanzania.

On the theoretical underpinning for modelling credit risk, option pricing theory is an intermediate step toward a unified theory, to answer questions about the pricing of a firm's liabilities and the term and risk structure of interest rates, originating from the theory of speculative markets (Hirshleifer et al., 2005). Rational option theory began in 1900 and was based on the assumption of stock prices following a Brownian motion with zero drift, using the theory of speculation (Bachelier, 1900). Like several other researchers, Merton (1973) extended the theory of rational option pricing and opened the spectrum for debate on the use of option pricing theory, by introducing the black Scholes model in his study. Based on the option pricing theory by Black and Scholes (1973), structural models were first introduced by Merton in 1974, using the Black-Scholes option pricing framework to calculate the probability of a firm's default, based on the value of its assets and liabilities (Hull et al., 2004).

Merton-type structural models of banks derived the method of how to conduct stress testing in the banking sector, by calibrating risk-adjusted balance sheets and implied assets of banks, which are then linked to domestic and international factor models (Merton, 1974). The benefit derived from the Merton model, was that it has an effective

feature of connecting credit risk to underlying structural variables, providing both an intuitive economic interpretation and an endogenous explanation of credit defaults, and it allows for application of option pricing methods. As a result, structural models not only facilitate security valuation, but also address the choice of financial structure. Nevertheless, the Merton model has the limitation of observing the market value of a firm's assets (Chatterjee, 2015).

The Merton approach was used to model the effect of macroeconomic changes on stock exchange prices, and then transformed these changes into default probabilities (Hull et al., 2004). The approach was further developed by researchers, whereby Drehmann (2005) modelled credit risk using the Merton model for corporate credit exposures of UK banks, by identifying systematic risk factors through embedding credit and market risks. Duellmann and Erdelmeier (2009) performed stress testing using the Merton model with an economic downturn of the automobile sector being the scenario, to focus on assessing credit portfolios for twenty eight banks in German. The Merton model is a simple way that clarifies the capability of a company to meet its financial obligations, service its debt, and weigh out the general possibility that it will go into credit default.

The Merton approach is popular due to its simplicity, however, it has the limitation of lacking direct observation of the firm value process, which makes it unrealistic to assume volatility as interest rates are not constant over time (Kafetzaki-Boulamatsis & Tasche, 2001). As opposed to option pricing theory, Cox and Ross (1976) introduced the arbitrage pricing theory with an heuristic argument, namely, that a one-factor model prevents the existence of arbitrage over static portfolios of capital assets, leading to a linear relationship between the expected return and its covariance (Huberman & Wang, 2005). Further, the theory of arbitrage pricing was developed as an alternative to the mean variance capital asset pricing model (CAPM) developed by Sharpe, as it takes into consideration a linear relationship between assets' expected returns and their covariance with other random variables (Huberman & Wang, 2005; Roll & Ross, 1980).

The arbitrage theory has been applied in the evaluation of stock exchanges, by determining risk premiums for equities as well as establishing instabilities with the related random variables (Roll & Ross, 1980). According to Azeez and Yonezawa (2006), who

assessed the pricing of macroeconomic factors in the Japanese stock market during the pre- and post-bubble period by adopting the arbitrage pricing theory, the implied across-equation pricing restrictions are not rejected during any part of the sample period, signaling instability at some point in time (Azeez & Yonezawa, 2006). Further, (Dada et al., 2021); Dhankar and Singh (2005); Iqbal and Haider (2005) applied the arbitrage pricing theory to model active trading stocks to assess the impact of macroeconomic factors, and how significant the impact was on the stock exchange.

As studies focused on the stock exchange and application of the arbitrage pricing theory, researchers also viewed its application to the banking sector (Cetin et al., 2010; Pesaran & Schuermann, 2003). Pesaran and Schuermann (2003) focused on using a GVAR model to predict returns, using the relationship between an expected return and macroeconomic factors. A similar approach is adopted in this study, by employing the GVAR approach to take into account the global transmissions in addition to the domestic variables, when assessing their linkages to credit risk in the Tanzanian banking sector. Pesaran et al. (2006) amplified that the Merton approach has been used to further advance and support the framework of the GVAR model, to link credit risk and business cycle fluctuations, and which will support the development a tool for policy analysis, risk management, and the pricing of credit assets.

T. C. Wilson (1997a) provides another view of modelling credit risk using econometric models that follow the economy theory, by developing the Credit Portfolio View (CPV) which links macroeconomic factors to probability of default. This model is commonly used for modeling banks' credit risks to simulate the evolution of default rates over time, by generating macroeconomic shocks for the evaluation of the fragility of financial systems (T. Wilson, 1997a; Wilson, 1997b). In contrast to the structural models that follow option theory, Castrén, Fitzpatrick, et al. (2008) argued that another way of quantifying credit risk, is by using the CPV approach that takes into account the discrete multi-period model, in which default probabilities are conditional on the macro variables that influence the credit cycle in the economy. For assessing the fragility of the Austrian banking system, Boss (2002), used the CPV model for scenario analysis, by linking the default rates to the macroeconomic variables. This approach was further extended for building a

macroeconomic credit risk model, by employing a lag effect of the macroeconomic variables to banks' credit risk to assess the impact of default rates on the banking sector (Virolainen, 2004). Moving from implication to credit risk to profit generation, Wong et al. (2006) developed a framework for stress testing by linking default rates of bank loans with macroeconomic shocks, to assess the ability of Hong Kong's retail banks to generate profits under stress conditions. This approach has been profound, not only for developing scenarios, but also for using historical data to develop defaults that are simulated into shocks (Başarır, 2016; Sanatkhani & Bazzazan, 2021; Schechtman & Gaglianone, 2012). The introduction of the CPV model has had a significant effect on the development of econometric models for credit risk stress tests adopted by different authorities (Grundke et al., 2019; Kattai, 2010; Küçüközmen & Yüksel, 2006; Sorge & Virolainen, 2006; Virolainen, 2004; Wong et al., 2006).

In terms of all the different theories, this study draws on the arbitrage pricing theory, by applying the Merton credit risk model that provides room for a global macro-econometric model; this allows for interdependencies between domestic and foreign variables as well as for the bank-specific business cycle effect and heterogeneous default thresholds (Pesaran et al., 2006). Different approaches have been employed to model credit risk, but this study adopts the global vector autoregressive model to capture the global linkages in relation to domestic variables of individual banks' credit risk.

3.2.2 Empirical literature review on macro credit risk stress testing

Few studies have empirically assessed macro credit risk stress testing, by adoption of the GVAR model to consider global linkages. GVAR models have grown in significance as the need to assess the impact of the global interactions and domestic variables on credit risk portfolios increases (Rakotonirainy et al., 2020). The limitation of this study was to concentrate on aggregate data, rather than on an analysis of individual banks to obtain more granular data. Another study by Castrén et al. (2010) adopted the Global VAR using vector error correction model (VECMs), that takes into account international linkages among macroeconomic and financial variables, in addition to domestic variables, to generate shocks to the financial system on the European Central Bank. This study covered data from 1992: Q1 to 2005:Q4, and the findings revealed that the expected

aggregate probability of defaults reacts more to shocks on GDP, the euro/US dollar exchange rate, equity prices, and oil prices, and that the sectors react in relatively the same way as aggregated data (Castrén, Déés, et al., 2008; Castrén et al., 2010).

Albertus et al. (2009) also deployed the GVAR model, and added an African component by introducing South Africa in the model, taking into account both retail and corporate credit risk. Therefore, with data covered from 1980:Q1 to 2006:Q4, the study was able to propose a framework that can be used as a correlation model within a South African-specific credit portfolio management tool (Albertus et al., 2009). In their study, Rakotonirainy et al. (2020) used aggregate data to assess the impact of macroeconomic shocks, which include both global transmission and domestic implications to credit risk, using non-performing loans (NPLs) as a model. The GVAR model was used for scenario development, and the satellite GVAR model combined the NPLs results to the shocks generated by the GVAR model, as was also adopted by (Castrén, Déés, et al., 2008). The study covered from Q2:2005 to Q2:2015, and revealed that the interaction between aggregate NPLs and economic evolutions follows the cyclical pattern (Rakotonirainy et al., 2020).

Studies of stress testing in the African countries' context, have shown different efforts in undertaking stress testing by adopting various methodologies to mitigate both internal and external exposures (Amediku, 2006; Farayibi, 2016; Youssef, 2018).

From a micro-prudential point of view, Méndez-Marcano (2021) chose a GVAR model to support global European systemic banks in the Internal Capital Adequacy Assessment Programs (ICAAP) process, to assess the compliance of prudential regulations and thus make it more appropriate for forecasting purposes; however, given the limited scope of this study, the impact on other small banks may not be obtained, which can also lead to a spillover effect. Pesaran et al. (2006), on the other hand, adopted a GVAR model in the corporate sector to compute the effects of a hypothetical negative equity price shock in Southeast Asia, which revealed that default probabilities are driven primarily by how firms are tied to business cycles. However, the findings of the study are only associated to corporates, and do not consider the banking sector.

Studies in stress testing have adopted different models from GVAR models. For example, several studies have adopted the usage of the Vector Autoregressive (VAR) model for projecting the stress scenarios, as they are flexible and relatively simple, although they do not include the economic structure that is incorporated in the macro modeling approach (Jiménez & Mencía, 2009; van den End et al., 2006). Abdolshah et al. (2020) estimated the potential credit losses in the Iranian banking sector using the VAR model against macroeconomic shocks, which resulted in estimates of minimum economic capital requirements. Başarır (2016), on the other hand, adopted VAR for developing a macro scenario analysis framework for assessing the behaviour of NPLs against unexpected events in the Turkish banking sector, and portrayed that the sector is resilient due to its effective management; however, the usage of the VAR model omitted global transmission and possible risks associated with it.

In his study, Barasinska et al. (2019) concentrated on stress testing the German real estate market, by presenting aggregate and individual banking sector data from 2018 to 2020, using a structural P-VAR model. The results revealed that the German banking sector has a wide expected distribution of losses. Nevertheless, the study noted the limitation of the second round effect from the expected losses, thus failing to link these with other transmission effects of related partner states.

The results of the study by Barasinska et al. (2019) showed that LTV loss rates in the residential mortgage portfolios of German banks, increase significantly in an adverse macroeconomic scenario. In another study of the Iranian banking sector, Askari et al. (2021b) deployed Wilson's model for estimating the default rates (PD) and use of the VAR model. The study showed that GDP growth has the greatest effect on default rate, though the banking system still remains resilient to macroeconomic shocks. Similarly, Messai and Gallali (2018) also adopted the credit portfolio view model using quarterly data from 2000 to 2011, for four Spanish sectors including agriculture, construction, services, and industry; the results revealed that construction was the most affected sector by the macroeconomic shocks applied. These studies' (Askari et al., 2021b; Barasinska et al., 2019; Messai & Gallali, 2018) findings imply the significance of real estate to the banking sector, and also called for a more integrated assessment of credit to capture beyond the

domestic effect, extending it to the global and the implications of trading partners, in order to expound on potential shocks.

Kanas and Molyneux (2018) employed an additive semi-parametric quantile approach using data from Q1:1984 to Q3:2013, for the U.S. banking system. Another study was conducted in India by Dua and Kapur (2018) employing a vector error correction model in an integrated framework, for quantifying the vulnerability of the banking sector to credit risk, with scenarios generated through adverse, policy-induced and other external shocks. (Vazquez et al., 2012) also observed how the use of insufficient granular credit data tends to underestimate the tail losses of riskier banks. The results of the study revealed a substantial variation in the pro-cyclical behavior of credit quality, with private and public banks behaving relatively the same. Further, the study shows a robust negative relationship between the logistic transformation of NPLs and GDP growth, with a lag response of up to three quarters.

3.2.3 Summary and gap in the literature for macro credit risk stress testing

The review of the empirical literature underpinning this study points to the fact that the area of macro credit risk stress testing, still has gaps specifically in the context of African countries, where limited research has been conducted (Amediku, 2006; Amel, 2018; Farayibi, 2016; Ouma, 2016; Rakotonirainy et al., 2020). Macro credit risk stress tests have gained momentum after the global financial crisis of 2007/09, as credit is the major function of most banking systems (Adrian et al., 2020). In Tanzania, despite the efforts made in the 2018 FSAP conducted with stress testing being part of the assessment tools for financial stability (IMF, 2018c), and the financial stability reviews conducted by the central bank, it can be noted that there is still limited research conducted on stress testing in the country (Leika et al., 2020).

More specifically, the gap exists in assessing macro credit risk stress tests, where global linkages and transmissions, in addition to macroeconomic, financial, and banking sector variables, have been integrated with a focus on bank-specific impact. Further, there is also gap in the literature in the case of Tanzania, to assess the impact and implication of specific bank credit risk relative to the scenarios generated by using the GVAR model on global linkages and transmission, which this study intends to fill. An additional contribution

is the expansion of the GVAR model that includes more African countries in addition to Madagascar (Rakotonirainy et al., 2020), such as Tanzania and Kenya, that were not there before, as well as South Africa and other trading partners with an extended time period ending in M12-2020.

To fill these gaps, this study will deploy the GVAR model for scenario development, to capture the transmission of global, external, and domestic macroeconomic and financial variables on banks' NPLs (Rakotonirainy et al. (2020).

3.3 Methodology

Macro credit risk stress testing is one of the risk management and macro-prudential tools used to assess the impact of domestic, foreign, and global macroeconomic shocks on credit risk. In doing so, several studies have used different models, namely: Vector Autoregressive (VAR) models (Abdolshah et al., 2020; Arestis & Jia, 2018; Buncic & Melecky, 2013; Kattai, 2010; Niyogi & Bhattacharya, 2011); a structural Panel VAR model (Barasinska et al., 2019); Wilson's Credit Portfolio View (Messai & Gallali, 2018); Value at Risk model (Kalirai & Scheicher, 2002; Ong, 2014); static and random fixed effect model (Amel, 2018; Havrylchyk, 2010); and Autoregressive Distribution Lag Model, or ARDL (Vuković, 2014). Each of these methods has its strengths and limitations.

Despite all the different methods used for the assessment of the impact of macroeconomic scenarios on credit risk, the Vector Autoregressive (VAR) approach is the econometric model which is predominantly preferred (Abdolshah et al., 2021; Başarır, 2016; Blaschke et al., 2001; Buncic & Melecky, 2013; Foglia, 2008; Kattai, 2010; Ong, 2014; Vuković, 2014). However, VAR has displayed a limitation around the non-linear relationship between credit risk and financial indicators, and an inability to capture the effect of the business cycle and global interactions (Rakotonirainy et al., 2020). The selected GVAR approach differs from other models such as Wilson's Credit Portfolio View, as it does not only use single-country macroeconomic factors, but rather multiple macro-econometric specifications, which allows for country/region-specific heterogeneities (Pesaran & Schuermann, 2003).

Therefore, this study aims to assess the impact of global, foreign, and domestic macroeconomic variables on individual banks' credit risk in Tanzania, using the GVAR model to develop scenarios. The aim of this is to cater for international transmission and interlinkages, by linking macroeconomic scenarios to credit risk using global, foreign, and domestic macroeconomic variables, through the GVAR model. The theoretical underpinning of the GVAR model came into place as an extension to existing global forecasting models adopted by the IMF, United Nations, and OECD, which were usually formed by linking traditional large-scale models.

Further, the National Institute's Global Economic Model (NiGEM) was designed to calibrate a common structure across the OECD, China and other regional blocks, to provide consistency of assessment and global interlinkages among economies, thus facilitating forecasting (Pesaran et al., 2004). However, these forecasting models are difficult to use for risk management, for which the proposed GVAR model aimed at filling the gap of capturing the global transmission and impact of international interlinkages (Pesaran et al., 2004). Later, the study by Dees et al. (2007) extended the work done by Pesaran et al. (2004), by increasing geographical coverage and variables as well as developing a sieve bootstrap procedure for a simulation of the GVAR model as a whole, in addition to the impulse responses.

The advantage of the GVAR model is that it takes into account the non-linear relationships between macroeconomic variables and financial variables, without modifying the model structure (Castrén et al., 2010; Pesaran & Chudik, 2014). Further, it also takes into account the global interactions and transmission (Feldkircher & Korhonen, 2014; Gurara & Ncube, 2013; Khan, 2020; Oyelami & Olomola, 2016; Rakotonirainy et al., 2020). In addition, the GVAR model allows a consistent and transparent evaluation of interdependence at multiple levels, in this particular case, both domestic and global dynamics (Gross et al., 2016; Gurara & Ncube, 2013). Furthermore, the model specifications support the reflection and matching of long- and short-term adjustment dynamics that are consistent with theory (Martin and Cuaresma, 2016).

The GVAR model developed by (Pesaran et al., 2004) adopted macroeconomic scenarios, and was used to conduct macro credit risk stress testing in Tanzania, as in

studies by (Barbieri et al., 2022; Méndez-Marcano, 2021; Rakotonirainy et al., 2020). The foreign variables are those of countries chosen because they are major trading partners of Tanzania's, in terms of aggregated export and import volumes. These countries also form part of the bucket for the computation of real effective exchange rates in seven countries, consisting of China, India, South Africa, the UAE, the Eurozone, the USA, and Kenya. Therefore, the new GVAR model and part of the contribution of the study, is to include the new countries into the Pesaran et al. (2004) model.

3.3.1 Model specification

To answer the question of how to **assess the impact of macro stress testing on credit risk**, this study has used the GVAR model (Albertus et al., 2009; Castrén et al., 2010; Dees et al., 2007; Pesaran et al., 2006; Rakotonirainy et al., 2020). The method has been used in some studies for assessing the impact of global, foreign, and domestic macroeconomic shocks on credit risk. In the study by Rakotonirainy et al. (2020), this was done in Madagascar using the aggregate banking sector. Meanwhile, Castrén et al. (2010) used this method for corporate defaults in European banks in assessing stress tests.

To undertake the development of macroeconomic scenarios, this study follows the GVAR model approach to consider the growing interconnections and interdependencies between domestic and international variables (Pesaran et al., 2004). The study focused on assessing the international transmission of macro shocks on the Tanzanian economy, using global and foreign variables, supported by the studies conducted in other countries like Nigeria and Madagascar (Castrén et al., 2010; Khan, 2020; Oyelami & Olomola, 2016; Rakotonirainy et al., 2020). The GVAR model is constructed using two steps. The first one is to model each of the seven countries (China, India, South Africa, the UAE, the Eurozone, the USA, and Kenya), using a country-specific, one lag, VAR specification.

Estimation of country specific VAR models: The GVAR model comprises of $N + 1$ countries, is indexed as $i = 0, 1, \dots, N$, where 0 is the cross reference, generally represented by the United States.

The GVAR model is specifically a set of VARX* (p_i, q_i) for each country as follows:

$$x_{it} = a_{i0} + a_{i1t} + \phi_{i1}x_{i,t-1} + \dots + \phi_{ip}x_{i,t-p} + \delta_{i0}x_{i,t}^* + \delta_{i1}x_{i,t-1}^* + \dots + \delta_{iq}x_{i,t-q}^* + a_{i2}d_t + \varepsilon_{it} \quad (3.3.1)$$

$$t = 1, 2, \dots, T \quad \text{and} \quad i = 0, 1, \dots, N$$

Where:

x_{it} is a $(k_i \times T)$ vector of variables of domestic specific endogenous variables for country i in time t ;

a_{i0} is a $(k_i \times 1)$ vector of constant coefficient;

a_{i1} is a $(k_i \times 1)$ vector of linear coefficient;

x_{it}^* is a $(k_i^* \times 1)$ vector of weighted foreign variables specific to country i , with δ_{i0} and δ_{i1} being a $(k_i \times k_i^*)$ matrix of fixed coefficient;

d_t is a $s \times T$ vector of global weekly exogenous variables including oil prices, raw materials; a_{i2} as a $(k_i^* \times s)$ matrix of fixed coefficients;

ϕ_{i1} and ϕ_{i2} are the lagged coefficients of domestic variables;

ε_{it} is a $(k_i \times 1)$ vector error assumed serially uncorrelated for country-specific shocks; and

p and q denote the lag lengths of the domestic and foreign variables.

In order to assess the impact of the global economy on domestic variables, the major trading partners' variables are looked at. To determine Tanzania's major trading partners, the countries that are used for computing real effective exchange rates are used.

Weight matrices: The weights are computed to obtain the vectors for foreign-specific variables x_{it}^* , using the weighted average of each variable across all countries in the sample. To construct the weights for the foreign variables x_{it}^* in a GVAR model, the study will use the weighted average of domestic variables (Castrén et al., 2010; Kempa & Khan, 2017; Khan, 2020).

$$x_{it}^* = \sum_{j=0}^N w_{ij} x_{jt} \quad w_{ii} = 0 \quad (3.3.2)$$

Where $w_{ij}, j = 0, 1, \dots, N$ a set of weights with $\sum_{j=0}^N w_{ij} = 1$.

The second step in modeling the GVAR model is to develop a global model: The study adopts an approach (Castrén et al., 2010; Gray et al., 2013; Martin and Cuaresma, 2016; Nazmun S. Khan, 2020) to define vectors that stack domestic and foreign variables, $z_{it}=(x_{it}, x_{it}^*)'$ using VARX*, and equation 1 is rewritten with its error form as:

$$A_{i0}Z_{it} = a_{i0} + a_{i1t}+A_{i1}z_{t-1}+\dots+A_{ipi}z_{i,t-pi} + \varepsilon_{it} \quad (3.3.3)$$

Where we assume $p=q$ and the global variables d_t to be empty.

$$A_{i0} = (I_{ki} - \delta_{io}), A_{i1}=(\emptyset_{ij}, \delta_{ij}) \text{ and } A_{ip}=(\emptyset_{ip}, \delta_{ip}) \text{ for } j = 1, \dots, p_i$$

Next, the local variables vectors z_{it} are mapped to the global endogenous variable vector x_t , which is the matrix $(k_i + k_i^*) \times k$, linked with matrix W_i , where the trade weights of matrix W_i , z_{it} , can be written as $z_{it}=W_ix_t$. Therefore, equation 1 can be rewritten as;

$$A_{i0}W_ix_t = a_{i0} + a_{i1t}+A_{i1}W_ix_{t-1}+\dots + A_{ipi}W_ix_{t-pi} + \varepsilon_{it} \text{ for } i = 0,1,2,3 \dots, N \quad (3.3.4)$$

This forms the global model by stacking all country specific VARX* as shown below;

$$G_0x_t = a_0 + a_{i1t}+G_1x_{t-1}+\dots + G_px_{t-p} + \varepsilon_{it} \quad (3.3.5)$$

Where $G_0 = (A_{00}W_0, A_{10}W_1, \dots, A_{N0}W_N)'$ is the $k \times k$ matrix that depends on trade weights and $G_j = (A_{0j}W_0, A_{1j}W_1, \dots, A_{Nj}W_N)'$ for $j = 0,1, \dots, p$. $a_0 = (a_{00}, a_{10}, \dots, a_{N0})'$ $a_1 = (a_{01}, a_{11}, \dots, a_{N1})'$ and $\varepsilon_t = (\varepsilon_{0t}, \varepsilon_{1t}, \dots, \varepsilon_{Nt})'$ and $p = \max(pi)$, for all i .

Pre-multiplying equation 5 by G_0^{-1} , the GVAR(p) model obtained is as shown below:

$$x_t = b_0 + b_{i1t}+F_1x_{t-1}+\dots + F_px_{t-p} + \varepsilon_{it} \quad (3.3.6)$$

$$b_0 = G_0^{-1}a_0 \quad b_1 = G_0^{-1}a_1, \quad F_j = G_0^{-1}G_j \quad \text{for } j = 1,2, \dots, p \text{ and } \varepsilon_t = G_0^{-1}u_t.$$

After obtaining the estimates of the parameters, the dynamic properties and forecasts of the model in [equation 3.3.6](#) can be obtained by constructing standard impulse response functions.

3.3.2 Discussion of variables and sources

It is desired to assess the impact of macro stress testing on credit risk from the period of M6-2006 to M12-2020. Predominantly, credit risk can be influenced by multiple factors

ranging from global, foreign, and domestic macro-economic and financial variables (Albertus et al., 2009; Castrén, Déés, et al., 2008; Rakotonirainy et al., 2020).

In this chapter, the dependent variable is credit risk and is represented by non-performing loans (NPLs), due to its flexibility to perform an aggregate, individual, and sector-wise analysis (Abdolshah et al., 2021; Arestis & Jia, 2018; Başarır, 2016; Ganbaatar & Selenge, 2012; Messai & Gallali, 2018; Rakotonirainy et al., 2020; Razafindravonona, 2021; Vazquez et al., 2012). Despite using NPLs, we acknowledge that several studies in the literature review opted for other credit risk proxies like loan loss provisions Amel (2018); Havrylchuk (2010); Vuković (2014), based on the data availability and reporting in the assessed countries. However, after thorough assessment, this study used NPLs due to the challenges of data availability in Tanzania, as a result of a lack of integration and submission of loan loss provisions by banks. This left NPLs as a good proxy for credit risk to attain the aims of the study on individual banks and a sector-wide analysis, as supported by different studies (Memdani, 2017; Rakotonirainy et al., 2020).

Drawing from the literature review, most of the common determinants of credit risk are macroeconomic variables based on their exogenous nature (Castrén et al., 2010; Rakotonirainy et al., 2020). For this particular study, the usage of the GVAR model for the development of scenarios called for a range of macroeconomic variables to be selected, ranging from global, foreign, and domestic variables. For the domestic variables, the endogenous variables that were employed for Tanzania included GDP, inflation, real effective exchange rate, overnight rate, lending rate, and average deposit rate. The data for the macroeconomic variables was for the period from Q1:2006 to Q4:2020. Given the nature of the GVAR model, foreign variables were employed in the model, as weak exogenous variables including GDP, inflation, exchange rate, and short-term interest rate.

Gross Domestic Product is a significant indicator that is usually used to control the economic cycle of a country. GDP is approximated by annual growth in real GDP in percentage. Studies show that during the expansion phase of the economy, borrowers need sufficient funds to support their repayments, while during a recession, borrowers' ability to service debt declines (Chaibi & Fiti, 2015). In this regard, credit extension may be absorbed by low quality debtors. Most studies conducted exhibit that GDP leads to a

negative relationship with NPLs, therefore economic activities are related to the functioning of the repayment pattern of banks (Ahmed et al., 2021; Koju et al., 2018; Louzis et al., 2012; Raiter, 2021).

The inflation rate is measured by the annual percentage change in the consumer price index of a country at a particular time (Chaibi & Ftit, 2015; Louzis et al., 2012; Vuković, 2014). Based on the literature review conducted, the inflation rate provides a more positively corrected aspect with NPLs, as higher costs imply that there is a tradeoff, where the cost of living goes up by the reduction in the buying power money thus repayment of loans becomes difficult (Ahmed et al., 2021; Ikram et al., 2016; Koju et al., 2018).

According to Razafindravonona (2021), the rise of the real effective exchange rate has a mixed impact, of which the appreciation in this indicator may weaken the competitiveness of export-oriented firms and reduce their ability to service debt. Further, other empirical studies show that the appreciation in the exchange rate has a negative impact to NPLs (Ekanayake & Azeez, 2015; Waqas et al., 2017). Conversely, the depreciation in exchange rate has a positive impact on companies that borrow foreign currency to service debt (Razafindravonona, 2021). However, Tanzania's financial sector has more lending of local currency accounting for more than 60 percent of the loan portfolio (BOT, 2019a); therefore, assessing the impact of currency appreciation is more relevant to study the magnitude of this impact on NPLs. Therefore, the study will follow the approach of a positive impact of exchange rate on NPLs (Ikram et al., 2016; Messai & Gallali, 2018).

Short-term interest rates are usually represented by the interbank cash market rate of the overnight or three months average. Empirical studies have shown that the existence of high short-term interest rates have an impact on the cost of funding, therefore leading to a higher cost of borrowing Kattai (2010), and as such, leading to challenges in the chances of repayment. In this case, the short-term interest rate is negatively correlated to credit risk (Ekanayake & Azeez, 2015; Rakotonirainy et al., 2020).

Global variables are also included in the model, namely, the all metals index, agriculture price index, and crude oil price index. The all metals index is one of the global variables adopted to assess the impact of global transmissions on the banking sector through credit.

Given the exposure of the country to metals, the volatility in the prices leads to an uncertain repayment pattern by borrowers and can affect the residual inflows (Nikolaidou & Vogiazas, 2017). A change in the all metals index has a positive impact on NPLs (Rakotonirainy et al., 2020).

In implementing the GVAR model, the use of the crude oil price index, as represented by oil prices, is a common global transmission indicator that can result in the co-movement of business (Castrén et al., 2010). Empirical studies show that a change in the crude oil price has a significant impact on the corporate sector as well as on the transmission mechanisms of these variables, hence hampering the repayment pattern (Amel, 2018; Khan, 2020).

The commodity price is represented by the agriculture price index, which forms part of this international variable (Khan, 2020; Oyelami & Olomola, 2016). The historical volatility in commodity prices can be modelled by scenarios that stress test the ability of the banking sector (Nikolaidou & Vogiazas, 2017). A change in commodity price has a positive impact on NPLs (Rakotonirainy et al., 2020). Table 3 summarizes the variables and sources, as shown below.

Table 3.1: A summary of variables and sources

| Foreign and domestic variables | | | | | |
|--------------------------------|--|---|--|----------------------|--|
| Sn o | Variables | Definition | Source | Hypothesis tested | References |
| 1. | GDP | Year by year change of gross domestic product in percentage. | Tanzania National Bureau of Statistics/International Monetary Fund | (-) | Chaibi and Ftiti (2015) Ikram et al. (2016) Raiter (2021) |
| 2. | Inflation | Annual Inflation growth rate at time t as measured by consumer price index. | Tanzania National Bureau of Statistics/International Monetary Fund | (+) | Ahmed et al. (2021) Chaibi and Ftiti (2015) Louzis et al. (2012) |
| 3. | Exchange rate (real effective exchange rate) | The weighted average of a country's currency in relation to an index or basket of other major currencies. | Tanzania National Bureau of Statistics/International Monetary Fund | (+) | Waqas et al. (2017) Ikram et al. (2016) Razafindravonona (2021) |
| 4. | Short term interest rate | The interbank cash market rate of the overnight or three months average. | Tanzania National Bureau of Statistics/International Monetary Fund | (-) | Ekanayake and Azeez (2015) Razafindravonona (2021) |

| Global macro variables | | | | | |
|------------------------|---------------------------|--|-----------------------|-----------------------|--|
| Sn o | Variables | Definition | Source | Hypothes is tested | References |
| 5. | All metals index | | World Bank Pink Sheet | (-) | Nikolaidou and Vogiazas (2017) Rakotonirainy et al. (2020) |
| 6. | Crude oil price index | OIL | World Bank Pink Sheet | (+) | Castrén et al. (2010) Amel (2018) |
| 7. | All commodity price index | A commodity index is an investment vehicle that tracks the prices and return on investment of a basket of commodities. | World Bank Pink Sheet | (+) | Khan (2020) Rakotonirainy et al. (2020) |
| Dependent variable | | | | | |
| Sn o | Variables | Definition | Source | Hypothes is tested | References |
| 8. | Non-performing loans | npl_{it} $= non\ performing / gross\ loans_{it}$ | Bank of Tanzania | | Abdolshah et al. (2021) Arestis and Jia (2018) Vazquez et al. (2012) Başarır (2016) |

Source; Author's own compilation (2023)

3.3.3 Trade and aggregate weights

To construct the foreign variables, this study used weights that are computed using the trade relationship between the total imports and exports of major trading countries, which account for more than 70 percent of total trade for the past 10 years (BOT, 2021). The countries used in this study are the USA, China, India, South Africa, Kenya, the UAE, and the Eurozone, based on their proportion of holding in terms of trade with Tanzania. The weight matrix is developed based on fixed weights to detect the foreign variable sensitivity for forecasts. Table 4 describes the trade weights with the rows representing the country and the columns showing the trade weights. This specific study shows that much of the trade was conducted between China and other countries in the sample. In addition, the trade between the USA and China, as well as with the Eurozone, is also significant. These countries continue to portray the dominance of transmission of shocks among countries.

Table 3.2: Trade weights based on the direction of trade statistics

| Country/Region | CHINA | EURO | INDIA | KENYA | SOUTH AFRICA | TANZANIA | UAE | USA |
|----------------|--------|--------|--------|--------|--------------|----------|--------|--------|
| CHINA | 0.0000 | 0.3927 | 0.2890 | 0.3763 | 0.3677 | 0.3519 | 0.2616 | 0.4513 |
| EURO | 0.3963 | 0.0000 | 0.2484 | 0.1894 | 0.3652 | 0.1149 | 0.2336 | 0.4563 |
| INDIA | 0.0661 | 0.0635 | 0.0000 | 0.1473 | 0.0951 | 0.2449 | 0.3253 | 0.0623 |
| KENYA | 0.0029 | 0.0019 | 0.0057 | 0.0000 | 0.0060 | 0.0477 | 0.0104 | 0.0008 |
| SOUTH AFRICA | 0.0199 | 0.0291 | 0.0270 | 0.0554 | 0.0000 | 0.0445 | 0.0202 | 0.0095 |
| TANZANIA | 0.0013 | 0.0008 | 0.0072 | 0.0341 | 0.0106 | 0.0000 | 0.0080 | 0.0002 |
| UAE | 0.0427 | 0.0334 | 0.1541 | 0.1236 | 0.0376 | 0.1609 | 0.0000 | 0.0197 |
| USA | 0.4708 | 0.4786 | 0.2686 | 0.0738 | 0.1179 | 0.0352 | 0.1409 | 0.0000 |

Source: Direction of Trade from the International Monetary Fund (IMF, 2020).

Note: Trade weights are computed as shares of exports and imports displayed in rows by region, such that a row, not a column, adds up to one.

3.3.4 GVAR estimation techniques

This section represents the results of the macro credit risk stress testing using the GVAR model, and taking into account international transmission. In doing so, the impact of external shocks to the banking sector is assessed by using exogenous and endogenous variables. On the one hand, this study applied the VECMX* model in GVAR estimation, by modelling the six economies that are Tanzania's major trading partners, and global variables considering them as exogenous variables. On the other hand, Tanzania's macroeconomic variables are included as the endogenous variables, of which GDP, inflation, exchange rate, as well as interest rate are applied. Empirical work has proven that small open economies like Tanzania are highly influenced by external shocks, due to free market activity, therefore the application of the GVAR model is important (Dridi & Nguyen, 2019; Ekeocha & Ogbuabor, 2019).

The banking sector variable, NPLs, is embedded in the GVAR model, and the generalized impulse response function (GIRFs) is used to assess the significance of macro credit risk

stress testing, by integrating a country exposure estimation based on the research question which aims to attain the objective of this study. Two hypotheses about the expectations of the relationship between macro credit risk stress testing and bank resilience in Tanzania are tested. Firstly, a presentation of the descriptive statistics and unit root tests performed for credit risk, as well as for global, foreign, and domestic variables is necessary, before conducting an estimation of the different stages of the panel model. Next, the reaction of the GVAR model to how credit risk (NPLs) was affected by the shocks is presented.

3.3.5 Descriptive statistics

Descriptive statistics are coefficients that help us to understand the nature of the data used for this study, and the results are detailed in appendices 1, 2, and 3 on domestic, foreign, and global variables, respectively. The GVAR model has an embedded feature which conducts measures of central tendency using mean and median, dispersion using standard deviation, and of normality using skewness and kurtosis. Appendix 1, which shows the mean of endogenous variables in the study, depicts that the USA has the highest average real GDP of 12.15 percent, followed by the Eurozone with 12.02 percent, and then China with 11.82 percent. In spite of having lower real GDP average rates of approximately 9 percent, Kenya and Tanzania have the highest non-performing loans, thus signaling that there is an inverse relationship between credit extension and economic growth, as well as inadequate repayment of loans in these countries. Appendix 3, which shows global variables, depicts that the raw material price index had the highest average of 1.94 percent, followed by metal with 1.92 percent. The oil price index had an average of 1.84 percent. Since the country is an oil importer, in terms of the interrelationship of the Tanzanian economy with the oil price index, a lower index is preferable.

3.3.6 Unit root test

The global VAR model can be applied to stationary and/or integrated variables, following Pesaran et al. (2004) and (Dees et al., 2007), which assume that the variables in the country- specific models are integrated with order one. The GVAR model embeds the unit root test analysis with the following hypothesis - H_0 : Panel data has unit roots; H_1 : Panel data has no unit roots (panel is stationary). Unit root is necessary to check that no variable

is I (2). Using the 5 percent level of significance, if the test statistic is more negative than the critical value, then the hypothesis of no unit root is rejected. The lag selection considered by the GVAR model is the Aikake Information Criterion (AIC), with a test having a maximum lag order of 4.

The study first performed unit root testing using Augmented Dickey-Fuller (ADF) tests on the level, first, and second differences of all country-specific domestic, foreign, as well as global variables in the GVAR model. The advantage of using the ADF test is that it can be used with serial correlation and can handle more complex models than the Dickey-Fuller test, while also being more powerful than the latter test (Mushtaq, 2011). In order to take into account the power properties of the unit root test, the study also made estimations using the weighted symmetric ADF test (WS-ADF) introduced by Park and Fuller (1995), which has better power properties than the ADF test. The results of both the ADF test and the ADF-WS test on the level, first, and second differences of all the variables (domestic, foreign, and global), indicate that the variables in the model are at I (1); this suggests that while the hypothesis of non-stationarity is rejected at level, it is accepted at first difference. Thus, it is assumed that all our variables are suitable for the estimation of GVAR. Application of the two tests provides room for crosschecking accuracy and comparison to ensure consistency. The results are presented in Appendix 4, Appendix 5, and Appendix 6, for domestic, foreign, and global variables, respectively. The results from the unit root test are in line with economic theory, as macroeconomic variables of order one are generally integrated.

3.3.7 Choice criteria for selecting the order of the VARX*

After the variables to be included in the different country models are specified, cointegration is done; initially we begin by choosing the order of VARX*(p_i, q_i). Appendix 8 of this study represents the results of the choice criteria for the selection of the lag order, which are considered in the models after identifying the results. The AIC and Schwartz Bayesian Criterion (SBC) were used to select lag order for each country-specific VARX* models, with the lag order of domestic variables and foreign variables being (p_i) and (q_i), respectively. Due to limited data availability constraints, this study gave lag order 1 to all the foreign variables (q_i), as adopted in the study by (Rakotonirainy et al., 2020). This

study revealed that the maximum lag orders allowed for both (p_i) and (q_i), is 2, with the test results having VARX*(2,1) being satisfactory for most countries except for China, the Eurozone, and India. The results also contain choice criteria for selecting the order of the VARX* models, together with corresponding residual serial correlation, F-statistics.

3.3.8 Cointegration of test results

The GVAR model estimation generates the rank of the cointegration analysis and the relationship between the VARX* models, as detailed in Appendix 9. This study revealed that the number of cointegration relation was 2 for China, India, the UAE and the USA; 1 for the Eurozone, South Africa, and Tanzania; and 3 for Kenya.

The rank for generating the cointegration is obtained using the Johansen's trace, and the results following the trace and maximal Eigen-value statistics, as described by (Pesaran et al., 2000). This is a robustness check that tests for the stability of the variables, to ensure that in long-term relationships, spurious regression problems are avoided. This study also tests for critical values using trace statistics at the 95 percent confidence interval, with the lag selected by AIC, for which the models' critical values with weakly exogenous variables are sourced from MacKinnon et al. (1999).

3.3.9 Testing for weak exogeneity in GVAR

When using the GVAR model for estimation, the main assumption for the construction of country specific foreign models, is weak exogeneity with respect to co-integrating relations. In this case, country-specific foreign variables and global variables are seen as being long run, forcing the domestic variables p_i ; thus these are conditional to the long-run parameters of the conditional models, with the study following the procedure as described by Johansen (1992) and Harbo et al. (1998). In line with the procedure by Dees et al. (2007), this test is based on the assumption of joint significance of the estimated error correction terms in auxiliary equations, for the country-specific foreign variables x_{it}^* . For each of the i^{th} element of x_{it}^* , the following regression model is carried out:

$$\Delta x_{it,l}^* = a_{il} + \sum_{j=i}^{r_i} \delta_{ij,l} ECM_{i,t-1}^j + \sum_{s=1}^{p_i} \phi'_{is,l} \Delta x_{i,t-s} + \sum_{s=1}^{q_i} \delta'_{is,l} \Delta x_{i,t-s}^* + \varepsilon_{it,l} \quad (3.3.7)$$

Where $ECM_{i,t-1}^j$, $j = 1, 2, \dots, r_i$ are the estimated error correction terms corresponding to the r_i co-integrating relations found for the i^{th} country model, and p and q are the order of lag for changes in both domestic and foreign variables. The weak exogenous test is an F-Statistic of the joint hypothesis such that $\delta_{ij,l} = 0$, $j = 1, 2, \dots, r_i$, in view of the above regression (4.1). When the indicated value is larger than the critical value, it is rejected at 5 percent, implying that the hypothesis is not accepted. *Table 3.3* displays the results with the F-Statistic: out of 64 cases, 11 are found to be significant at the 5 percent significance level. The weak exogenous tests are rejected for GDP (ys) in India and Tanzania, inflation (Dps) in Kenya and the USA, short-term interest rate (rs) in China and the USA, non-performing loans (npls) for South Africa, raw material price (pmat) in China and the USA, and metal price (pmetal) in South Africa and Tanzania. Since the majority of the weak exogeneity tests are rejected, the tests suggest that the key assumptions that underlie the GVAR modelling are not generally violated.

Table 3.3: F-Statistics for testing Weak Exogeneity at the 5% significance level

| Country/Region | F test | Fcrit_0 .05 | ys | Dps | eps | rs | npls | Poil | pmat | pmetal |
|----------------|--------------|-------------|--------------|--------------|-------------|--------------|--------------|-------------|--------------|--------------|
| CHINA | F(2,1 60) | 3.0525 3 | 0.131 62 | 0.870 37 | 1.547 82 | 3.239 85* | 0.889 62 | 1.237 63 | 5.711 85* | 1.606 96 |
| EURO | F(1,1 61) | 3.8998 7 | 1.220 96 | 1.538 71 | 0.007 52 | 0.851 98 | 0.501 20 | 0.004 33 | 0.429 88 | 0.474 69 |
| INDIA | F(2,1 60) | 3.0525 3 | 4.585 31* | 0.401 94 | 1.933 18 | 0.041 79 | 0.565 82 | 0.507 24 | 1.864 68 | 2.064 13 |
| KENYA | F(3,1 59) | 2.6614 7 | 1.135 79 | 3.469 85* | 0.148 83 | 0.346 71 | 0.139 10 | 0.771 63 | 2.022 32 | 1.698 89 |
| SOUTH AFRICA | F(1,1 61) | 3.8998 7 | 0.061 60 | 2.825 01 | 0.015 18 | 3.409 30 | 8.478 07* | 1.190 25 | 0.243 67 | 3.982 54* |
| TANZANIA | F(1,1 61) | 3.8998 7 | 8.551 48* | 0.286 12 | 2.434 92 | 2.235 05 | 0.112 05 | 1.322 04 | 2.885 56 | 7.199 23* |
| UAE | F(2,1 60) | 3.0525 3 | 0.650 45 | 1.516 32 | 0.688 73 | 0.673 87 | 1.426 64 | 1.239 10 | 2.425 13 | 2.981 77 |
| USA | F(2,1 60) | 3.0525 3 | 0.487 51 | 3.593 85* | 0.507 65 | 3.758 54* | 2.363 56 | 1.025 73 | 5.460 43* | 0.945 17 |

Source: Author's own computation (2023)

3.3.10 Structural stability test

The GVAR model also facilitates testing for structural breaks and parameter stability. A structural break is usually when there is an abrupt change at a point in time that occurs in a time series. These structural breaks are where the distribution of the relevant likelihood ratio λ for model parameters were analyzed, on the basis of the empirical distribution resulting from some sampling experiments (Quandt, 1960). The structural break test was conducted to assess the presence of breaks in the sample chosen for this study.

This study has conducted both parameter stability as well as Walt tests. Parameter stability tests are maximum OLS cumulative sum (CUSUM) statistics created by Ploberger and Krämer (1992), and are denoted PKsup with their mean variance PK msq, while using Nyblom (1989) tests for the parameter constancy against non-stationary alternatives. Andrews and Ploberger (1994) showed the sequential Walt test of a one-time structural change at an unknown point. The results of the structural break are shown depicting the period when the breaks occurred, as shown in Table 3.4, where the structural breaks for real GDP occurred at different periods, thus reflecting that countries behave differently across the globe.

Table 3.4: Structural Stability Tests: Break Dates for QLR Tests

| Variables | y | Dp | ep | r | npl |
|--------------|---------|--------|---------|---------|---------|
| CHINA | 2013M10 | 2008M6 | 2015M7 | 2008M11 | 2011M2 |
| EURO | 2014M4 | 2018M1 | 2013M5 | 2013M12 | 2014M1 |
| INDIA | 2010M1 | 2010M3 | 2008M9 | 2010M7 | 2015M12 |
| KENYA | 2012M1 | 2008M5 | 2008M5 | 2011M10 | 2015M12 |
| SOUTH AFRICA | 2010M1 | 2009M6 | 2008M5 | 2009M6 | 2010M2 |
| TANZANIA | 2016M1 | 2009M1 | 2008M11 | 2011M9 | 2016M12 |
| UAE | 2009M1 | 2008M9 | 2008M8 | 2008M11 | 2014M8 |
| USA | 2010M8 | 2010M3 | 2008M8 | 2018M8 | 2009M10 |

Source: Author's own computation (2023)

3.3.11 Contemporaneous effects

Another estimation undertaken by the GVAR model consists of the contemporaneous effects of the foreign variables on their domestic counterparts. Contemporaneous effects show how each country is affected by the combined effect of the same variables from other countries. In the same way as conducted by Khan (2020), this study considers the coefficient, Newey-West heteroscedasticity, and auto-correlation consistent t-ratios, of which the results are represented in Table 3.5. The results can be viewed as impact elasticity and show how interconnected the countries are to each other. The results of the coefficients show the responses of a domestic country's variables to a 1 percent change in their foreign counterparts. On the one hand, a 1 percent increase in the GDP (y) of the rest of the countries (foreign growth), leads to a 0.78 percent increase in China's growth in the domestic economy. The same 1 percent increase in the rest of the countries' GDP leads to a 1.14 percent increase in Tanzania's growth. On the other hand, the same 1 percent increase results in a decline of 0.09 percent and 0.41 percent in domestic growth in Kenya and India, respectively. An appreciation in the foreign exchange rates leads to an appreciation in growth in India, South Africa, and Tanzania, while a depreciation in growth can be seen in China, the Eurozone, Kenya, and the UAE.

A study by Wei and Zhang (2005) adopted the Newey-West heteroscedasticity and auto-correlation consistent t-ratios to assess the relationship between variables, as the sample in this study is large. The merit of this test is that it controls residual issues in the model and improves its robustness, when it comes to hypothesis testing and the precision of estimates (Newey & West, 1986). Therefore, this study has also taken into account the Newey-West heteroscedasticity and auto correlation consistent t-ratios, where the results show that all the countries are fairly interlinked. The results show that growth (y) and NPLs had more significant contemporary effects compared to other factors looking at in this chapter.

Table 3.5: Contemporaneous Effects of Foreign Variables on Domestic Counterparts

| Country/Region | | y | Dp | ep | r | npl |
|----------------|-------------------|----------------|----------|-----------|----------|----------------|
| CHINA | Coefficient | 0.78144 | -0.18914 | -0.13011 | 0.16403 | 0.53793 |
| CHINA | t-ratio_NeweyWest | 6.90619 | -0.97149 | -2.53040 | 1.38757 | 8.59928 |
| EURO | Coefficient | 1.48699 | 0.03036 | -2.49378 | -0.02450 | 0.27906 |
| EURO | t-ratio_NeweyWest | 5.51075 | 0.33240 | -21.18890 | -0.12472 | 2.90752 |
| INDIA | Coefficient | -0.40964 | -0.49844 | 0.04751 | 0.57533 | 0.66287 |
| INDIA | t-ratio_NeweyWest | -1.36328 | -2.31639 | 2.34691 | 2.53860 | 2.51136 |
| KENYA | Coefficient | -0.09377 | 0.91248 | -0.01298 | 0.35707 | 3.90076 |
| KENYA | t-ratio_NeweyWest | -0.53447 | 1.79568 | -1.16029 | 1.24108 | 4.59076 |
| SOUTH AFRICA | Coefficient | 0.45304 | 0.28393 | 0.08245 | -0.30153 | 0.55740 |
| SOUTH AFRICA | t-ratio_NeweyWest | 2.12844 | 2.61437 | 1.07415 | -1.39333 | 2.62916 |
| TANZANIA | Coefficient | 1.14582 | 0.40603 | 0.00012 | 0.06484 | 0.38998 |
| TANZANIA | t-ratio_NeweyWest | 6.67020 | 1.83321 | 0.12721 | 0.33123 | 0.64391 |
| UAE | Coefficient | 2.35946 | 0.02516 | -0.66090 | 0.08388 | 0.29610 |
| UAE | t-ratio_NeweyWest | 5.63399 | 0.16349 | -6.88803 | 0.64495 | 2.53519 |
| USA | Coefficient | 0.06892 | 0.00454 | -1.24520 | 0.13258 | 0.09074 |
| USA | t-ratio_NeweyWest | 1.54298 | 0.08889 | -20.11767 | 1.32048 | 2.26675 |

Source: Author's own calculation (2023)

3.3.12 Pair-wise cross-section correlations

One of the key assumptions of the GVAR model estimation, is that the idiosyncratic shocks of the individual country models should be weakly correlated cross-sectionally. This is similar to the cross-sectional dependence as conducted by (Pesaran et al., 2004). This implies that the covariance between the foreign variables and the error terms of the VARX* model are zero, as the number of countries in the model approaches infinity, and thus the weak exogeneity of foreign variables in the model is established. The average pair-wise cross-section correlations are also important for common factor interdependencies and international co-movements of business cycles.

Appendix 9 presents the results using levels, first difference, and the estimated residuals of the VECMX*. The results show that the cross-section relations are high for the level, followed by first difference, and then residual. At a level analysis, inflation (Dp) results showed the highest cross-section correlation of about 94 percent to 99 percent, followed by growth (y) that ranged from 20 percent to 80 percent, exchange rate (ep) ranging from -40 percent to 20 percent, interest rates (r) ranging from -35 percent to 30 percent, and non-performing loans (npls) ranging from -25 percent to 30 percent. The first difference depicts a wide difference among the variables implying that banks vary in their credit risk exposure.

The average pairwise cross-country correlation of residuals is observed to be smaller compared to level and first difference. Other than exchange rate shock for all countries, that depicted a residual value of more than 0.1 percent, the rest of the shocks show very low residual correlation. On individual analysis, out of the 40 computed correlations, 11 are in the range of 8 percent to 50 percent, 10 are in the range of 0 percent to 7 percent, and 10 are in the range of -14 percent to 0 percent; this suggests that most of the individual shocks are not much affected by other shocks in the GVAR model applied in this study.

3.3.13 Dynamic (impulse response) analysis

The dynamic analysis in the GVAR model relies strongly on the concept of generalized impulse response functions (GIRFs), to trace out the dispersion of shocks to macroeconomic variables across countries. Inference by definition is a conclusion reached on the basis of evidence and reasoning, and in terms of impulse response analysis, it is a judgment of the sign and significance of a given response based on confidence intervals. The GIRFs and the variance decompositions can show what happened to a variable when there was a positive or negative shock in the error term. In spite of its convenient features, it can be argued that shocks in GIRFs are not orthogonal, and therefore the origins of the shocks are difficult to interpret economically. The usage of GIRFs provides the advantage of providing invariance to the ordering of variables and countries.

This study focuses on assessing the domestic impact of GDP, inflation, exchange rate, and short-term interest rate on Tanzania. From a global analysis, it looks at the impact of

a negative shock on raw materials, oil, and metals. In terms of an analysis of foreign variables, it looks at the impact of a negative shock from the macroeconomic environment of Tanzania's seven major trading partners (the USA, the Eurozone, the UAE, South Africa, Kenya, China, and India). The GIRF for a single country shock can be represented as:

$$w_{\varepsilon j}(h) = E \left(\frac{x_{t+y}}{\varepsilon_{jt}} = \sqrt{\sigma_{jj}}, I_{t-1} \right) - E \left(\frac{x_{t+y}}{I_{t-1}} \right), = \frac{Z_y G_0^{-1} \sum e_j}{\sqrt{e_j \sum e_j}} \quad (3.3.8)$$

$w_{\varepsilon j}$ is the general impulse response function, at period y , in a $k \times 1$ vector, where j represents the country index of the respective country. The E outside the parenthesis is the expectation with respect to the VAR model. Within the parenthesis is the vector of x_t at period h , once a shock of ε_{jt} is felt, at time period t by country j . The expectation is equal to the square of the shocks, at size σ_{jj} . I_{t-1} is the information at $t-1$, which has been defined as the collection of vectors x_t at period $t-1$. Z_y is a vector $k \times k$ G_0^{-1} linking the variables together, as the summation of the Cholesky factor. e_j is a vector that selects the element of the shocks.

The impulse response functions of global shocks vary slightly, with a slight variance in a country from a global shock being mathematically expressed in equation 3.3.9. The difference is ε_{jt} , rather than $\varepsilon_{m,t}^g$, which can be rewritten as $m' \varepsilon_t$, with m being the vector of weights linked to the global economy or region.

$$w_{\varepsilon j}(h) = E \left(\frac{x_{t+y}}{\varepsilon_{m,t}^g} = \sqrt{m', \sum m} I_{t-1} \right) - E \left(\frac{x_{t+y}}{I_{t-1}} \right), = \frac{R_y G_0^{-1} \sum m}{\sqrt{m' \sum m}} \quad (3.3.9)$$

The functions analysis of impulse response forms the core of the GVAR model, where bootstrapping is used to define the upper and lower bounds, as defined by the confidence interval which is 90 percent in this study. Bootstrapping is a method which approximates the model, and is repeated continuously until the solution is stable (Dees et al., 2007). Moving from the previous sections that showed how we solved the GVAR model for impulse functions, the model is comprised of a large number of unit-specific models, in this case countries, that are estimated by a VARX* model.

The course of dimensionality is overcome by estimating the country-specific, error-correcting models separately, and is conditional on foreign variables, which are treated as weakly exogenous (Pesaran et al. (2004) and tested; the results are displayed in Table 3.4 Dees et al. (2007) show that the US has been treated differently considering its global importance. Country-specific models are simultaneously solved for all endogenous variables in the global model.

3.4 GVAR empirical results

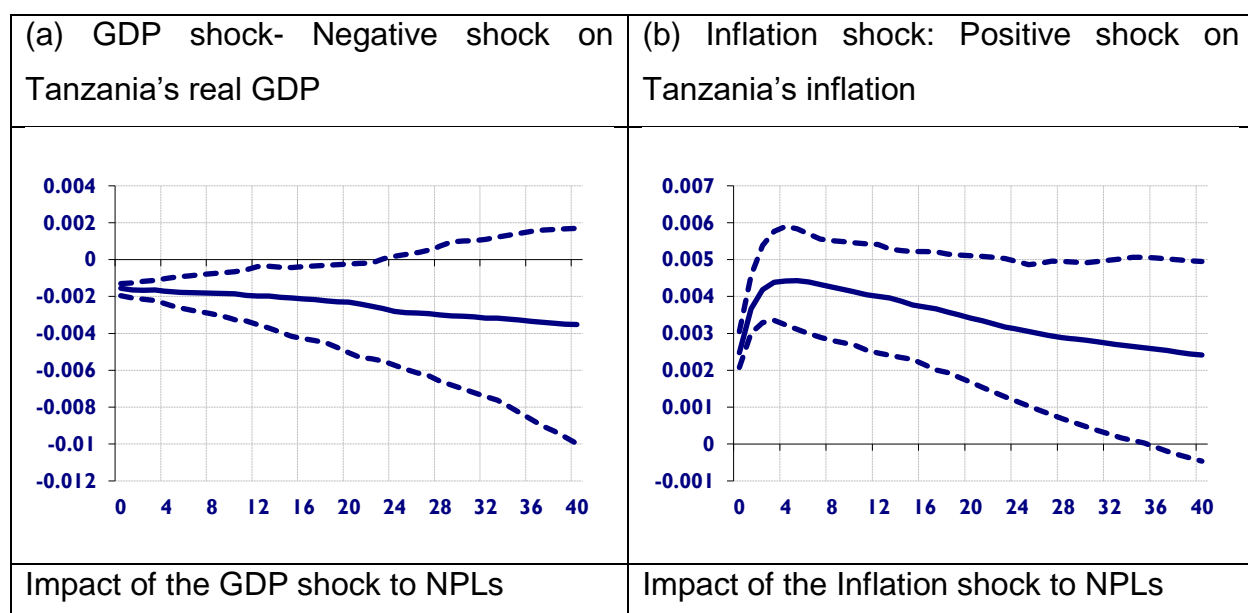
In this chapter, a macro credit risk stress test was conducted to assess the impact of both domestic and foreign macroeconomic shocks, as well as global shocks, on the banking sector, using credit risk as a proxy. The results are presented in the form of GIRFs, in which impulse response functions show the effects of shocks on the adjustment path of the variables. Therefore, the findings of this study focus on the stress scenarios using: one standard error shock on domestic macroeconomic and financial variables; and global variables as well as a group of foreign variables, which are all seven major trading partners included in the model, affecting credit risk. The results provide a measurement of the reactions compared with the baseline scenario. The bootstrap results show that the aggregate NPLs' reaction in Tanzania is within the confidence interval of 95 percent.

3.4.1 Impact of domestic macroeconomic shocks on NPLs

The results reveal the response of Tanzanian NPLs to the impacts of negative GDP shock, positive inflation, exchange rate, and interest rate shocks in the country's economy. The results are of the response of one standard positive error shock to Tanzania's real GDP, and correspondingly of how this affects NPLs from the period of M12:2020 (represented by 0), to the final month (represented by 40) of a 40-month forecast period. The results refer to bootstrap median estimates with 90 percent bootstrap error bounds, and reveal that the negative shock over the period depicts a decline in domestic real GDP(y) of 0.00352 percent; this is observed in the 40th month of the forecast, as shown in Figure 7(a). This decline in y over the time horizon of the forecasts is transmitted into the Tanzanian banking sector's NPLs, by first revealing an increase in y in the first five months, followed by a continuous decrease in y , beginning in M6:2021, to a low of 0.00064

percent observed in the 32nd month. However, the NPLs' reaction is within the confidence interval of 95 percent. This reflects that GDP has a slight impact on NPLs in the long term, since GDP growth in Tanzania is not directly reflected in banks' balance sheets, given that close to 70 percent of the GDP is financed by the informal sector not the banking sector. The GDP shock results in this chapter slightly depart from the arbitrage pricing theory, as attested by Pesaran et al. (2006). In addition, the findings are contrary to the studies by Rakotonirainy et al. (2020) and Vazquez et al. (2012), where their findings showed that domestic GDP shocks have a significant impact on credit risk in the short term.

Meanwhile, Figure 8(b) plots a positive standard error shock that leads to an increase in inflation over the 40-month forecast horizon, to 0.0024 percent in the 40th month. The increase in inflation consequently leads to a corresponding increase in NPLs right from the beginning of the forecast horizon to its 40th month ending. The results suggest that out of the two selected macroeconomic variables in Tanzania, real GDP growth and inflation, it can be noted that inflation is transmitted more quickly to NPLs in the banking sector compared to GDP growth, given the lag of the reaction as well as the price reflection in consumers' purchasing power. These findings of the impact of inflation shock is in line with the findings of (Amel, 2018) and Abdolshah et al. (2020), where credit risk is affected in the short term by changes in the inflation rate.



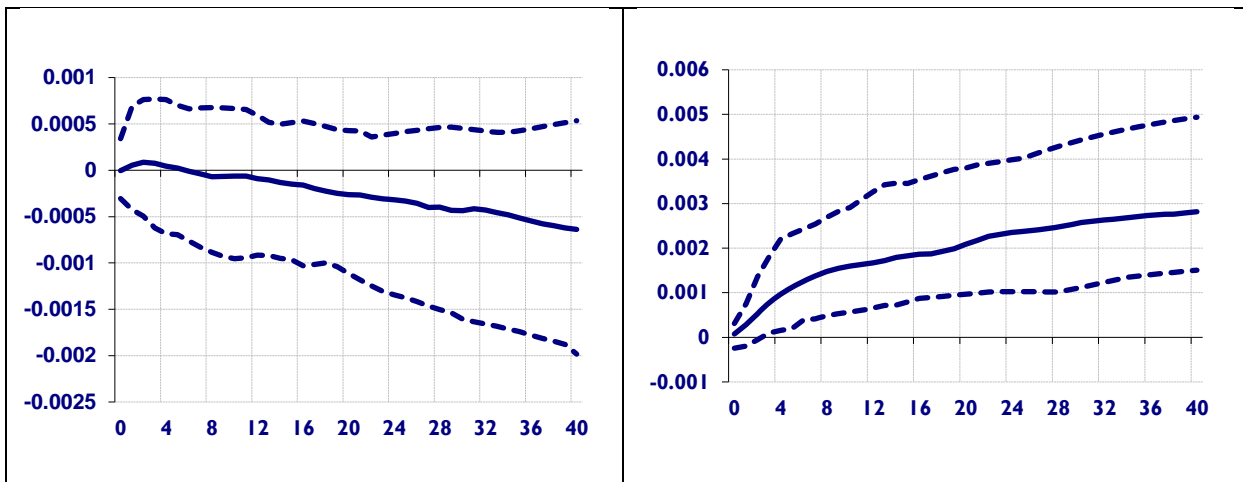


Figure 3.1: Generalised Impulse responses of selected domestic-macro economic variables shock and impact on NPLs

Source: Author's own estimation (2023) of computation of GVAR (bootstrap median estimates with 90 percent error bounds)

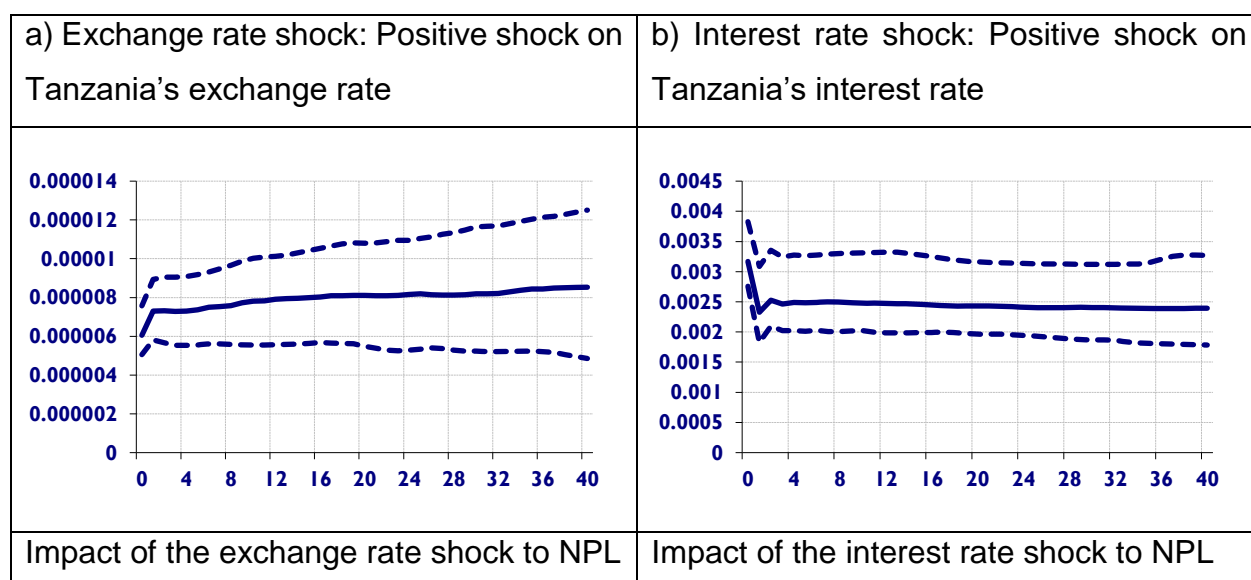
Subsequently, for conducting a stress test, the scenario for exchange rate depends on a positive shock of one standard error in the exchange rate, and the response of the rate itself and its transmission to a bank's balance sheet through NPLs.

The impact of domestic shocks is found, first by assessing how one standard error affects the exchange rate and interest rate, and later how it affects NPLs. *Figure 3.2* where the results refer to bootstrap median estimates with 90 percent bootstrap error bounds, a one standard error positive shock on exchange rate led to a 0.0000085 percent increase in exchange rate by the 40th month of the forecast. The positive shock of the exchange rate resulted in a positive impact to NPLs from the first month the 23rd month of the forecast, with a 0.000013 percent decrease in NPLs; later, an increase of 0.00020 percent in NPLs is witnessed from the 24th month to the 40th month of the forecast. These results reveal that the magnitude of credit exposure of Tanzania's banking sector is not significantly related to exchange rate in the short run, but rather responds with a lag of two years.

The foreign exchange loan portfolio of the banking sector accounts for about 30 percent of the total banking sector (Tanzania (2020), while the NPLs in Tanzania usually originate from domestic currency loans rather than foreign currency loans, as attested by the scenario and stress testing results. Since Tanzania operates in its domestic currency and

close to 60 percent of the loan portfolio is denominated by domestic currency, this confirms that the reaction does not have significance. The findings are similar to the results of Havrylchyk (2010), where exchange rate shocks did not affect credit risk in the South African banking sector, but contrary to Castrén et al. (2010), where exchange rate had a significant impact on credit in the Eurozone’s corporate sector.

Figure 3.2(b) displays results of the impact of domestic shocks, first by assessing how a one standard positive error shock affects short- term interest rate, and later how it affects NPLs. The results refer to bootstrap median estimates with 90 percent bootstrap error bounds; the one standard error positive shock on interest rate depicted an increase of 0.002392 percent in the short-term interest rate in the 40th month of the forecast horizon. The positive shock of the short-term interest rate resulted in an increase of 0.0000131 percent in NPLs, from the first month to the 30th month, and later a decline to 0.0000625 up to the 40th month of the forecast. These results reveal that there is not much of a degree of exposure to short-term interest rates. The findings in this study are in line with the findings of Farayibi (2016) and Razafindravonona (2021), where interest rate shock has no significant effect on credit risk in Nigeria’s and Madagascar’s banking sectors, respectively. Nevertheless, The findings in this chapter are contrary to those of Sorge and Virolainen (2006), where interest rate shocks have a significant impact on credit risk in Austria’s banking sector.



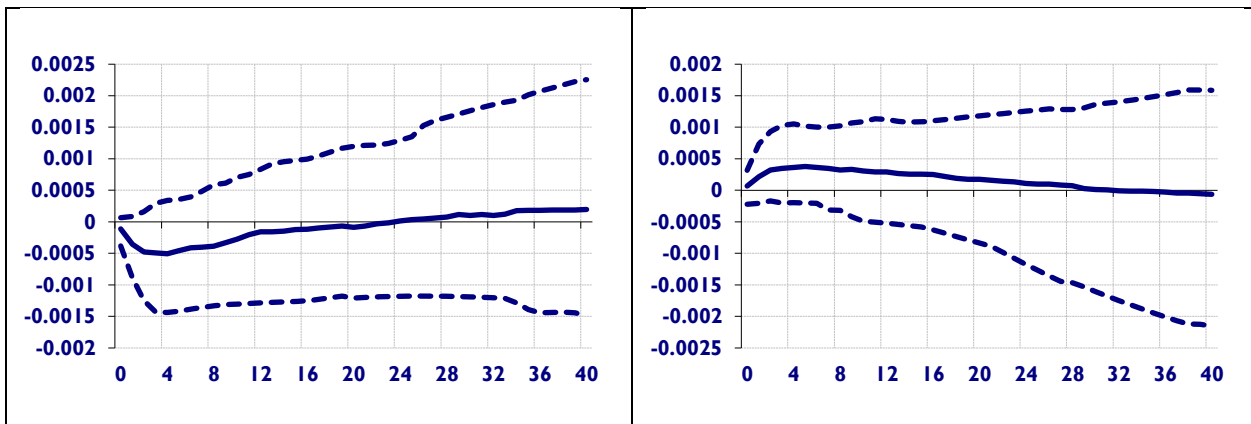


Figure 3.2: Generalised Impulse responses of selected domestic-macro financial variables shock and impact on NPLs

Source: Author's own computation (2023) from GVAR (bootstrap median estimates with 90 percent error bounds)

3.4.2 Impact of global shocks on NPLs

As Tanzania is a net oil importer, the stress scenario that would have a responsive impact has an impact on the performance of the banking sector, which will be based on an increase in oil prices. In *Figure 3.3*, the stress scenario will be a one standard error shock on oil prices from a positive shock to oil prices, signaling a continued increase in price. The results refer to bootstrap median estimates with 90 percent bootstrap error bounds; the response of oil prices from one standard error shock on exchange revealed a continuous increase throughout the forecast horizon, leading to an increase of 0.035 percent by the 40th month of the forecast.

The reaction of NPLs to an oil price shock is reflected right from the first month of the forecast, signaling oil prices' significant impact on NPLs in Tanzania. Oil prices have a substantial spillover effect, due to the interconnectedness of the functioning of the economy being highly dependent on oil, including transport, trade, and therefore rising food prices; later, this translates into decreasing disposable household incomes, due to increased prices, thus lowering repayments of loans. The results agree with other studies where the oil price index affected credit risk with a significant impact (Amel, 2018; Castrén et al., 2010).

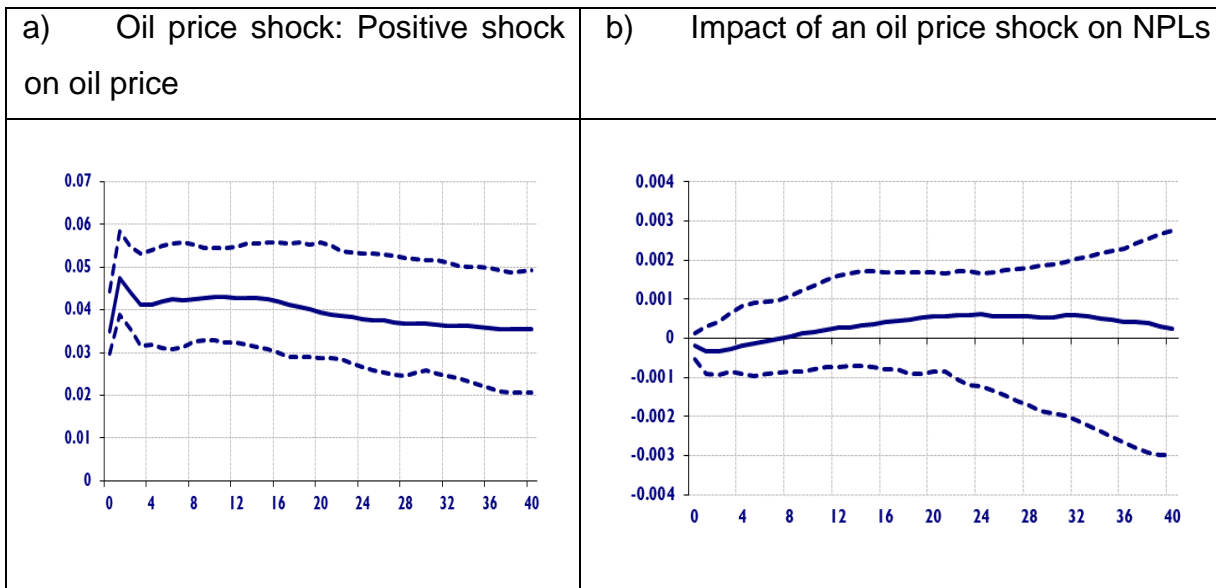


Figure 3.3: Generalised Impulse responses of oil price shock and impact on NPLs
Source: Author's own computation (2023) from GVAR (bootstrap median estimates with 90 percent error bounds)

The agricultural sector contributes to about 30 percent of GDP growth in Tanzania, and accounts for almost 8.0 percent of the share of lending in the banking sector. The existence of the agricultural sector has a spillover effect on related sectors like trade that accounts for about 15 percent, and manufacturing that account for about 9.0 percent as an associated sector thus, the need to assess the impact of raw material prices is significant. *Figure 3.4* displays the results of the impact of one standard error shock on raw material prices, and impact of the latter on aggregate NPLs in Tanzania. The impact of the standard error scenario reflects a short-run response to inflation, compared to GDP which responds in the long run. A one standard error negative shock has a continuous declining effect on raw material prices over the forecast horizon, reducing their price by 0.0088 percent. The simultaneous impact of shock on raw material price reduces the value of NPLs by 0.00075 percent, right from the first month of the forecast horizon to the 40th. The impact of the decline in raw material prices exhibits the direct exposure of banking performance in Tanzania to global changes in raw material prices. The findings are in line with the findings of Havrylchyk (2010), where the raw material price index affected the credit risk of the banking sector in a similar way to macroeconomic variables. Conversely, the findings of the study by Rakotonirainy et al. (2020) are contrary to the

ones in this study, where it was found that the index for raw material prices was not an important factor in impacting credit risk exposure in Madagascar's banking sector.

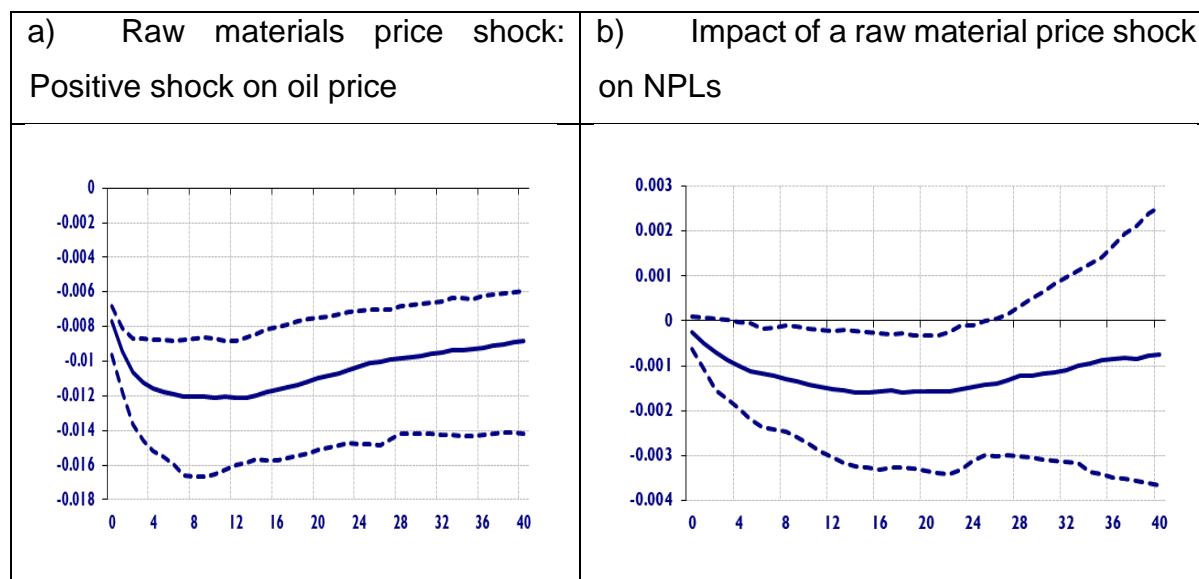


Figure 3.4: Generalised Impulse responses of raw materials price shock and impact on NPLs

Source: Author's own computation (2023) from GVAR (bootstrap median estimates with 90 percent error bounds)

Tanzania is a metal exporting country and expects to obtain revenue this way to assist in the repayment of loans, thus a negative shock on metal prices is expected to have a stressing effect on NPLs. Figure 13 shows the results associated with bootstrap median estimates with 90 percent bootstrap error bounds. A one standard error negative shock impacts metal prices over the forecast horizon, reducing the price by 0.017 percent. The simultaneous impact of shock on metal price reduces the value of NPLs by 0.00054 percent, right from the first month of the forecast horizon to 40th. The impact of a decline in metal prices has a spontaneous transmission on the NPLs in the banking sector in Tanzania, signaling direct exposure of the sector to global changes in metal prices. Thus the results are not different from those in the study by (Rakotonirainy et al., 2020).

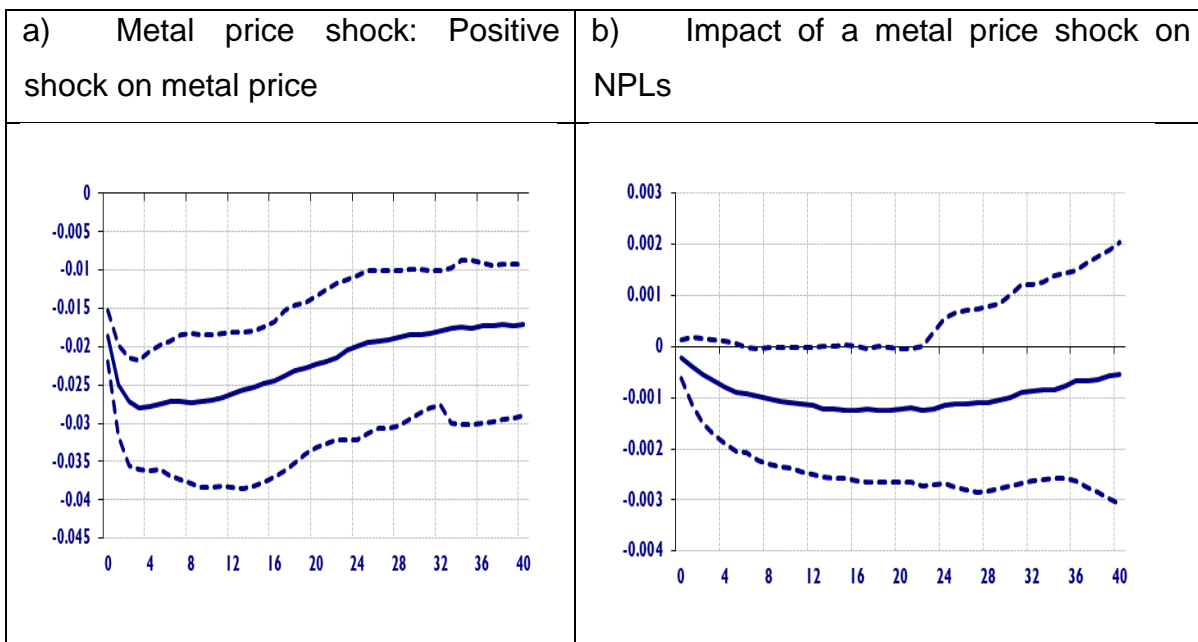


Figure 3.5: Generalised Impulse responses of metals price shock and impact on NPLs
Source: Authors' Own computation (2023) from GVAR bootstrap median estimates with 90 percent error bounds

3.4.3 Impact of foreign countries' shocks on NPLs

Generally, Tanzania is an open economy trading with different countries around the globe, more specifically, as determined by trade statistics, its major trading partners are China, India, the USA, the Eurozone, South Africa, Kenya, and the UAE. The selected countries in this study assist in assessing the extent of exposure to macroeconomic changes in the respective countries, and how they transmit to the domestic macroeconomic variables, later affecting the banking sector through credit risk, as demoted by non-performing loans. The stress scenarios that have been applied to assess the impact on the banking sector of both related macro variables, including real GDP, nominal interest rate, exchange rate, and inflation, as well as of credit risk are denoted by the NPLs ratio in Tanzania. The results derived from the stress scenarios depict that, through the negative shock on real GDP in all the selected countries, the Tanzanian banking sector is more responsive to the USA, China, Kenya, and the UAE in terms of observed increase in the NPLs ratio.

The stress scenario of an interest rate shock on the selected countries resulted in a change in NPLs in the Tanzania banking sector, and the increased forecast change is anticipated to predominantly originate from India, the Eurozone, and Kenya, with China, the USA, and the UAE showing a mixed trend throughout the projected horizon. Selected countries' exchange rate shocks demonstrate a mixed trend in their transmission to the Tanzanian banking sector through the NPLs ratio; notably, the USA depicts a more significant impact compared to the other countries or region. The inflation rate shock originating from the selected foreign countries or regional countries, shows that the Tanzanian banking sector is more responsive to inflation changes in South Africa, the USA, and India compared to those changes in the other countries in the study.

Generally, this signals the close relationship between these countries' performance having a potential spillover effect on the banking sector, in the forecasted period up to 2024. In connection to this, specific macroeconomic variables are assessed to work out which country is anticipated to be more significantly impacted by these in the next 40-period horizon, as detailed below.

3.4.4 Impact of foreign countries' real GDP shocks on NPLs

This sub-section shows the response of a one standard error, negative real GDP shock of the USA, Eurozone, China, India, South Africa, Kenya, and the UAE on Tanzania's real GDP as well as on NPLs. The results presented below refer to bootstrap median estimates with 90 percent bootstrap error bounds, over a 40-month period forecast horizon from January 2022 to December 2022, in the response of Tanzania's real GDP and its impact on the country's NPLs, as detailed in *Figure 3.6*.

In so far as the developed economies' effects on Tanzania, the USA and Eurozone economies' transmissions on the Tanzanian economy and banking sector, are presented next. In response to real GDP shock in the USA, the forecast for is that Tanzania's real GDP shows a decline of 0.000157 percent up to the 11th time horizon, and later a recovery of 0.0067 percent by the 40th time horizon. As for their impact on NPLs, the ratio declined by 2.51 percent up to the ninth time horizon, and later increased by 0.00168 percent up to the last time horizon. This signals that the magnitude of transmission to the real economy is reflected more in the short run, while the impact on the banking sector is

deferred for some period of time, due to a trickledown effect. In so far as the effects from the Eurozone, the forecast is that Tanzania's real GDP is anticipated to decline by 0.00186 percent, with a corresponding decline in the domestic NPL by 0.00179 percent by the 40th time horizon.

In terms of the Asian economies, the transmissions from China and India's economies on the Tanzanian economy and banking sector are presented next. In response to a real GDP shock in China, the forecast is that Tanzania's GDP is expected to decline from the sixth month to 19th month by 0.0000289 percent, then increase, with a corresponding anticipated increase in domestic NPLs of 0.0000124 percent up to the 34th month forecast horizon, followed by a later decrease in these. In the case of India, the forecast is that Tanzania's GDP is expected to decline by 0.000011 percent up to the 22nd month, and the increase thereafter. In the case of the impact of the shock in India's real GDP on Tanzania's NPLs ratio, a decline of 0.0000284 percent is witnessed in the 37th month, followed by an increase thereafter.

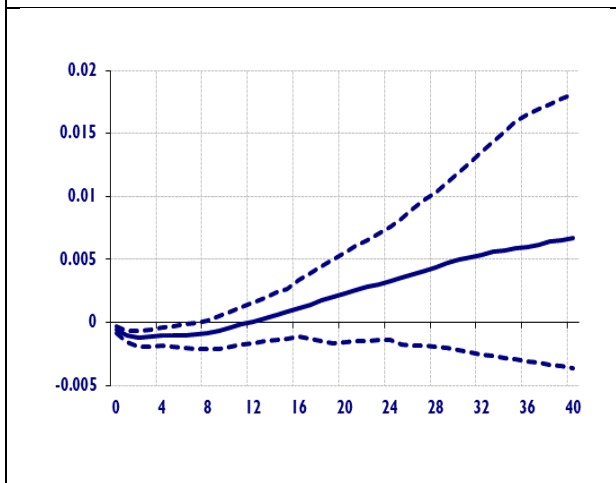
In the context of the African economy, the transmissions of the South African and Kenyan economies on the Tanzanian economy and banking sector are presented next. In response to a real GDP shock in South Africa, the forecast is that Tanzania's GDP is expected to decline to 0.0000339 percent by the 13th month, then increase, with a corresponding anticipated decrease of 6.815209 percent in domestic NPLs by the 27th month followed by a later increase in these. In the case of Kenya, the forecast is that Tanzania's GDP is expected to decline to 0.0000323 percent by the 30th month and later increase, with a corresponding increase of 0.001537 percent on NPLs.

In the context of the Middle East, the UAE's transmission to the Tanzanian economy and banking sector is as follows. In response to a real GDP shock in the UAE, the forecast is that Tanzania's GDP is expected to decline to 0.0001828 percent on the fifth month and later increase to 0.002462 percent, with an increased impact of 0.00002677 percent on domestic NPLs. The results of these findings show a slight difference compared to the ideas described in arbitrage pricing theory (Cetin et al., 2010; Pesaran & Schuermann, 2003), as evidenced in the studies by Pesaran et al. (2006) and Rakotonirainy et al.

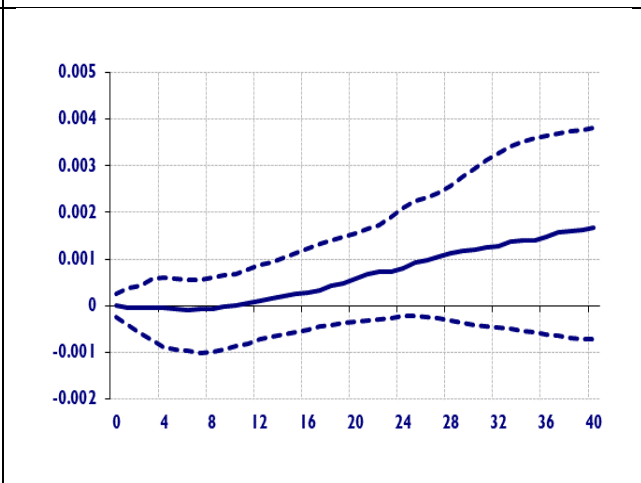
(2020), where the results revealed that credit risk was highly exposed to foreign GDP shocks.

Developed economies

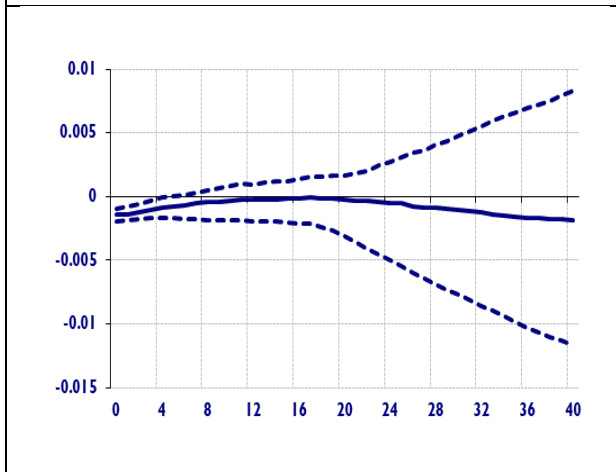
a) USA: Response of Tanzania's real GDP



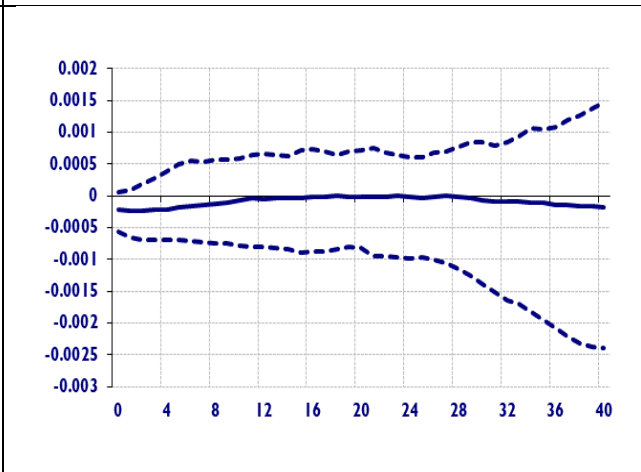
b) USA: Impact on Tanzania's NPLs



c) Eurozone: Response of Tanzania's real GDP



d) Eurozone: Impact on Tanzania's NPLs



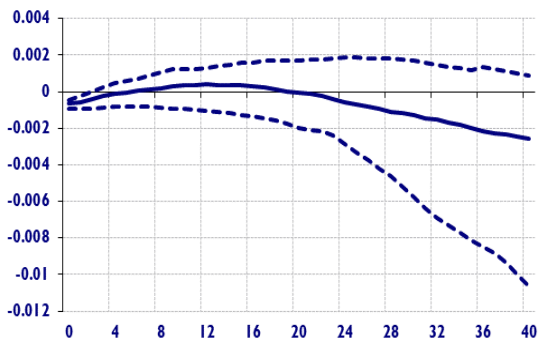
Emerging economies

e) China: Response of Tanzania's real GDP

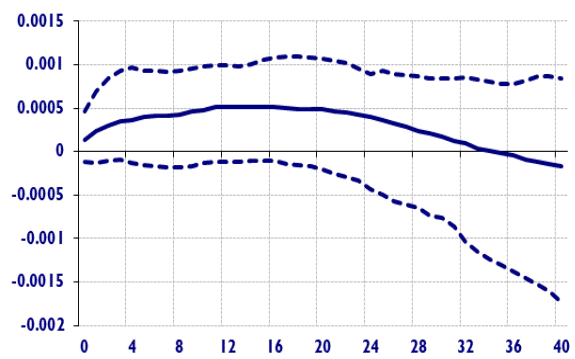


f) China: Impact on Tanzania's NPLs

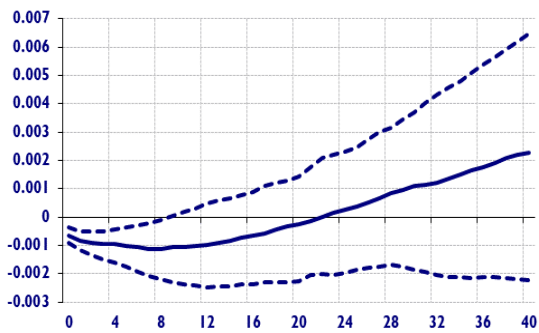




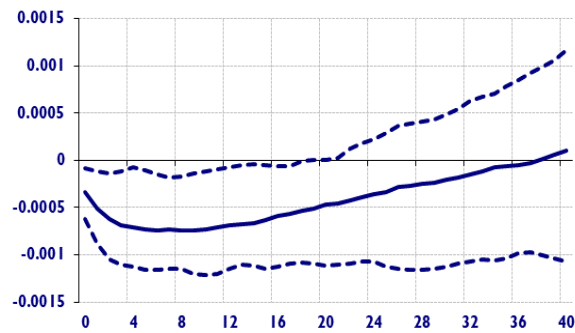
g) India: Response of Tanzania's real GDP



h) India: Impact on Tanzania's NPLs

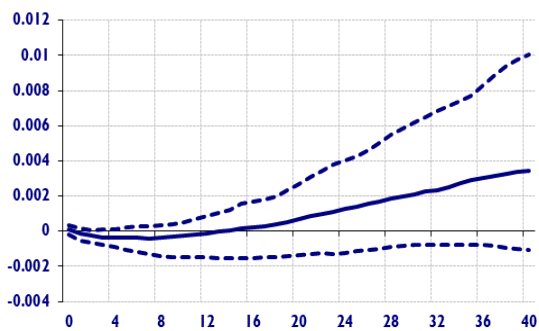


i) South Africa: Response of Tanzania's real GDP

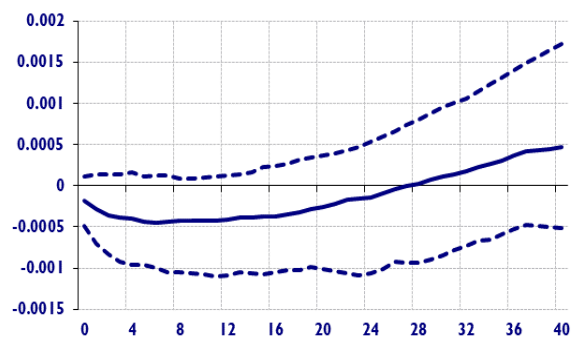


j) South Africa: Impact on Tanzania's NPLs

African countries



k) Kenya: Response of Tanzania's real GDP



l) Kenya: Impact on Tanzania's NPLs

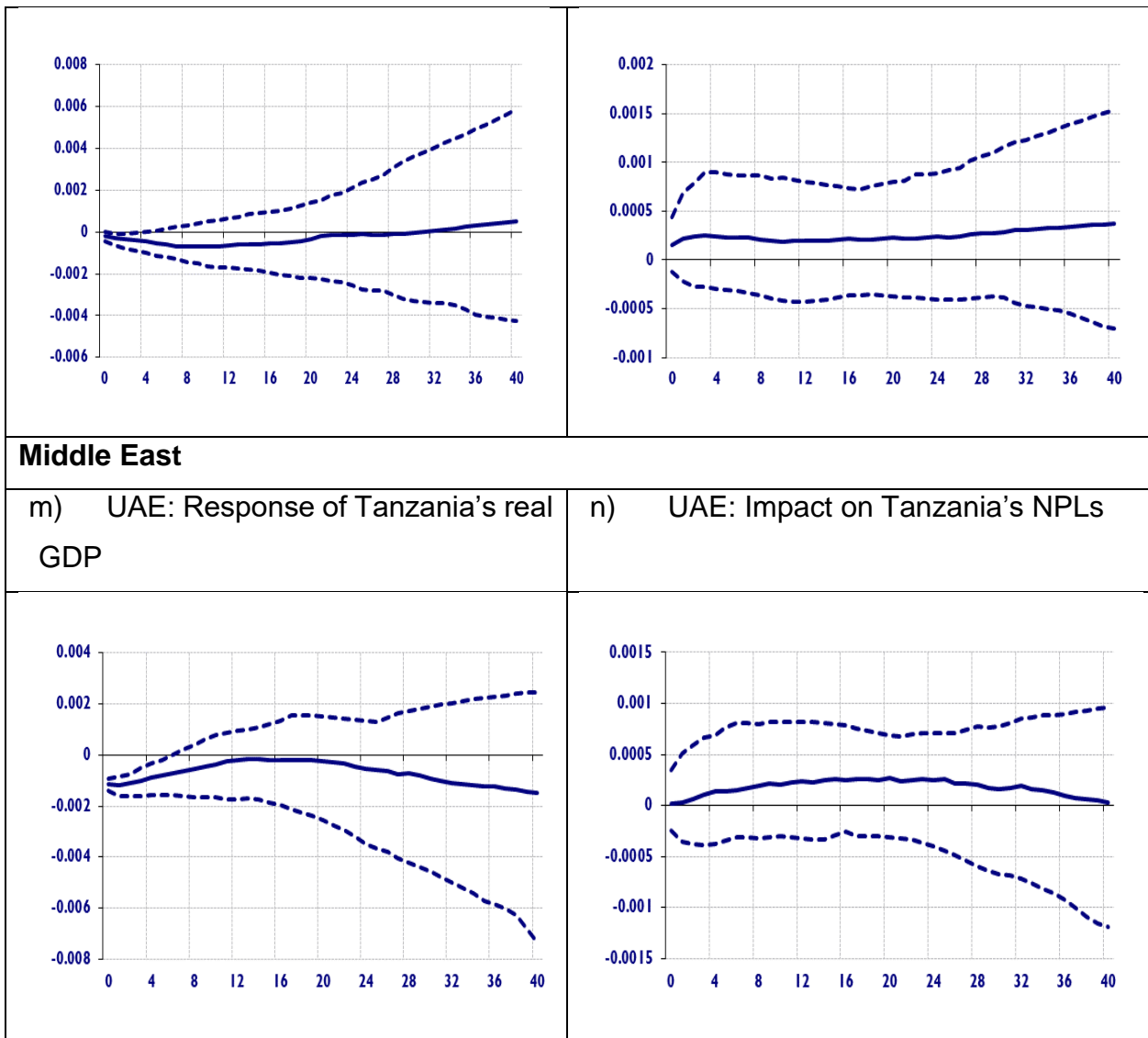


Figure 3.6: Generalised Impulse responses of foreign countries negative GDP shock and impact on Tanzania's NPLs

Source: Authors' Own computation 2023 from GVAR (bootstrap median estimates with 90percent error bounds)

3.4.5 Interest rate exposure from foreign countries

Figure 3.7 denotes the response of a one standard error positive shock of interest rates from the USA, Eurozone, China, India, South Africa, Kenya, and the UAE on Tanzania's interest rate as well as its NPLs. The results refer to bootstrap median estimates with 90 percent bootstrap error bounds, with a 40-month period forecast horizon from January 2022 to December 2022, in the response of Tanzania's short-term interest rate and its

impact on Tanzania's NPLs. In terms of the developed economies, the USA and Eurozone economies' transmissions on the Tanzanian economy and banking sector are presented next. In response to an interest rate shock in the USA, the forecast is that the Tanzanian interest rate will increase by 9.5928027 percent up to the 23rd time horizon, and later increase to 0.0001456 percent by the 40th time horizon. As for impact on NPLs, the ratio continues to increase to 0.00003089 percent in the 25th month horizon of the forecast, and then decline to 0.0007440 percent by the 40th time horizon.

This signals that the magnitude of transmission to the real economy is reflected more in the short run, while the impact on banking sector is not reflected for some period of time, due to a trickledown effect. In the Eurozone, the forecast is that the Tanzanian interest rate is anticipated to decline by 0.00003039 percent, followed by a corresponding decline of 0.00003685 percent in domestic NPLs, and later an increase of 0.002628 percent by the 40th time horizon. Notably, the Tanzanian interest rate is more responsive to changes in the USA than in the Eurozone, and on a similar note, the implication to credit risk is also paramount.

The results for the transmission of the Asian economies, represented by the Chinese and Indian economies, on the Tanzanian economy and banking sector, are shown in Figure 16. In response to an interest rate shock in China, the forecast is that Tanzania's interest rate is expected to increase by 0.00002544 percent by the 24th month, and later decline by 0.0003361 percent by the 40th month. This comes with an anticipated corresponding increase of 0.00002540 percent in domestic NPLs up to the 21st month forecast horizon, and later decline up to the 40th month. In the case of India, the forecast is that Tanzania's interest rate is expected to increase by 0.000314109 percent. The corresponding response on NPLs is an increase of 0.000848579 percent.

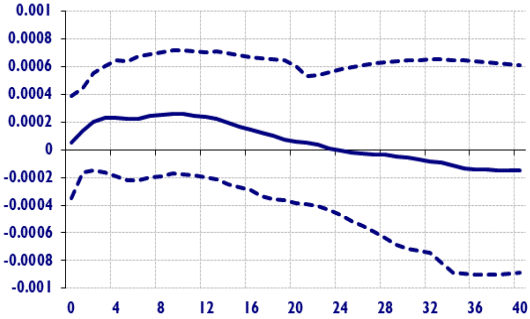
In the African economy context, represented by the South African and Kenyan economies, the transmission to the Tanzanian economy and banking sector are the following. In response to an interest rate shock in South Africa, the forecast is that Tanzania's short-term interest rate is anticipated to decline throughout the 40-months horizon, with an anticipated corresponding increase in domestic NPLs. In the same way, in response to

shocks to Kenya's interest rate, the forecast is that Tanzania's interest rate is expected to increase by 0.0001392 percent by the 40th month, with a corresponding impact on NPLs, with an increase of 0.002026 percent. This signals that changes in interest rates in the selected African countries, have a direct impact on both the domestic interest rate as well as the credit exposure.

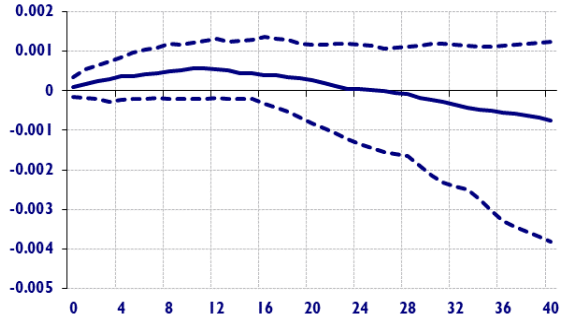
In the context of the Middle East, the UAE's transmission to the Tanzanian economy and banking sector is as follows. In response to a nominal interest rate shock in the UAE, the forecast is that Tanzania's short-term interest rate is expected to increase by 0.000116197 percent, with an increased impact of 0.00002677 percent on domestic NPLs.

Developed economies

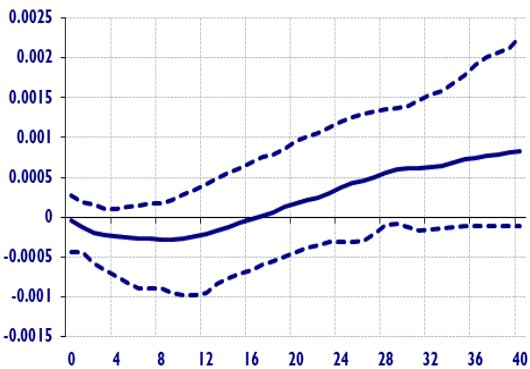
a) USA: Positive shock on nominal interest rate



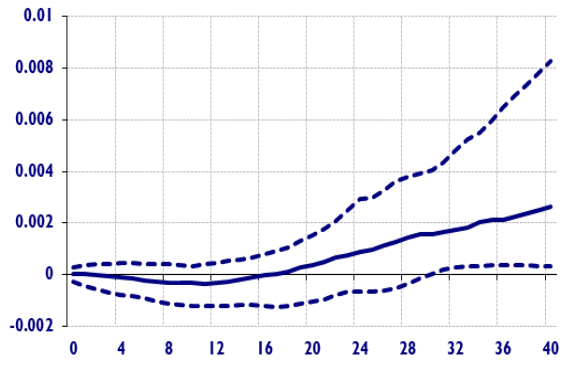
b) USA: Impact on Tanzania's NPLs



c) Eurozone: Positive shock on nominal interest rate



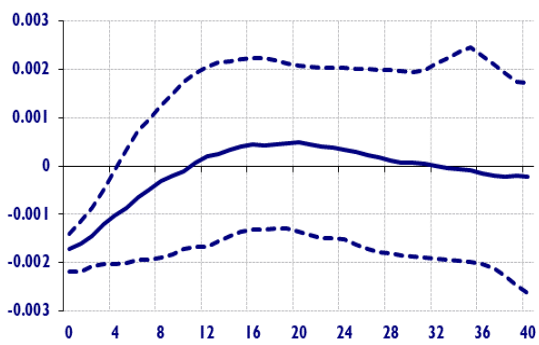
d) Eurozone: Impact on Tanzania's NPLs



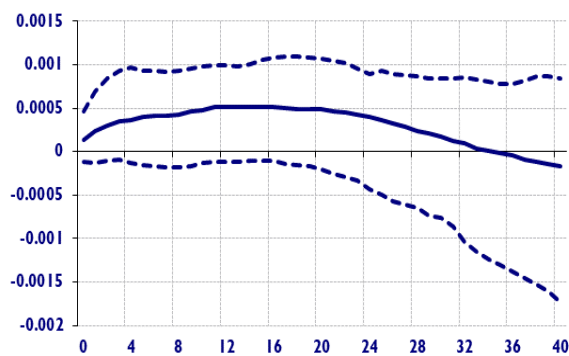
Emerging economies

e) China: Positive shock on nominal interest rate

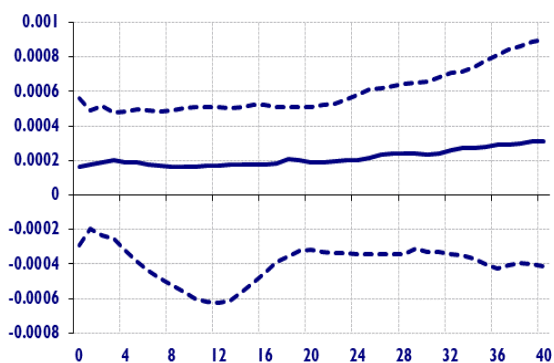
f) China: Impact on Tanzania's NPLs



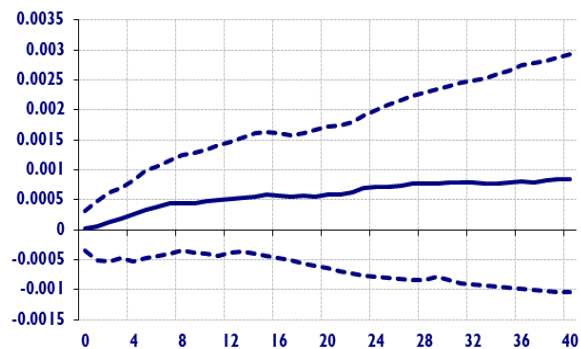
g) India: positive shock on nominal interest rate



h) India: impact on Tanzania NPLs

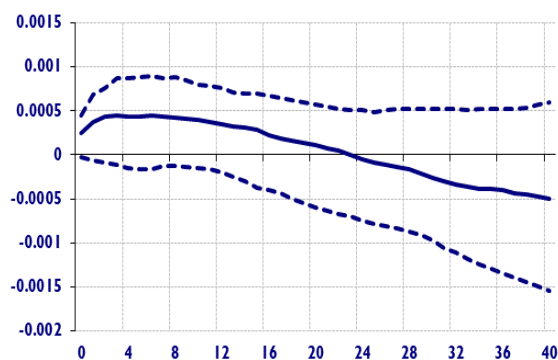
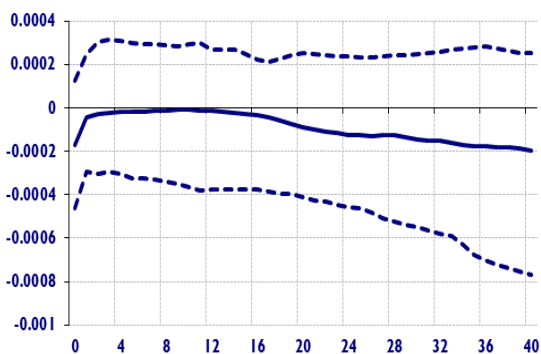


i) South Africa: Positive shock on nominal interest rate



j) South Africa: Impact on Tanzania's NPLs

African countries



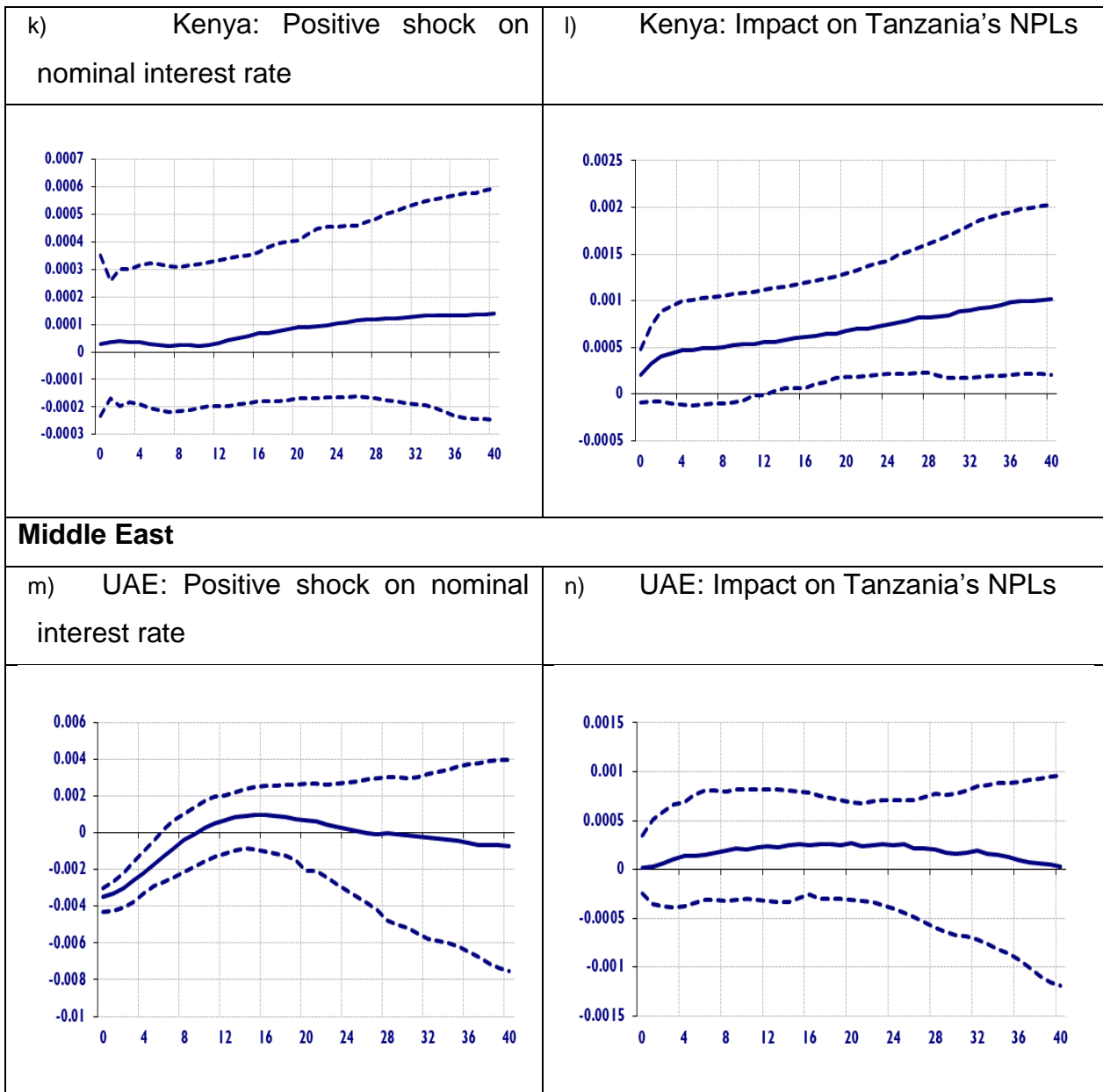


Figure 3.7: Generalised Impulse responses of foreign countries positive nominal interest rate shock and impact on Tanzania's NPLs

Source: Authors' Own computation (2023) from GVAR (bootstrap median estimates with 90 percent error bounds)

3.4.6 Exchange rate exposure from foreign countries

Figure 17 denotes the response of a one standard error positive exchange rate shock of the USA, Eurozone, China, India, South Africa, Kenya, and the UAE on Tanzania's exchange rate as well as its NPLs. The results refer to bootstrap median estimates with 90 percent bootstrap error bounds, with a 40-month period forecast horizon from January 2022 to December 2022, in the response of Tanzania's exchange rate and its impact on the country's NPLs.

The results for the effect of a positive shock in the selected developed economies', namely the USA and Eurozone economies, on the Tanzanian economy and banking sector, are presented next. Tanzania's real effective exchange rate is anticipated to increase by 0.000001776 percent by the 40th month, in response to an exchange rate shock in the USA, raising the NPLs ratio by 0.0001491 percent in the same period; this points to the foreign-denominated lending in the Tanzanian banking sector, which accounts for around 30 percent of lending, and has an impact on credit risk. In the case of the Eurozone, the forecast is that Tanzania's real effective exchange rate is anticipated to increase to 1.1053059percent in the 22nd month of the forecast horizon, and later decrease, with a corresponding increase of 3.1540786 percent in the domestic NPLs ratio in the 4th time horizon, and later a decrease up to the 40th month.

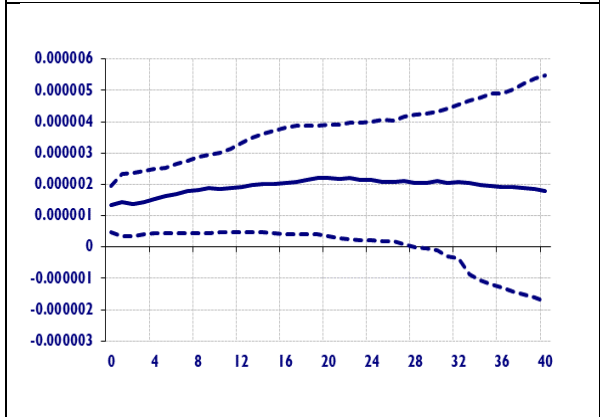
Figure 3.8, shows the transmissions from the Asian economies, as represented by China and India, on the Tanzanian economy and banking sector. The results reveal that Tanzania's real effective exchange rate is anticipated to decline by 0.0000289 percent, from the sixth month to 19th month. In response to an envisaged positive shock of 1.23125 percent on China's exchange, the forecast showed that Tanzania's real effective exchange rate is anticipated to decline by 0.0004816 percent by the 40th month, with an anticipated corresponding increase of 0.0000124 percent in domestic NPLs up to the 34th month forecast horizon, followed by a later decrease. In case of a positive shock in India's exchange rate, the forecast is that Tanzania's exchange rate is expected to increase by 2.22341 percent throughout the 40-month forecast horizon. The anticipated impact of this on the NPLs ratio, is a decline of 1.51571 percent by the 25th-month horizon, and later an increase of 0.0005278 percent by the 40th-month horizon.

Taking South Africa and Kenya as representative of the African context, the transmissions to the Tanzanian economy and banking sector, in response to a positive exchange rate shock in these countries, is as follows. The results in *figure 4.8*, depict that South Africa's exchange rate increases by 2.22341 percent for the forecasted 40-month period. The impact of this on Tanzania's NPLs response is an anticipated increase of 0.0005278 percent throughout the time horizon. In the case of Kenya's transmission, the forecast is that Tanzania's exchange rate is expected to decline by 0000323 percent by the 30th month, and later increase, with a corresponding impact on NPLs leading to an increase in 0.001537 percent.

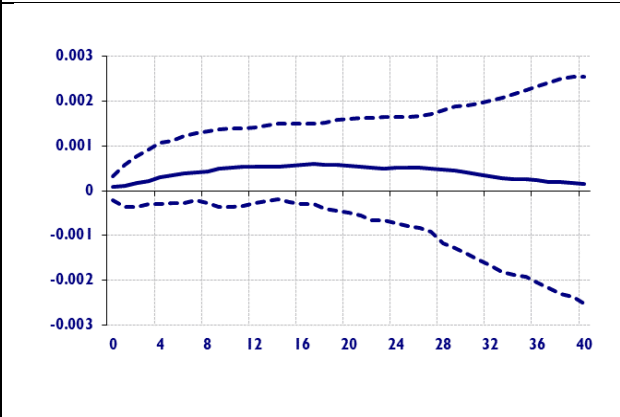
In the context of the Middle East, the UAE's transmission to the Tanzanian economy and banking sector is set to be as follows. In response to a real GDP shock in the UAE, the forecast is that Tanzania's GDP is expected to decline by 0.0001828 percent by the 5th month and later increase by 0.002462 percent, with an increased impact of 0.00002677 percent on domestic NPLs.

Developed economies

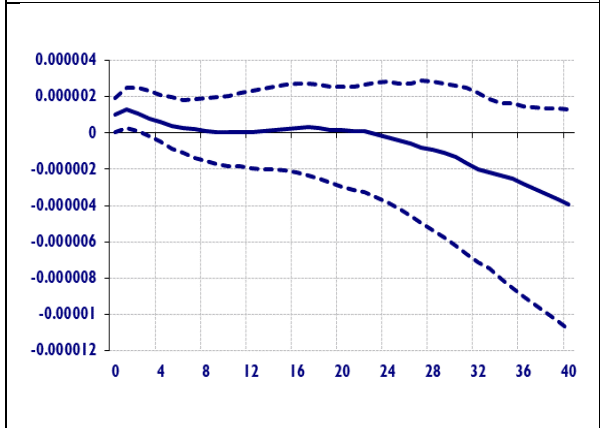
a) USA: Positive shock on exchange rate



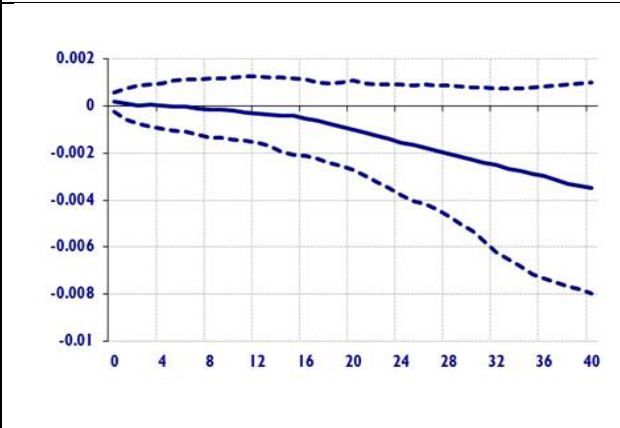
b) USA: Impact on Tanzania's NPLs



c) Eurozone: Positive shock on exchange rate



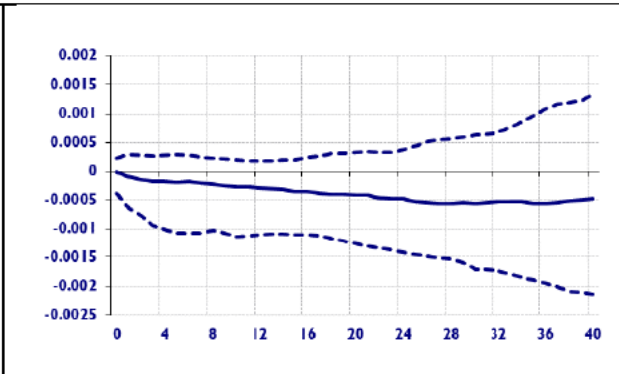
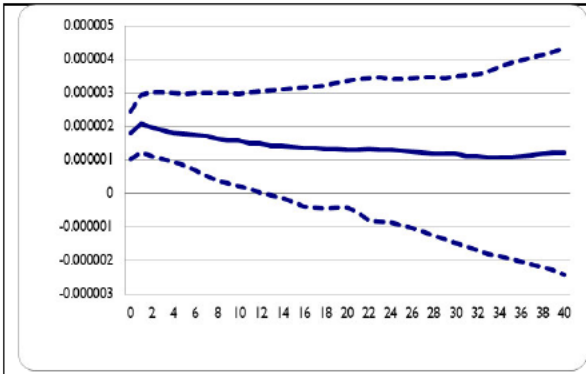
d) Euro: Impact on Tanzania's NPLs



Emerging economies

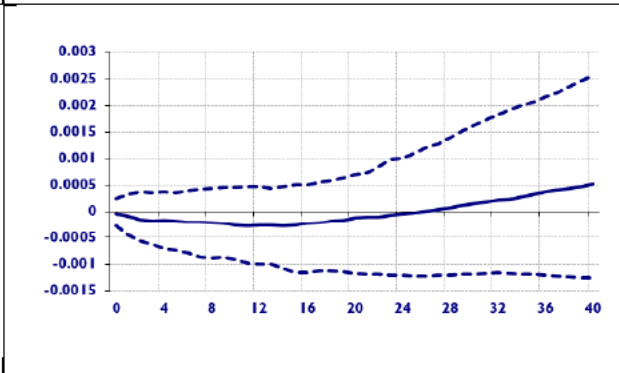
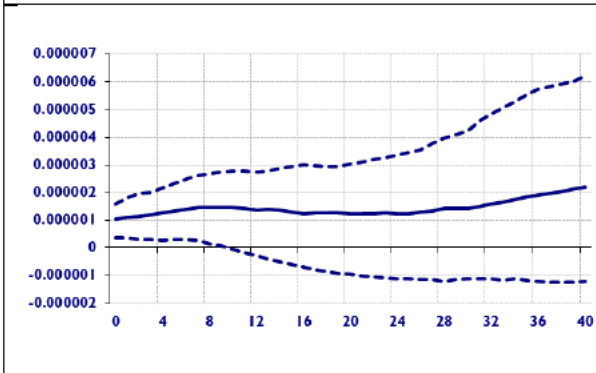
e) China: Positive shock on exchange rate

f) China: Impact on Tanzania's NPLs



g) India: Positive shock on exchange rate

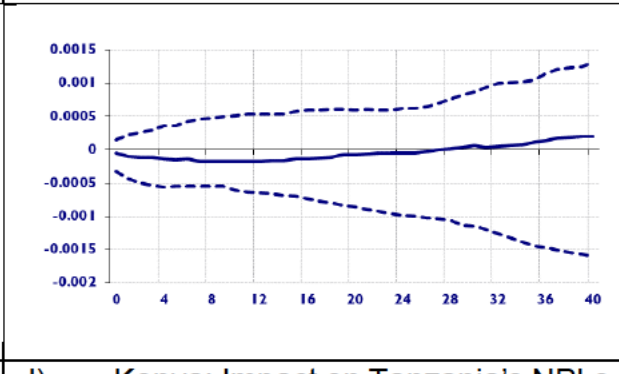
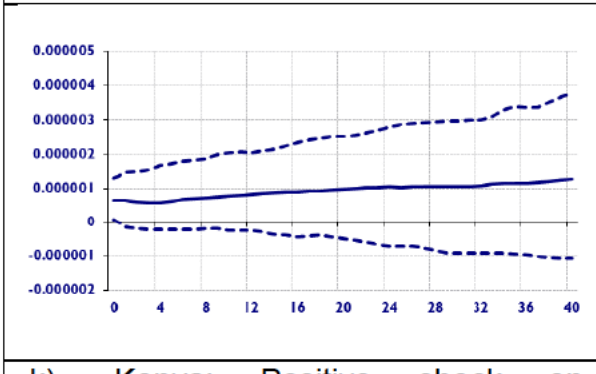
h) India: Impact on Tanzania's NPLs



African countries

i) South Africa: Positive shock on exchange rate

j) South Africa: Impact on Tanzania's NPLs



k) Kenya: Positive shock on exchange rate

l) Kenya: Impact on Tanzania's NPLs

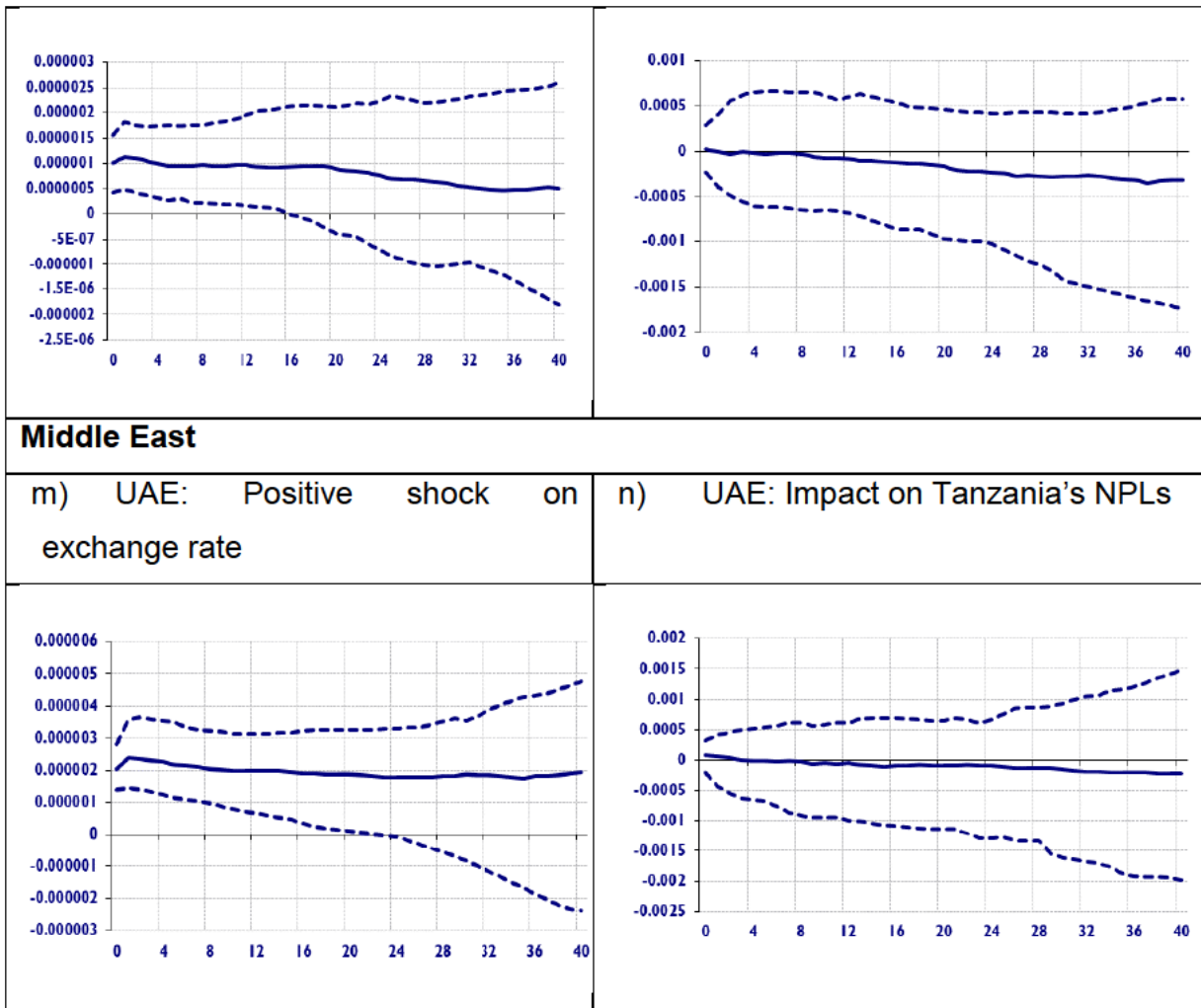


Figure 3.8: Generalised Impulse responses of foreign countries positive exchange rate shock and impact on Tanzania's NPLs
 Source: Author's own computation (2023) from GVAR (bootstrap median estimates with 90 percent error bounds)

3.4.7 Inflation rate exposure from foreign countries

Figure 3.9 denotes the response of a one standard error positive shock of the inflation rate in the USA, the Eurozone, China, India, South Africa, Kenya, and the UAE on Tanzania's inflation rate as well as its NPLs. The results refer to bootstrap median estimates with 90 percent bootstrap error bounds, with a 40-month forecast horizon from January 2022 to December 2022, in the response of Tanzania's inflation rate and its impact on Tanzania's NPLs.

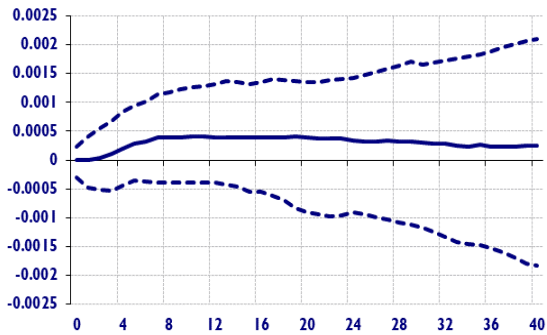
In assessing the response of one standard positive shock of inflation rate applied to developed economies, namely the USA and Eurozone economies, on the Tanzanian economy and banking sector, the following results were found. The response to an inflation rate shock in the USA results in a decline of 7.8456079 percent in the anticipated Tanzania inflation rate in the first month, and later an increase of 0.000256974 percent in the remaining 39-month horizon. As for the impact on NPLs, the ratio continued to increase by 0.00193233 percent in the 40-month horizon. In response to an inflation rate shock in the Eurozone, the forecast is that Tanzania's inflation rate is anticipated to decline by 0.00141294 percent; this effect will lead to a decrease of 0.000012767 percent in the domestic NPLs ratio in the 11th month, and later an increase of 0.00076124 percent. For the Asian economy, the Chinese and Indian economies' transmissions to the Tanzanian economy and banking sector are discussed next. In response to an inflation rate shock in China, the forecast is that Tanzania's inflation rate is expected to decrease by 0.0000170997 percent, with a corresponding decline in the NPLs ratio of 0.0000170997 percent up to the 17th month, and later an increase of 0.001924983percent. In the case of an inflation rate shock in India, the forecast is that Tanzania's inflation rate is expected to increase by 0.000064269 percent up to the 22nd month, and later decline by 0.001331056 percent. The response of a positive shock in the inflation rate in India results in a decrease of 0.000053662 percent in the domestic NPLs ratio, and later an increase of 0.00111047212 percent.

In the context of African economies, the transmissions from the South African and Kenyan economies to the Tanzanian economy and banking sector are presented next. In response to an inflation rate shock in South Africa, the forecast is that Tanzania's inflation rate is expected to increase by 0.000195491 percent, throughout the 40-month horizon, with a corresponding anticipated increase of 0.001213969 percent in domestic NPLs during this period. In the case of an inflation rate shock in Kenya, the forecast is that Tanzania's inflation rate is expected to decline by 0.0000683605 percent throughout the 40-month horizon, with a corresponding decline of 0.000493443percent in NPLs. In the Middle Eastern context, the transmission from the UAE to the Tanzanian economy and banking sector is presented next. In response to an inflation rate shock in the UAE, the

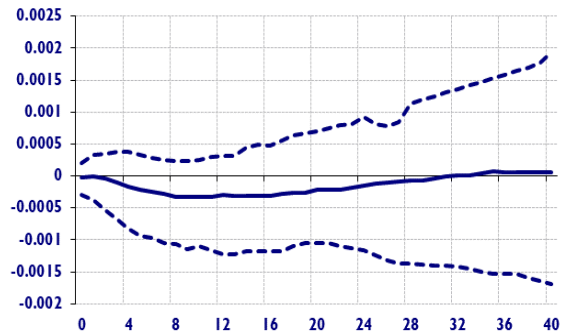
forecast is that Tanzania's inflation rate is expected to decline by 0.000116979 percent over the 40-month horizon, with a decline of 0.00038105802 percent in domestic NPLs.

Developed economies

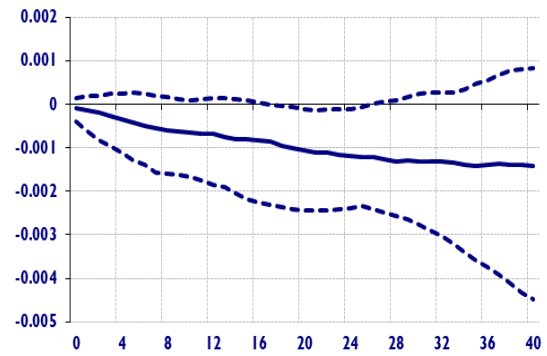
a)USA: Positive shock on inflation rate



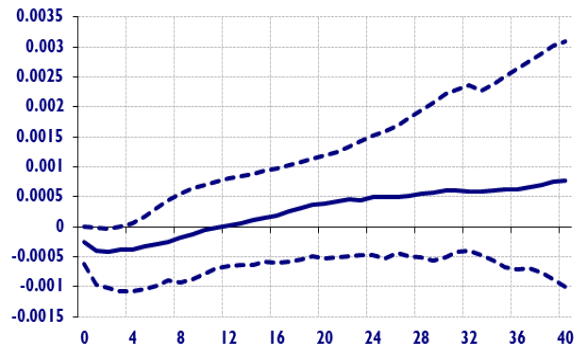
b)USA: Impact on Tanzania's NPLs



c)Eurozone: Positive shock on inflation rate

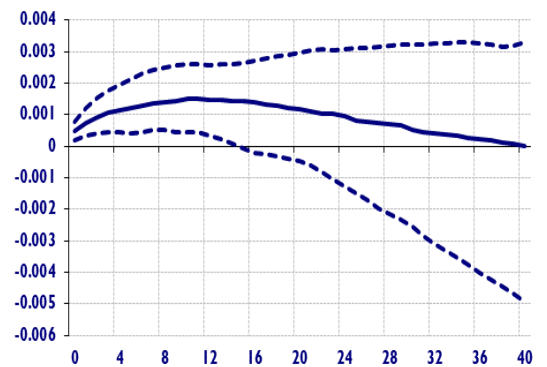


d)Eurozone: Impact on Tanzania's NPLs

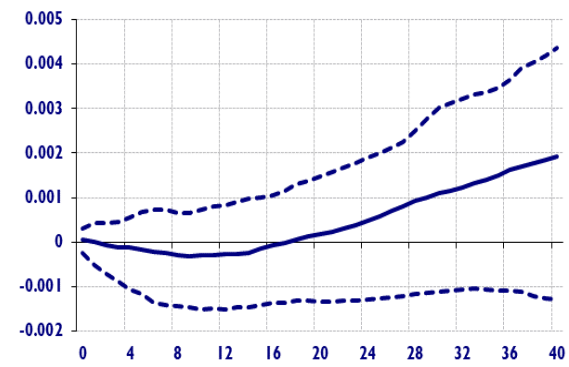


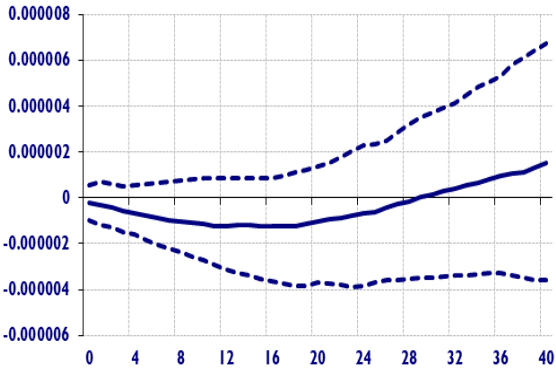
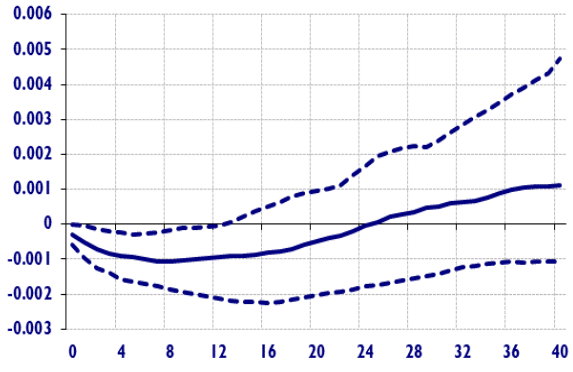
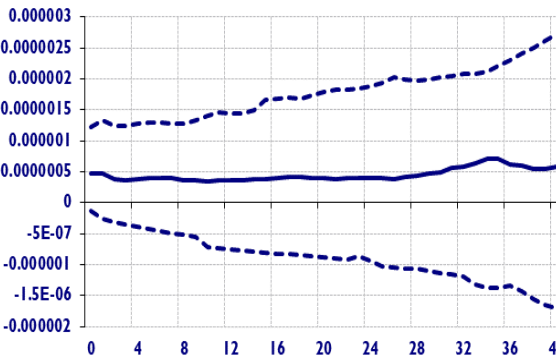
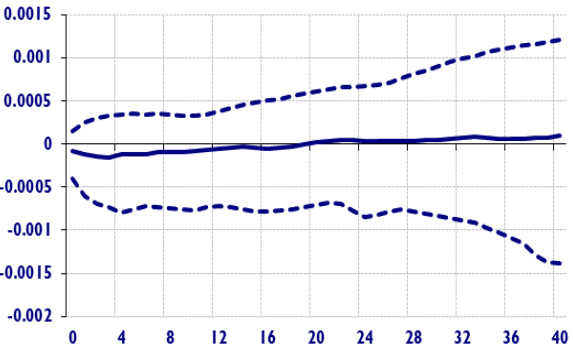
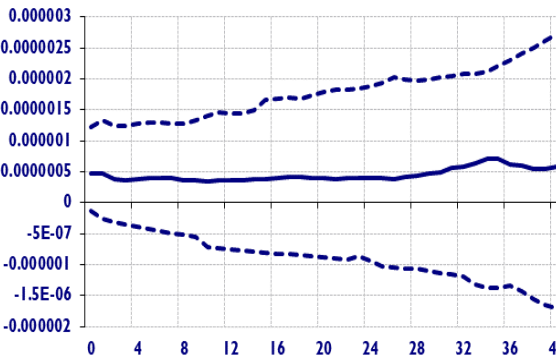
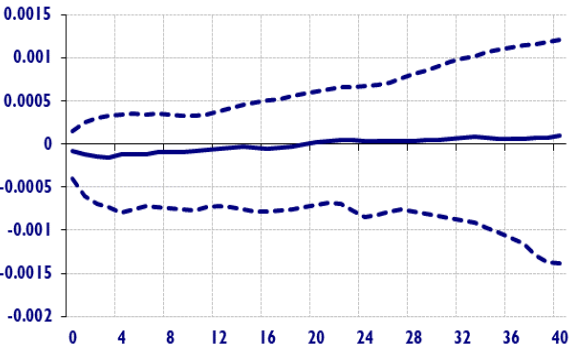
Emerging economies

e)China: Positive shock on inflation rate



f) China: Impact on Tanzania's NPLs



| | |
|---|---|
| <p>g) India: Positive shock on inflation rate</p>  | <p>h) India: Impact on Tanzania's NPLs</p>  |
| <p>African countries</p> | |
| <p>i) South Africa: Positive shock on inflation rate</p>  | <p>j) South Africa: Impact on Tanzania's NPLs</p>  |
| <p>k) Kenya: Positive shock on inflation rate</p>  | <p>l) Kenya: Impact on Tanzania's NPLs</p>  |

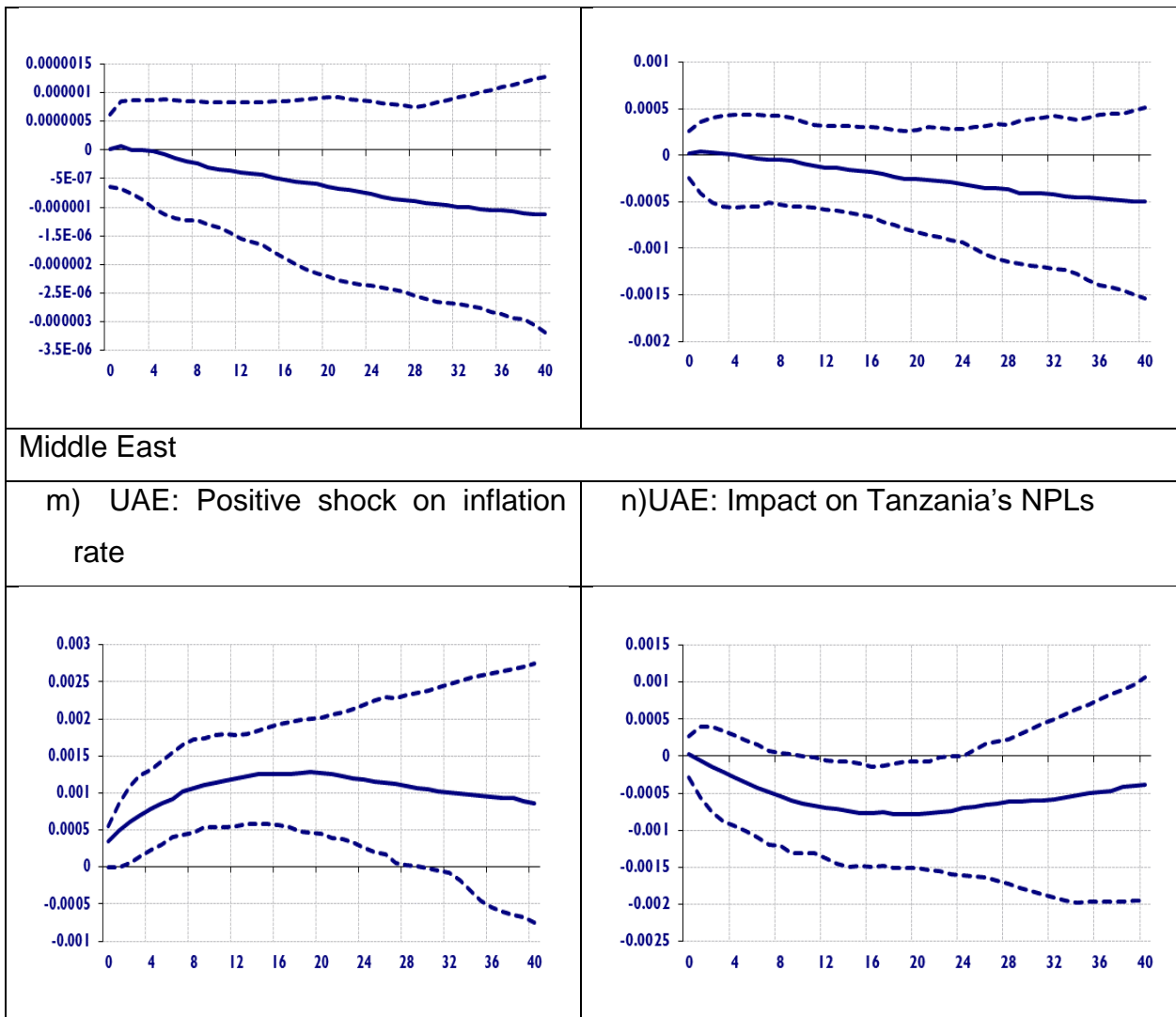


Figure 3.9: Generalised Impulse responses of foreign countries positive exchange rate shock and impact on Tanzania's NPLs

Source: Author's own computation (2023) from GVAR (bootstrap median estimates with 90 percent error bounds)

3.5 Chapter Summary

This chapter conducted macro credit risk stress testing in Tanzania, in light of the growing interlinkages between Tanzania and the global economy at large, using the global vector autoregressive model (GVAR) and covering eight countries. The models that were reviewed supported the expectation that, in the midst of risk assessment, forward-looking tools for predicting anticipated risks are important in quantifying the amount of exposure

expected, in case a scenario materialises. Credit risk was modeled using non-performing loans; due to the availability of data, domestic variables were represented by real gross domestic product (GDP), inflation, real effective exchange rate, and short-term interest rate. The global variables selected were metal prices, oil prices, and the raw materials price index. The foreign variables for Tanzania's major trading partners, namely, the USA, Eurozone, China, India, the UAE, South Africa, and Kenya, were represented by the macroeconomic variables of real gross domestic product (GDP), inflation, exchange rate, and nominal interest rate.

Forty months of forecasts were generated for all the domestic, global, and foreign variables, from M6:2006 to M12:2020. The study concluded that in the domestic context, the credit exposure of the Tanzanian banking sector was more responsive to rate changes in domestic inflation than other macroeconomic variables, including real GDP, exchange rate, and interest rate. In terms of exposure to foreign countries, the impact of interest rate, inflation rate, and real GDP shocks were more significant across the countries, compared to exchange rate which showed mixed results. Insofar as the global variables applied, the credit in the Tanzanian banking sector is very exposed to changes in increases in oil prices compared to changes in metal and raw material prices, as fuel is the engine driving the country's major economic sectors. This study departs from the results obtained by the Rakotonirainy et al. (2020) and , where oil prices were the most significant factor that affected credit risk.

The results of this chapter provide a foundation for Chapter 4, by expanding on credit risk exposure to estimate the magnitude of impact to capital adequacy for selected banks in the Tanzanian banking sector. The outcome will amplify on the assessment of proper banking sector resilience, ensuring financial stability by providing mitigation measures in advance to contain the anticipated exposure. This study contributes to the literature on macro credit risk stress testing in Africa, as well as the rest of the world, by adopting the usage of the GVAR model and updating the model with statistics and countries, using the selected trading partners of Tanzania. As noted, this is the first study concentrating on Tanzania, while adding countries like Kenya and the UAE in the GVAR model, which were previously not figuring. This chapter provided the basis for scenario development and

assessing the impact of macroeconomic factors to credit risk exposures, which will later be translated to banking sector resilience, as detailed in the next chapter, to fulfill objective one of this study.

CHAPTER 4: STRESS TESTING AND BANKING SECTOR RESILIENCE

4.1 Introduction

This chapter intends to show the relationship between stress testing and banking sector resilience. It expands on chapters two and three, which viewed macro credit risk stress tests in Tanzania and form a part of the implementation of objective one of the study. Objective one assessed the impact of macro credit risk stress testing on banking sector resilience in Tanzania. Various literature reviews, both theoretical and empirical, were conducted. Financial stability is an engine of economic growth, as stable and resilient financial systems ensure the sustainability of the economy. The expansion of Chapter two dwells on an analysis of the financial sector, more specifically the banking sector, which accounts for more than 70 percent of the assets of the financial sector. descriptive analysis was conducted on the performance of the Tanzanian banking sector in relation to peer EAC countries, to gain an understating of the indicators in the sector (Kishimba et al., 2022b).

In addition, the expansion on Chapter three was on the shocks from the GVAR analysis, to assess the impact of domestic and foreign macroeconomic variables, as well as of global variables, on credit risk in the banking sector. Henceforth, the interlinkage between extending exposure from the impact of credit risk to the banking sector's capital position, exposed a state of potential loss that calls for enhanced supervision framework as important instruments, to ensure the resilience of the banking sector. Efforts have been taken from the colonial era up to the present, to improve the functioning of the financial sector in order to support developmental initiatives, hence also stimulate growth in Tanzania.

This chapter assesses the relationship between macro credit risk stress testing and individual bank resilience, in addition to the impact of bank-specific factors in Tanzania. This is done to amplify the effect of the relationship between macro credit risk stress testing and banking sector resilience on individual banks. The scenarios generated in Chapter 3 are adopted in this chapter. Financial stability assessment through stress testing has been an integral function of the IMF in collaboration with the World Bank since 1999 (Sorge, 2004). Various studies have been conducted and designed using stress

testing frameworks, with the aim to assess the relationship between stress tests and the banking sector (Amel, 2018; Başarır, 2016; Farayibi, 2016; Kattai, 2010; Messai & Gallali, 2018; Niyogi & Bhattacharya, 2011; Ong, 2014; Rakotonirainy et al., 2020; Rouabah & Theal, 2010). This study fills the gap by embedding global transmissions, macroeconomic variables, and banking sector indicators to assess individual bank resilience in Tanzania, which is a study that has not been covered before, to the best of the author's knowledge.

Since the global financial crisis of 2007/09, countries have been aggressive in mitigating exposure, therefore ensuring resilience is a core function, by securing additional capital buffers beyond the minimum required threshold. The standard question is whether the stress tests are adequate enough to capture the magnitude of exposure, especially credit risk. The impact of banking resilience, as measured by capital adequacy, can be impaired not only by domestic macroeconomic variables, as major studies by Abdolshah et al. (2020); Foglia (2008); Taskinsoy (2018) have assessed, but rather by global linkages as narrated by (Rakotonirainy et al., 2020). Further, exposure can either be bank specific or from the external environment, such that the expanded coverage of these parameters is crucial in the assessment of banking sector resilience, from a credit risk perspective (Ahmed et al., 2021; Raiter, 2021; Razafindravonona, 2021).

In 2003, stress testing formed an integral part of the Financial Sector Assessment Program (FSAP), which assesses the soundness of the banking system to ensure financial stability (IMF/WB, 2003). Tanzania adopted top-down stress testing in 2009 after the global financial crisis, under the technical assistance from the International Monetary Fund (IMF), bearing in mind the nascent stage of its banking sector in terms of complex instruments and business products (IMF, 2014). In 2010, the "Risk Management Guidelines, 2010" stated that banks needed to conduct stress tests as a part of the risk management process for market, liquidity, and credit risks (BOT, 2010a). Therefore, since then stress tests form part of the risk management tools that are used on for the onsite and offsite surveillance of individual banks (BOT, 2010a). Banking sector resilience in Tanzania is assessed using capital adequacy ratios of core and total ratios, with regulatory capital requirements being 10 and 12 percent, respectively. As of 2019, the

core and total capital ratios in Tanzania stood at 16.7 percent and 17.9 percent (Tanzania, 2019).

Further, the growing interlinkages with a concentration of more than 50 percent of the financial sector's total assets being held by five banks, signals an early warning indicator that calls for close monitoring to ensure financial stability (Tanzania, 2020). Over the recent years, stress tests have been conducted by the Central Bank of Tanzania on a quarterly basis (Leika et al., 2020), as well as by the IMF/World Bank, under the Financial Sector Assessment programs conducted in 2018 (IMF, 2018b). All these aim at assessing the resilience of the banking sector in Tanzania to different risks, and the implication of the interconnectedness among banks to identify systemic impacts (IMF, 2018a; Tanzania, 2020). However, the results generated from the stress tests do not capture the global impact as well as specific bank factors, which can also impair the resilience of the banking sector.

To address the gap in the research on integrating global transmission, banking sector impact, and macroeconomic factors, the use of stress tests in Tanzania was inevitable to deduce potential exposures related to credit risk and later capital position; hence there is the need to retain capital buffers to ensure sustainability in case shocks occur. Since stress testing is an important risk management tool, and adoption of the same is inevitable, this chapter will contribute to the existing literature on stress testing, in terms of understanding the relationship between global transmissions and specific banking sector factors, by concentrating on Tanzania as a developing economy. Referencing this study and its findings will support specific banking measures with different responses, based on the magnitude of exposure, to support existing supervisory tools for onsite and offsite surveillance. According to this study, there is no study that has explicitly explored stress testing in relation to banking sector resilience in Tanzania, by associating global, domestic, and banking sector impacts. In order to attain the stated objective of the study, this chapter is structured to review the literature, both theoretical and empirical methodology adopted, as well as the analysis of the empirical findings, in sections 4.2, 4.3, and 4.4, respectively.

4.2 Literature review on stress testing and banking sector resilience

Stress testing and banking sector resilience go hand in hand, as the common objective of these is to assess whether the banking sector is able to withstand shocks, while maintaining the minimum required capital as prescribed. There has been a growing debate since right after the global financial crisis and the implementation of ICAAP under Basel II, regarding cases where stressed capital forms part of capital, which has raised concern among shareholders, who ultimately take responsibility for capital injection in case they go under (Basel, 2014; Waithaka, 2013).

The theories elaborated next stress on the linkages between risk, shareholder responsibility, and return on investment, while maintaining the required minimum regulatory requirements to ensure resilience as well as stability (Choudhry, 2011; Donnellan & Rutledge, 2016; Erwin et al., 2018; Fabozzi et al., 2002; Mapororo, 2018). The following section covers both the theoretical and empirical literature reviews.

4.2.1 Theoretical literature review on stress testing and bank resilience

The foundation of the theories on the relationship between stress testing and banking sector resilience, took root after the global financial crisis of 2008/09, where the significance of banks conducting stress tests with the ultimate aim of assessing the resilience of the sector to shocks in case they materialise, took shape (Abdolshah et al., 2021; Dua & Kapur, 2018; Niyogi & Bhattacharya, 2011; Patra & Padhi, 2020a; Rakotonirainy et al., 2020; Razafindravonona, 2021).

This development brought on board bank resilience, which is one of the aims of banks insofar as risk management, through using stress tests to detect early warning signals. The negative impact of the global financial crisis provided a significant opportunity for banks to improve their ability to control risk and tolerance, as well as to ameliorate the soundness of the financial sector. It follows suit that credit risk is the most affected risk in a solvency stress test, given its direct exposure to the macroeconomic variables and economic activities in the economy (IMF, 2014). The theories that are reviewed to assess the impact of macro credit risk stress tests to banking sector resilience, are agency, modern portfolio, and asset liability management (Donnellan & Rutledge, 2016; Farayibi, 2016; Mapororo, 2018).

Agency theory considers the principal and agent relationship, while modern portfolio theory (MPT) advocates that risk and return go hand in hand; meanwhile, investors prefer a low-risk portfolio of assets over a high-risk one for a given return, with the assumption that they are risk averse (Markowitz, 1952). In another study by Markowitz (1959), the theory developed a framework, where any expected return is composed of various future outcomes, so as to capture the relationship between risk and return, and how it can be optimized through diversification.

Agency theory has been used in various disciplines ranging from marketing, accounting finance economics, public administration, political science, as well as organizational behaviour, with the aim of elaborating and resolving issues in the relationship between business principals and their agents (Eisenhardt, 1989). The study by Jensen and Meckling (1976) broadened the scope of agency theory, by considering the risk aspect that can be influenced by the level of oversight. Agency theory research has moved from contemporary relationships between principal and agent, to associating risk and bank performance, by considering risk reward theory (Bromiley, 1991; Miller & Bromiley, 1990).

In their work, Donnellan and Rutledge (2016) argued that the emergence of strategic investment decisions on different risk types, basically liquidity and credit risk, did not exist during the time of the global financial crisis. In their study, they argued that extended agency theory could assist in understanding the financial and reputational impact on the banking industry, due to credit risk and the subsequent impact on liquidity (Donnellan & Rutledge, 2016). In agency theory, the agency costs are incurred by the principal (shareholders) while monitoring their agents (managers), as the two parties have different priorities (Mapororo, 2018). The impact of potential exposures on the capital position of banks, may have a positive impact on their risk-taking ability, as banks are required to adhere to the Internal Capital Adequacy Assessment Program under Basel II, which makes stress tests results have a direct effect on capital adjustments.

Stevenson and Fadil (1994) later considered applying MPT on commercial loans, as most studies concentrated on equity and bonds. Modern portfolio theory is commonly considered as mean-variance analysis, whereby investors are concerned with return

distributions over a single period, placing large data requirements and their implications to the company (Fabozzi et al., 2002).

Studies using MPT range from real estate, to the banking and insurance sectors (Kazan & Uludağ, 2014; Lydenberg, 2016). On the one hand, Kazan and Uludağ (2014) applied Markowitz Portfolio Theory to assess the banking sector risk, by viewing how the rate in the repayment of loans increased, hence minimizing credit risk, for the specific sectors of construction, textile, wholesale, and retail. On the other hand, Frost (1983) considered adoption of MPT to assess the implications for life assurance companies when applied in actuarial evaluations. A well-capitalised banking sector can maximize return and meet regulatory requirements, by expanding the diversification of risky assets for different lending categories (Waithaka, 2013). Macroeconomic shocks have an impact on credit risk and later on a bank's capital position, hence testing the bank's resilience to absorb shocks. This chapter intends to assess the impact of global shocks on individual banks in Tanzania, and how much they are able to maintain capital adequacy within the prudential regulatory requirement of core capital ratio of 10.0 percent.

Another theory that can relate stress testing and banking resilience is the asset liability management theory. The idea of managing assets and liabilities collectively is witnessed in a number of sectors, including pension funds, insurance, banking, as well as in households (Romanyuk, 2010). To this vast range of sectors, the theory of asset and liability management is basically a practice used by financial institutions to mitigate financial risks resulting from a mismatch of assets and liabilities, and thereby achieve greater efficiency and profitability while also reducing risk (Erwin et al., 2018). In their study, Inshira and Jahfer (2019) relied on the asset and liability theory to examine the effects of liquidity risk on domestically licensed commercial banks in Sri Lanka; once these banks are affected by this, a decline in investor confidence, panic withdrawals, and daily operation problems can result.

A study by Ali (2004) narrates that asset liability management (ALM) theory has historically concentrated on managing interest rate risks; however, the unpredictable impacts of economic environment and investment constraints have brought the need to

expand the theory further. This study aims to attain the objectives of controlling risks, hedge banks' risk exposure, as well as sustain and increase profits and growth.

Jahera Jr (2018) developed an approach that has significant implications for public policy and managerial behaviour, through linking the explicit channels for bank control of actively managed liabilities into the Kane-Malkiel model of bank portfolio allocation, thus reacting to exogenous disturbances elsewhere in the balance sheet. Charumathi (2008) has viewed asset liability as a dynamic process of planning and focusing on interest rate risk, as well as of establishing the gap and assessing the magnitude of exposure of a bank to interest rate risk. Notably through this, as the theory states, credit retention and monitoring is substantial enough to ensure that capital position is maintained, therefore ensuring resilience (Farayibi, 2016). This chapter adopted the asset liability theory to assess the relationship between banking sector variables and a bank's resilience, using capital adequacy ratios as a proxy, following the results obtained after assessing the impact of shocks generated to credit risk, as detailed in *Chapter three*.

4.2.2 Empirical literature review on stress testing and banking sector resilience

At the heart of stress testing lies the ability to gauge whether a bank is still able to operate in a safe and sound way within the prudential limit (Hirtle & Lehnert, 2015). Previous studies have analysed how stress testing is adopted as a risk management tool for macro-prudential assessment, to ensure potential risks are identified and mitigation measures proposed in order to enhance the stability of the financial sector (Andersen et al., 2019; Borio et al., 2014; KOK, 2013). These studies derived the relevance of analysing credit risk as an individual risk aspect in relation to the assessment of exposures.

In another context, studies have adopted stress testing to assess the magnitude of impact of credit risk on banking sector resilience, particularly capital position, both on individual banks and the aggregate sector (Abdolshah et al., 2021; Amel, 2018; Messai & Gallali, 2018; Onder et al., 2016; Patra & Padhi, 2020a). These particularly showed that the assessment of banking sector resilience for more than one scenario, in this particular case, was either baseline, adverse, or severe, providing more potential for the provision of buffers to meet the minimum requirements (Patra & Padhi, 2020a; Razafindravonona,

2021). When conducting stress testing, the result can be a bank-specific effect or an assessment of the variable that more greatly affects capital adequacy. Henceforth, some studies diagnosed the banking sector based on individual assessment, like Patra and Padhi (2020a); in their study of the Indian banking sector, they revealed that public banks were more vulnerable to severe scenarios compared to private and foreign banks. These results are similar to the analysis observed by Amel (2018), where the public banks in the Tunisian banking sector were more exposed to foreign banks. Hence, there is the need to amplify the significance of the analysis of individual banks, to identify capital challenges on a more granular form rather than at an aggregated level.

Meanwhile, Dua and Kapur (2018) noted that the sector remained largely sound in terms of the total regulatory capital adequacy ratio, with expansionary monetary policy having a greater impact on credit quality and capital adequacy in a positive and significant manner, via its effect on the economy's growth rate. Başarır (2016) also contributed to the empirical literature on stress testing and banking sector resilience, with his findings that the impact of shocks on the Turkish banking sector gave a bank a capital position within the minimum requirements, hence portraying a good financial structure and effective management of the sector. These findings are in line with the studies that adopted the theories of modern portfolio and asset liability management (Donnellan & Rutledge, 2016; Farayibi, 2016; Mapororo, 2018; Waithaka, 2013).

Other empirical studies have shown that stress testing was adopted to assess the resilience of the banking sector, using solvency models in relation to the effect of individual risk factors and their interconnectedness. According to Čihák (2007), a macro stress testing framework was adopted to assess the solvency level in response to adverse effects to major risks; for example, for credit risk, shocks were applied to aggregate levels of NPLs and later the magnitude of the capital that was needed to restore the minimum requirements of capital, was calculated. Subsequently, Taskinsoy (2018) adopted the stress testing framework created by Čihák (2007), which assessed the solvency level in response to adverse effects to major risks, such as credit risk, with data from 2013 to 2015 covering the entire banking sector, consisting of 56 financial institutions. The argument raised was to extend stress testing to individual bank exposure, and later

assess the aggregated impact to evaluate how the Malaysian banking sector fared in terms of resilience and interconnectedness. On this note, the results showed high levels with no bank failure, liquidation, or suspension of license (Taskinsoy, 2018). It was found that aggregate banks had enough capital buffers, since they were already maintaining additional requirements as part of regulatory requirements; hence, individual bank analysis unearthed specific bank capital deficiency.

Empirical studies have moved from solvency assessment to specific risk stress testing. In their study, Buncic and Melecky (2013) proposed macro-prudential stress testing using the vector auto regressive model (VAR) with credit portfolio classes. This has been amplified, as stated in the theoretical review of asset liability management (Romanyuk, 2010). With the ongoing global challenges, policymakers across the globe are adopting various methodologies to diagnose risk to a granular extent, so as to deduce the potential impact prior to severity and maintain buffers to secure the same. As such, some studies have adopted panel data models, including fixed, static, and dynamic models, which have assisted in analysing the impact that is transmitted from credit risk, to risk-weighted assets, to capital positions (Amel, 2018; Chaibi & Ftiti, 2015; Patra & Padhi, 2020a; Razafindravonona, 2021).

Other studies like one by Kosmidou and Moutsianas (2015) assessed the relationship between macroeconomic variables and credit risk, using loan loss as a proxy, in the period from 2001 to 2013, and how these factors affected the capital position of banks in the Greek banking sector, in the worst case scenario. They found that, since banks were already maintaining buffers, the elevation of loan loss provisions led to high capital buffers being channelled towards financing the economy. As addressed by (Borio et al., 2014), stress testing approaches and tools differ given the level of complexity, risks associated, and availability of data in a particular country. A significant contribution has been made on using stress testing to assess banking sector resilience - more precisely using credit risk as a major area of concern, but the results differed due to the nature of the banking sector in different economies and the models adopted to undertake risk assessment (Abdolshah et al., 2021).

Further, Kanas and Molyneux (2018), in their study for undertaking macro stress testing in the U.S. banking system, employed an additive semi-parametric, quantile approach using data from Q1:1984 to Q3:2013. The method selected for the study aimed at addressing the limitations of a non-parametric model; as it does not suffer dimensionality, it achieved greater estimation precision and flexibility in the form of the regression function. For determining macro variables, the study used factors that influence NPLs and banking stability, such as real GDP growth, interest rates, and disposable income.

Empirical studies have concentrated on developing credit-related macro stress test frameworks for assessing resilience in the banking sectors, following the impact of credit-related exposures having a significant effect (IMF, 2014). Askari et al. (2021a) argued that despite the impact of a decrease in GDP growth, which resulted in the impact on default rate, the Iranian banking system still remained resilient to macroeconomic shocks. Their study examined the impact of macroeconomic variables, by adopting Wilson's model for estimating the default rates (PD) and using the VAR model for studying the relationship between macroeconomic variables, using data from 2006 to 2019.

According to Vazquez et al. (2012), their study found that the use of insufficient granular credit data tended to underestimate the tail losses of the riskier banks. The results of their study revealed a substantial variation in the pro-cyclical behaviour of credit quality, with private and public banks behaving in relatively the same way. Further, their study showed a robust negative relationship between the logistic transformation of NPLs and GDP growth, with a lag response of up to three quarters (Vazquez et al., 2012). Hence, this revealed that beyond resilience assessment, there is a need to assess the relationship among variables in order to identify causality, and propose remedies in due course.

On the other hand, Messai and Gallali (2018) expanded their assessment from individual bank to sector analysis, using four sectors in Spain, namely, agriculture, construction, services, and industry; it was revealed that the most affected sector was construction. Their study deployed macroeconomic shocks using a historical scenario based on the subprime crisis and the European monetary crisis of the early 1990s, by embedding extreme inflation, gross domestic product, and unemployment rates, together with NPLs

as a credit proxy. Their findings called for the need to diagnose sector-specific exposures in addition to individual banks.

Empirical studies on stress testing and banking sector resilience in African banking sectors, have revealed the need to diagnose credit risk, as most banking activities originate from it (Leika et al., 2020). Credit extension has largely impact on the banking sector at large, which many studies have continued to focus on, although there is little literature regarding this in the African context (Aboagye & Ahenkora, 2018; Amel, 2018; Havrylchuk, 2010; Rakotonirainy et al., 2020; Razafindravonona, 2021).

In amplifying this abovementioned point, Havrylchuk (2010) adopted random effect panel data model in the South African banking sector, with loan loss provision being the proxy for credit risk from 1994 to 2008. The assessment revealed that the South African banking sector is resilient to macroeconomic shocks, even during severe events, despite the impact on credit losses as well as banks being very sensitive to changes in real interest rates and property prices, due to the high credit holding of mortgages (Havrylchuk, 2010). In another study, realised that the Tunisian banking sector was resilient to adverse scenarios using a credit risk stress testing model, where a static fixed model was used for scenario development, deploying both macroeconomic and banking sector variables. His study adopted the Monte-Carlo simulation for generating credit risk losses, suggesting a negative relationship between credit risk and real GDP growth, by using a panel data analysis for the top ten banks in the Tunisian banking system from 2002-2016. The previously mentioned studies considered the domestic interaction among both macroeconomic variables and banking sector factors to assess resilience, but global transmission was not captured in their models. However, it was captured in a study by Rakotonirainy et al. (2020), who adopted the GVAR model to assess the resilience of the banking sector in Madagascar.

Extended studies have been done to enrich the assessment of stress testing for individual banks, through risk identification and resilience by embedding global transmission (Abdolshah et al., 2021; Méndez-Marcano, 2021; Razafindravonona, 2021). Rakotonirainy et al. (2020) assessed the impact of macroeconomic evolution on credit quality, using non-performing loans (NPLs) as a proxy for the aggregate banking sector.

Their study deployed the GVAR model incorporating the impact of international interlinkages into the domestic economy, and later determined the resilience of the banking sector in Madagascar. As seen in capital positions, the reaction was most noted in GDP shocks, though the banking sector remained resilient to all shocks within the regulatory capital ratio (Rakotonirainy et al., 2020). This study expressed how global transmissions can affect aggregate capital position. To amplify this point, Razafindravonona (2021) assessed the resilience of Madagascar's banking sector by taking six of the 10 banks which account for 90 percent its banking sector, using NPLs to project capital using the dynamic panel model. The study revealed that only one bank was unable to meet its capital requirement of eight percent under Basel III. This study also incorporated banking-specific factors in addition to domestic and global shocks as a determinant of credit risk, as adopted by (Chaibi & Fiti, 2015).

In the Tanzanian context, there has been no study that has explicitly explored stress testing in relation to banking sector resilience in Tanzania, associating global, domestic, and banking sector impacts. This study will amplify on the existing empirical studies by Amel (2018); Razafindravonona (2021) in relation to stress tests, by considering banking specific variables; however, the gap of global linkages for countries like Tanzania will also be addressed. This study will be in addition to the envisaged FSAPs conducted by the IMF in different countries using stress tests, as one of the analytical tools to assess the resilience of the banking sectors in specific jurisdictions countries (Adrian et al., 2020; Leika et al., 2020). A few empirical studies Amel (2018); Rakotonirainy et al. (2020) have focused on Africa and also assessed how stress tests were used to determine banking resilience, taking into account the impact of both domestic and global variables, as well as banking-specific impacts.

4.3 Methodology for stress testing and bank resilience

Following from the outcomes of Chapter 4, which assessed the impact of global and domestic macroeconomic variables on credit risk on the aggregate banking sector, this objective investigates the relationship between stress testing and banking sector resilience, using the dynamic panel model with fixed effects. Several studies have been done to assess the relationship between macro credit risk stress tests and resilience for

the banking sector, on either aggregate or individual banks, using the proposed dynamic panel model adopted in this study (Amel, 2018; Chaibi & Ftiti, 2015; Ganbaatar & Selenge, 2012; Patra & Padhi, 2020a; Razafindravonona, 2021). In other studies, researchers have used the Monte-Carlo simulation Amel (2018) , random fixed effect model (Dua & Kapur, 2018; Razafindravonona, 2021), and static fixed effect models (Amel, 2018; Louzis et al., 2012). These all have their strengths and limitations.

Unlike other estimators, this study adopted system generalised method of moments (GMM), due to its robustness and the fact that it does not require information on the exact distribution of the disturbances, thus being important for assessing the relationship between macroeconomic and bank-specific variables on credit risk. The estimator used system GMM, permitting the researcher to solve the problems of serial correlation, heteroscedasticity, and endogeneity of explanatory variables. The sample size was not robust enough for two-step system GMM, therefore one step system GMM was adopted.

The use of panel data created room for analysis of more difficult behavioural models, hence leading to more variability, less correlation and collinearity, and controlled heterogeneity within individual data (Baltagi & Baltagi, 2008). Besides assessing the integration between banking sector-specific and macroeconomic variables, particularly in Tanzania, this is another area in which this present study is different from those by (Amel, 2018; Razafindravonona, 2021). Later, the study assessed the impact on the banking sector performance of a two-year horizon on a baseline, and an adverse but plausible scenario. However, it was expanded to consider individual commercial banks rather than aggregate ones. The next section looks at model specifications as well as data variables and sources for GMM models.

4.3.1 Specifications for GMM models

This section on model specifications aimed to conduct stress tests to assess banking sector resilience in Tanzania, and involved three stages. The first stage involved linking credit risk with the bank variables and macroeconomic variables using the dynamic panel model. The second one involved projecting NPLs under different scenarios using the GVAR model. The last stage involved projecting a bank's capital position using the adverse scenarios generated. The intention behind these steps was ultimately to meet

the objective of assessing banking sector resilience for individual banks in Tanzania, with a projection of anticipated future outcomes.

4.3.2 Panel model

The dynamic panel model approach was used to link credit risk with economic and banking sector variables for modelling NPLs, through referencing various studies conducted in different countries (Chaibi & Ftiti, 2015; Onder et al., 2016; Razafindravonona, 2021). The main advantage of the panel model is to avoid the dynamic panel bias in fixed effect panel econometric models, and to get more efficient estimations (Chaibi and Ftiti (2015), hence this study adopted this type of generalised method of moments (GMM), as shown below:

$$Y_{it} = \alpha_i + \mu(p_{it}) + \sum_{s=1}^k \delta_s p_{it} Y_{i,t-s} + \beta(p_{it})' X_{it} + \gamma(p_{it})' Z_t \quad (4.1)$$

Where: $i = 1, 2, \dots, N$ represents the number of banks and $t = 1, 2, \dots, T$ i represents the quarters for this study.

Y_{it} is the endogenous variable, in our case the NPL credit risk indicator.

X_{it} is a vector of the quarterly variables specific to each bank, including bank size, liquidity ratio, loan to deposit ratio, return on assets (ROA), and leverage ratio ($l \times 1$).

The elements of the vector parameter are unknown functions which must be estimated.

$$[\theta(\mu_{it}) = \mu p_{it}, \delta_1(p_{it}), \dots, \delta_k(p_{it}), \beta_1(p_{it}), \dots, \beta_l(p_{it}), \dots, \gamma_1(p_{it}), \dots, \gamma_m(p_{it})] \theta_s: [0, 1] \rightarrow R, s = 1, \dots, (1 + k + l + m) \quad (4.2)$$

α_i represents specific fixed effects, assumed to be independent, and is intended to control any unobserved cross-sectional heterogeneity (assumed to be invariant over time) which are not taken into account by the banking variables $(p_{it})X_{it}$.

(Z_t) is a vector of macroeconomic variables $m \times 1$

Therefore, the dynamic model to be estimated is rewritten as:

$$npl_{it} = \alpha_i + \delta_{i,t} npl_{i,t-1} + \beta' X_{i,t} + \gamma' Z_t + \sigma_i + \varepsilon_{i,t} \quad (4.3)$$

With constant term α_i

i denotes the number of banks and T denotes the dimension of the time series. With i denoting the cross-section going from bank 1 to 15; and t denoting the chronological dimensions going from Q2-2006 to Q4-2020.

npl_{it} is the non-performing loans ratio of bank i and for period t .

$X_{i,t}$ is the vector of explanatory variables, which for this study are banking variables specific to each bank (return on assets, leverage ratio, bank size and loan to deposit ratio).

Z_t are the vector macroeconomic variables, common to all banks, showing the predetermined macroeconomic scenarios.

$\delta_{i,t}$ are the vectors of coefficients to be estimated $\beta' \gamma'$.

σ_i are unobserved effects to individual banks.

$\varepsilon_{i,t}$ is the error term.

The application of instrumental variables assists in eliminating econometric biases that can arise from the traditional panel data estimators, like pooled-OLS, and fixed and random effect (Chaibi & Ftiti, 2015). In this way, the introduction of dynamic models estimated using generalised method of moments (GMM) increases efficiency (Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998). This study will use GMM developed by Arellano and Bond (1991), based on the first difference transformation for estimating the dynamic panel models, in order to account for correlation between the credit risk indicator (NPLs) and the unobserved specific bank effect. Therefore, the equation can be rewritten as follows:

$$npl_{it} - npl_{it-1} = (\delta npl_{i,t-1} - npl_{i,t-2}) + \beta'(X_{i,t-1} - X_{i,t-2}) + \gamma'(Z_t - Z_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-2}) \quad (4.4)$$

$$\Delta npl_{it} = \delta \Delta npl_{i,t-1} + \beta' \Delta X_{i,t} \gamma' \Delta Z_t + \Delta \varepsilon_{i,t} \quad (4.5)$$

While Equation 4.4 assists in eliminating the individual level effect through differencing, another bias developed, where the lagged dependent variable npl_{it-1} , is correlated with the new error term $(\varepsilon_{i,t} - \varepsilon_{i,t-2})$.

The assumption is that a serial uncorrelated error term and explanatory variable are weakly exogenous, as depicted in Chapter 3, Sub-section 3.3.2.

$$E[npl_{i,t-w}(\Delta\epsilon_{i,t-1})] = 0 \quad \text{for } t = 3, \dots, T; \quad w \geq 2 \quad (4.6)$$

$$E[X_{i,t-w}(\Delta\epsilon_{i,t-1})] = 0 \quad \text{for } t = 3, \dots, T; \quad w \geq 2 \quad (4.7)$$

4.3.3 Stress testing and banking sector resilience

This chapter assesses the losses due to credit risk of the commercial banks in Tanzania, and uses both baseline and adverse scenarios for assessing the banking sector's resilience.

Baseline scenario: The study assumed that the bank profits for the forecast horizon are zero, and therefore don't increase equity capital (Vuković (2014), with 18 percent tax charges deducted as per the Tanzanian tax law (Tanzania, 2020). In addition, it is assumed that the regulatory and supervisory interventions are reflected in the available data, therefore there is no impact. Further, the risk-weighted assets (RWA), total assets, and gross loans are constant, in line with the assumption that banks do not change their balance sheet structure during the forecast horizon (Razafindravonona, 2021).

Adverse scenario: In addition to macroeconomic shocks, the study assumes that the RWA increase by the average of credit growth over the previous five years, for the aggregate banking sector depicted in the Tanzanian economy. Assuming a one standard deviation increase and decrease of the variable considered for the shock:

- A negative shock scenario for local GDP corresponds to the result of the generalised impulse functions (GIFs) of the G-VAR model on local variables, due to a reduction of one standard deviation in local GDP.
- A positive shock scenario for oil price corresponds to the result of GIFs of the G-VAR model on local variables, following an increase of one standard deviation in the oil price.
- A positive shock to the real effective exchange rate is a depreciation of the currency.

- A negative shock to the prices of agricultural commodities, due to an increase of one standard deviation in global agricultural commodity prices.

After the different scenarios are determined, the stressed results of the impact of the macroeconomic scenarios through credit quality on capital adequacy are obtained. The difference between NPLs before and after the stressed scenarios is computed to model capital losses as follows:

$$CAR = \alpha + B_1 NPL_{i,t} + \varepsilon_{i,t} \quad (4.8)$$

4.3.4 Data description and sources

To assess the impact of macro credit risk stress testing on banking sector resilience, the study looked at 15 banks accounting for more than 70 percent of the total assets of the commercial banks operating in Tanzania by 2020, in the period of Q1:2006 to Q4:2020. The selected sample ensured uniformity and consistency in terms of existence and merging. Credit risk can be influenced by multiple factors, ranging from banking-specific, macroeconomic, and financial variables (Amel, 2018; Chaibi & Ftiti, 2015; Razafindravonona, 2021).

For banking-specific variables, the panel had 1069 observations. The selected banking-specific variables that were simulated to influence credit risk in this study, were liquidity, leverage, profitability, and size of the bank. The study noted the fact that banking-specific variables can also be contributing determinants of credit risk despite their endogenous nature, there was therefore the need to expand on the list of commonly adopted macroeconomic variables (Louzis et al., 2012; Vuković, 2014). The banking sector variables focus on improving efficiency and risk management, and are therefore more likely to influence NPLs' evolution. Banking-specific variables for this study included bank size, liquidity ratio, loan-to-deposit ratio, return on assets (ROA), and leverage ratio (Kiemo et al., 2019; Raiter, 2021).

Bank size is a significant determinant of credit risk. With the presumption that they are 'too big to fail', large banks tend to take excessive risks and are more prone to the causes of crises, given the significance of their exposure and ability to spill over due to their interlinkages (Altman & Saunders, 1997; Chaibi & Ftiti, 2015). It is further narrated how

the 'too big to fail' banks had a significant impact on the financial sector in the global financial crisis of 2007/09 (Adrian et al., 2020). Therefore, size is negatively associated with credit risk, hence it is important to identify the magnitude of impact (Amel, 2018; Razafindravonona, 2021).

On the one hand, Boudriga et al. (2010) view return on assets (ROA) as a bank performance indicator in terms of profitability, gauging that banks with higher profitability have less pressure on revenue creation, and tend to take cautious risk approaches on the extension of credit. On the other hand, Chaibi and Ftiti (2015) narrate that bank efficiency ratio is approximated by ROA, meaning that a low cost-efficiency ratio implies an inability to manage resources and poor loan management. This results in mismanagement as well as inefficiency, which are associated with an increase in future NPLs. Therefore, there is a negative relationship between a decline in ROA and credit risk (Ahmed et al., 2021; Ekanayake & Azeez, 2015).

The liquidity ratio, as depicted by loan-to-deposit ratio, assesses the moral hazard behaviour of banks in consuming deposits collected to finance loans. Loan portfolios can increase riskiness, as the loan-to-deposit ratio increases, implying that more loans being disbursed are not backed up deposits being collected (Vuković, 2014). The significance of liquidity risk, by using the loan-to-deposit ratio, can be noted since it behaves negatively with respect to credit risk (Koju et al., 2018; Louzis et al., 2012). Another liquidity indicator that may affect credit risk, is the sum of available liquidity assets against the demand liabilities ratio. Ejoh et al. (2014) narrated that the ability of banks to turn their assets into cash and meet current obligations, is important and has a negative impact on credit risk.

The leverage ratio, as depicted by core capital against total assets, is also another determinant of credit risk. The capital structure of a bank is a significant factor, as the higher the leveraged capital, the higher the probability of taking more excessive risk to obtain returns with lower capital (Chaibi & Ftiti, 2015). This forms one of the determinants of moral hazard with respect to credit risk, as less capitalized banks may take riskier loans, hence resulting in a negative effect on NPLs (Chaibi & Ftiti, 2015; Tehulu & Olana, 2014).

Figure 4.1 depicts the averages of the banking-specific variables in this study, for the dimension of ownership of domestic and foreign banks. The statistics show that the banking sector in Tanzania is dominated by foreign banks in number; however, in terms of asset composition, the domestic banks account for 56 percent of the 15 banks in the sample, thus their performance is very significant in the economy (Tanzania, 2020). This study has brought into view the relevance of the individual banking sector's performance to the economy, by assessing the interlinkage between each bank in the sample through global and macro shocks to their resilience.

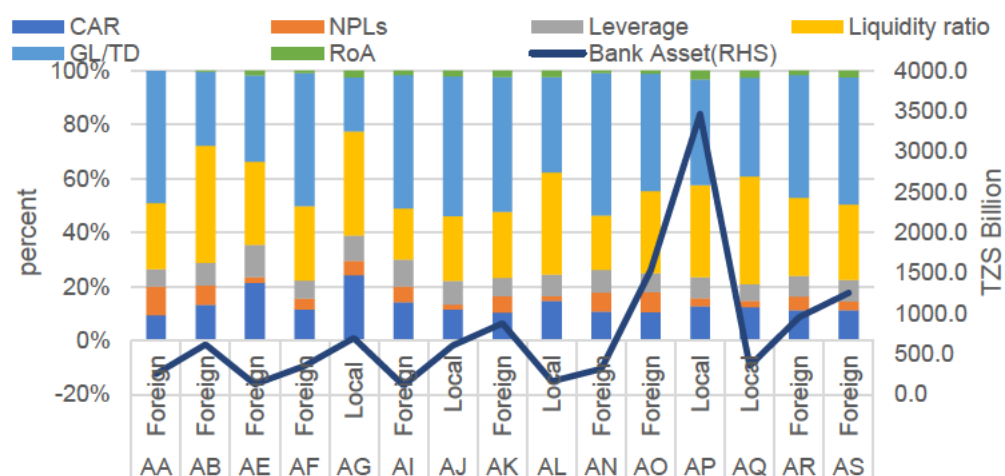


Figure 4.1: Average of banking sector variables from Q2-2006 to Q4-2020 for the 15 banks

Source: Author's own computation (2023)

Drawing from the literature review, most of the common determinants of credit risk are macroeconomic variables based on their exogenous nature (Castrén et al., 2010; Rakotonirainy et al., 2020). For this particular study, the usage of the GVAR model for the development of scenarios called for a range of macroeconomic variables to be selected, ranging between global, foreign, and domestic variables. For the domestic variables, the endogenous variables that were employed for Tanzania included GDP, inflation, real effective exchange rate, overnight rate, lending rate, and average deposit rate. The data for the macroeconomic variables was from the period of Q1:2006 to Q4:2020. Given the nature of the GVAR model outputs, foreign variables will be employed in the model as weak exogenous variables, including GDP, inflation, exchange rate, and short-term interest rate.

Gross Domestic Product is a significant indicator that is usually used to track the economic cycle of a country. GDP is approximated by the annual growth of real GDP in percentage. Studies show that during the expansion phase of an economy, borrowers need sufficient funds to support their repayments, while during a recession, their ability to service debt declines (Chaibi & Ftiti, 2015). In this regard, credit extension may be absorbed by low-quality debtors. Most studies conducted show that GDP has a negative relationship with NPLs, therefore economic activities are related to the functioning of the repayment pattern of banks (Ahmed et al., 2021; Koju et al., 2018; Louzis et al., 2012; Raiter, 2021).

The inflation rate is measured by the annual percentage change in the consumer price index of a country at a particular time (Chaibi & Ftiti, 2015; Louzis et al., 2012; Vuković, 2014). Based on the literature review conducted, the inflation rate is positively correlated to NPLs, as higher costs imply that loans are becoming expensive to repay (Ahmed et al., 2021; Ikram et al., 2016; Koju et al., 2018).

According to Razafindravonona (2021), the rise of the real effective exchange rate has a mixed impact, as the appreciation of this indicator may weaken the competitiveness of export-oriented firms and reduce their debt servicing ability. Further, other empirical studies show that the appreciation of the exchange rate has an impact on NPLs (Ekanayake & Azeez, 2015; Waqas et al., 2017). Conversely, the depreciation of the exchange rate has a positive impact on companies that borrow foreign currency to service debt (Razafindravonona, 2021). However, Tanzania's financial sector has more local currency lending, which accounts for more than 60 percent of the loan portfolio (BOT, 2019a), therefore, assessing the impact of currency appreciation is more relevant to studying the magnitude of this impact on NPLs. As such, the study will follow the approach of a positive impact of the exchange rate on NPLs (Ikram et al., 2016; Messai & Gallali, 2018).

Short-term interest rates are usually a proxy of the interbank cash market rate of the overnight or three months' average. Empirical studies have shown that the existence of high short-term interest rates has an impact on the cost of funding, therefore leading to a higher cost of borrowing (Kattai, 2010); this in turns leads to a high possibility of

challenges in repayments. In this case, the short-term interest rate is negatively correlated to credit risk (Ekanayake & Azeez, 2015; Rakotonirainy et al., 2020).

The capital adequacy ratio (CAR) is defined as the core capital against risk-weighted assets, under macroeconomic stress conditions (Rakotonirainy et al., 2020), and according to Razafindravonona (2021), it is calculated for banks to verify the impact of macroeconomic shocks on each one. After defining the macroeconomic scenarios and assessing their implication on credit risk, the study intends to assess the resilience of the banking sector. CAR is another dependent variable used in this study, which is one of the bank-specific variables. (Buncic & Melecky, 2013).

Table 4.1 is a summary of the variables for this chapter. However, the global variables adopted in this chapter are the same as those in Chapter three, Section 3.3.2, where they were broadly described.

Table 4.1: A summary of the variables

| Foreign and domestic variables | | | | |
|--------------------------------|--|--|-------------------|--|
| Sno. | Variables | Definition | Hypothesis tested | References |
| 1. | GDP | Year-on-year change of gross domestic product in percentage. | (-) | Chaibi and Ftiti (2015) Ikram et al. (2016) Raiter (2021) |
| 2. | Inflation | Annual inflation growth rate at time t as measured by consumer price index. | (+) | Ahmed et al. (2021) Chaibi and Ftiti (2015) Louzis et al. (2012) |
| 3. | Exchange rate (real effective exchange rate) | The weighted average of a country's currency in relation to an index or basket of other major currencies. | (+) | Waqas et al. (2017) Ikram et al. (2016) Razafindravonona (2021) |
| 4. | Short-term interest rate | The interbank cash market rate of the overnight or three months' average. | (-) | Ekanayake and Azeez (2015) Razafindravonona (2021) |
| Global macro variables | | | | |
| Sno | Variables | Definition | Hypothesis tested | References |
| 5. | All metal index | This is designed to reflect the behaviour and performance of the metals sector (including mining). | (-) | Nikolaidou and Vogiazas (2017) Rakotonirainy et al. (2020) |
| 6. | Crude oil price index | This provides investors with a reliable and publicly available benchmark for investment performance in the crude oil market. | (+) | Castrén et al. (2010) B. Amel, Youssef (2018) |
| 7. | All commodity price index | A commodity index is an investment vehicle that tracks the prices and return on investment of a basket of commodities. | (+) | Khan (2020) Rakotonirainy et al. (2020) |
| Sno. | Banking Variables | Definition | Hypothesis tested | References |

| | | | | |
|-----|------------------------------|---|-------|--|
| 8. | Non-performing loans | $npl_{it} = \frac{\text{non performing loans}_{it}}{\text{gross loans}_{it}}$ | | Abdolshah et al. (2021) Arestis and Jia (2018) Vazquez et al. (2012) Başarır (2016) |
| 9. | Return on assets | $RoA_{it} = \frac{\text{Net Profit}_{it}}{\text{Total Assets}_{it}}$ | (-) | Boudriga et al.(2010) Altman and Saunders (1997) Ekanayake and Azeez (2015) |
| 10. | Bank size | $B_S = \frac{\text{Total Assets}_{it}}{\text{Total Assets}_{it}}$ | (-) | Chaibi and Ftiti (2015) B. Amel, Youssef (2018) |
| 11. | Loan-to--deposit ratio | $LTD_{it} = \text{Loans}_{it} / \text{Deposit}_{it}$ | (+) | Vuković (2014) Louzis et al. (2012) Ahmad and Ariff (2008) |
| 12. | Liquidity ratio | $LiR = \frac{\text{Current Assets}_{it}}{\text{Demand Liabilities}_{it}}$ | (-) | (Ejoh et al., 2014) |
| 13. | Leverage ratio | $LR_{it} = \text{Core capital}_{it} / \text{Total assets}_{it}$ | (+/-) | Chaibi and Ftiti (2015) |
| 14. | Capital adequacy ratio (CAR) | $= \frac{\text{Core capital}_{it}}{\text{Risk weighted Assets}_{it}}$ | | B. Amel, Youssef (2018) Rakotonirainy et al. (2020) Taskinsoy (2018) |

Source; Author's own collection

4.4 Estimated results

This section presents the results of the estimation based on the question linked to attaining the objective of this study. Two hypotheses about our expectation of the relationship between macro credit risk stress testing and bank resilience in Tanzania, are tested. A presentation of the descriptive statistics used in the model, for both the banking-specific and domestic variables, is necessary before presenting the results of the different stages of the estimation of the panel model. Later the reactions of credit risk (NPLs) under adverse macroeconomic scenarios are measured, and subsequently reflected in the capital adequacy position.

4.4.1 Descriptive statistics

The descriptive statistics for the banking-specific and domestic variables used in the study, are shown with their mean, minimum, maximum, and standard deviation for the quarterly data for the period in review. This data is processed using the E-views software. The sample is of 15 banks that account for approximately 79 percent of total assets, with 1062 observations, and the results are shown in Table 9 below. The key variables discussed in this summary of the statistics are dependent variables, NPLs and CAR, independent variables, and bank-specific and macroeconomic variables.

The summary of the statistics for the banking-related variables depict that, on average, the NPLs level stood at 7.47 percent - slightly higher than the acceptable level of 5.0 percent, thus calling for their close monitoring to minimize credit risk in Tanzania. The average CAR for the sampled banks stood at 19.07 percent, with a standard deviation spread far from the mean of 8.47 percent. As the Tanzanian banking sector recorded a high average CAR, above the core and total regulatory minimum requirements of 10 percent and 12 percent, respectively, the ROA was averaged at 2.48 percent. This implies that the ability for the Tanzanian banks to enhance profit generation by the issuance of loans, their key function, was low; this was mainly driven by challenges in the lending market linked to collateral management and repayments (Tanzania, 2020). In addition, the average leverage ratios depict the reliance on debt compared to equity in financing the bank's operations, and they stood above the minimum requirements of 20 percent, hence there was sustainability to meet current short-term obligations.

The banking-related factors show that the degree of normality skewedness was positive for all indicators, except ROA, and the kurtosis of the curve was leptokurtic for all the indicators. This was amplified by the probability of the Jarque-Bera test that showed less than 5 percent significance, thus accepting the alternative hypothesis of normal distribution.

Over the period of study, the macroeconomic variables denote an average of 6.57 percent for GDP, 7.52 percent for inflation, 6.98 percent for interest rate, and 1.05 percent for REER. On the skewness side, all the variables were positive except for GDP, while the

results for kurtosis represent a leptokurtic distribution for inflation and interest rate. As denoted by the Jarque-Bera, the probability for all the variables was less than a 5 percent level of significance, except for GDP, rejecting the null hypothesis and representing normal distribution.

Table 4.2: Summary statistics

| Particular | N | Mean | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | Probability |
|--|-----|---------|---------|----------|-----------|----------|----------|-------------|
| Banking-related indicators | | | | | | | | |
| NPLS | 106 | 7.47165 | 34.9500 | 0.00000 | 5.98362 | | 5.81346 | |
| | 2 | 7 | 0 | 0 | 9 | 1.581471 | 0 | 0.000000 |
| ROA | 106 | 2.47740 | 19.8800 | | 2.16759 | | 9.71264 | |
| | 2 | 1 | 0 | -12.6300 | 5 | -0.1203 | 5 | 0.000000 |
| LEV | 106 | 11.8511 | 38.9300 | | 4.21437 | | 6.81852 | |
| | 2 | 5 | 0 | -2.7900 | 7 | 1.149924 | 3 | 0.000000 |
| BAT | 106 | 879.881 | 7254.99 | 24.1140 | 1237.69 | | 11.9885 | |
| | 2 | 8 | 8 | 0 | 8 | 2.909626 | 9 | 0.000000 |
| LIQ | 106 | | | | | | | |
| | 2 | 42.0252 | 83.7900 | 9.8200 | 14.8926 | 0.3943 | 2.3800 | 0.000000 |
| CAR | 106 | 19.0780 | 57.0400 | | 8.47585 | | 6.89625 | |
| | 2 | 4 | 0 | -3.9400 | 4 | 1.856899 | 6 | 0.000000 |
| Macroeconomic related variables | | | | | | | | |
| GDP | 106 | 6.57127 | 10.2294 | 2.93130 | 1.63083 | | 2.67321 | |
| | 2 | 4 | 2 | 0 | 9 | -0.0054 | 7 | 0.093931 |
| INF | 106 | 7.51869 | 19.8000 | 3.10000 | 4.09358 | | 4.02255 | |
| | 2 | 2 | 0 | 0 | 5 | 1.260263 | 8 | 0.000000 |
| REE | 106 | 1.05041 | 1.27677 | 0.83617 | 0.11486 | | 2.16209 | |
| | 2 | 8 | 5 | 1 | 7 | 0.250946 | 7 | 0.000000 |
| OIL | 106 | 159.176 | 263.486 | 76.2196 | 47.4829 | | 1.99853 | |
| | 2 | 8 | 3 | 8 | 3 | 0.242221 | 8 | 0.000000 |
| INT | 106 | 6.98429 | 19.0557 | 0.79579 | 4.41613 | | 3.20392 | |
| | 2 | 9 | 2 | 2 | 5 | 0.883903 | 4 | 0.000000 |

Source: Author's own collection (2023)

4.4.2 Panel unit root test

This is conducted to identify non-stationarity, which is the presence of unit root tests. The study conducted panel unit root tests using: ADF-Fisher Chi-square; Levin, Lin & Chu t; Im, Pesaran and Shin; and PP - Fisher Chi-square. The study was based on the assumption that all these tests had the hypothesis of: where null hypothesis stated that, *panel data are not stationary*, meaning there is unit root and alternative hypothesis, was where *panel data are stationary*, meaning there is no presence of unit root, $p_i = 1$; $p_i \neq 1$. The adoption of more than one test provides room for cross-checking accuracy and comparison to ensure consistency. These panel unit root tests are selected due to their robustness, ease in computation, usage in studies for which parametric assumptions cannot be met, and their flexibility in handling data (Gengenbach et al., 2009). On a similar

note, a panel data analysis is important due to its robustness compared to time series tests, as it avoids wrong inferences and spurious regressions (Baltagi & Baltagi, 2008).

$$Y_{it} = p_{it}Y_{it-1} + X_{it}\phi_{it} + \varepsilon_t \quad (4.7)$$

Where $i = 1, 2, \dots, 15$ banks, over the period of $t = 2006, \dots, 2020$

X_{it} represent all the explanatory variables used in the model.

p_i represent the autoregressive coefficients

ε_t represent the error terms

This means that the dependent variable was dependent on its own delay, and that it contained a unit root (not stationary), which can lead to erroneous results when testing the significance hypothesis of the explanatory variables $/p_i/ = 1 Y_i Y_i$. The summary of the panel unit root test are shown in the table below:

Table 4.3 and *Table 4.4* show a summary of unit root tests of panel data for banking-related indicators and macroeconomic variables, respectively. Table 10 denotes that NPLs and CAR are stationary at level using all unit root test approaches, except for Levin, Lin & Chu t, that showed that there was a unit root test at first difference. Further, LEV and ROA show that all the unit root test approaches were reported to be stationary at level. The bank size in all the unit root approaches was reported to be stationary at first difference. *Table 4.4* shows the summary of the statistics for the macroeconomic variables, with GDP, oil, and interest rate all recorded to be stationary at level for all the unit root approaches, except for inflation and REER, for Levin, Lin & Chu t and PP-Fisher Chi-square at first difference, respectively. Conversely, all the unit root approaches adopted in this study confirm that the variables are stationary.

Table 4.3: Unit root test results for banking related indicators

| Banking-related Indicators | Test | Statistical Value | | P-value | |
|----------------------------|-------------------------|-------------------|------------|-----------|------------|
| | | level | First Diff | level | First Diff |
| NPLs | Levin, Lin & Chu t | -0.85 | -15.42 | 0.19 | 0.000*** |
| | Im, Pesaran and Shin | -3.34 | | 0.000*** | |
| | ADF - Fisher Chi-square | 67.01 | | 0.0023*** | |
| | PP - Fisher Chi-square | 74.88 | | 0.000*** | |
| ROA | Levin, Lin & Chu t | -2.52 | | 0.005*** | |
| | Im, Pesaran and Shin | -4.86 | | 0.000*** | |
| | ADF - Fisher Chi-square | 90.09 | | 0.000*** | |
| | PP - Fisher Chi-square | 117.11 | | 0.000*** | |
| LEV | Levin, Lin & Chu t | -1.43 | | 0.07* | |
| | Im, Pesaran and Shin | -2.82 | | 0.002*** | |
| | ADF - Fisher Chi-square | 64.41 | | 0.002*** | |
| | PP - Fisher Chi-square | 96.53 | | 0.000*** | |
| BAT | Levin, Lin & Chu t | 1.47 | -18.1 | 0.93 | 0.000*** |
| | Im, Pesaran and Shin | -0.4 | -18.69 | 0.34 | 0.000*** |
| | ADF - Fisher Chi-square | 39.2 | 377.66 | 0.32 | 0.000*** |
| | PP - Fisher Chi-square | 41.74 | 690.2 | 0.23 | 0.000*** |
| CAR | Levin, Lin & Chu t | -0.36 | -19.93 | 0.35 | 0.000*** |
| | Im, Pesaran and Shin | -2.33 | | 0.009*** | |
| | ADF - Fisher Chi-square | 61.99 | | 0.004*** | |
| | PP - Fisher Chi-square | 82.08 | | 0.000*** | |

***, **, * represent the level of significance of 1 percent, 5 percent, and 10 percent, respectively.

Source: Own estimation using E-views 12 (2023)

Table 4.4: Unit root tests results for macroeconomic variables

| Macroeconomic Variables | Test | Statistical Value | | P-value | |
|-------------------------|-------------------------|-------------------|------------|----------|------------|
| | | level | First Diff | level | First Diff |
| GDP | Levin, Lin & Chu t | -9.14 | | 0.000*** | |
| | Im, Pesaran and Shin | -13.09 | | 0.000*** | |
| | ADF - Fisher Chi-square | 238.62 | | 0.000*** | |
| | PP - Fisher Chi-square | 373.01 | | 0.000*** | |
| INF | Levin, Lin & Chu t | -0.46 | -1.46 | 0.32 | 0.07* |
| | Im, Pesaran and Shin | -3.65 | | 0.000*** | |
| | ADF - Fisher Chi-square | 61.49 | | 0.005*** | |
| | PP - Fisher Chi-square | 55.73 | | 0.019** | |
| REE | Levin, Lin & Chu t | -2.01 | | 0.027** | |
| | Im, Pesaran and Shin | -3.62 | | 0.000*** | |
| | ADF - Fisher Chi-square | 61.22 | | 0.005*** | |
| | PP - Fisher Chi-square | 43.75 | 425.45 | 0.175 | 0.000*** |
| OIL | Levin, Lin & Chu t | -2.44 | | 0.007*** | |
| | Im, Pesaran and Shin | -4.74 | | 0.000*** | |
| | ADF - Fisher Chi-square | 78.83 | | 0.000*** | |
| | PP - Fisher Chi-square | 78.83 | | 0.000*** | |
| INT | Levin, Lin & Chu t | -9.38 | | 0.000*** | |
| | Im, Pesaran and Shin | -7.82 | | 0.000*** | |
| | ADF - Fisher Chi-square | 128.02 | | 0.000*** | |
| | PP - Fisher Chi-square | 146.97 | | 0.000*** | |

***, **, * represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Own estimation using E-views 12 (2023)

4.4.3 Diagnostic test

Before proceeding with the use of the GMM estimation results, it is important to check for the instrument validity and reliability of the models. Diagnostic test were done using Sargen- Hansen test for instrument validity test and autocorrelation test was assessed using Arellano bond test. The results are detailed in sub section 4.4.3.1 and 4.4.3.2.

4.4.3.1 Instrument validity test

Tests for instrument validity are usually done either using the method proposed in the study by (Hansen, 1982) or by using the Sargan test for the validity of the instruments (Newey, 1985). For testing the overall validity of the instruments, the study has adopted the Sargen- Hansen test, also known as the J test, which is a statistical test used for testing over-identifying restrictions in a statistical model (Hansen & Singleton, 1982). Considering a null hypothesis, $H_0 = \text{the instruments are valid}$, and an alternative hypothesis, $H_a = \text{the instruments are not valid}$, if p is less than the 5 percent level of significance, the null hypothesis is rejected. Table 4.5 shows that the probability was above the 5 percent level, therefore, the output presents evidence that the null hypothesis should not be rejected; as such, the over-identifying restrictions of the instruments are valid. The number of instruments in this study was 898 and the probability value was 0.45.

4.4.3.2 Autocorrelation test

Different studies have adopted several methods for testing serial error correlation tests, ranging from the Arellano bond test (Wursten, 2018), to the Wooldridge test as described by (Patel et al., 2020). This study adopted the Arellano bond test, which is a test for zero autocorrelation in first differenced errors based on the residuals of the estimation, with a null hypothesis of $H_0 = \text{there is no autocorrelation or serial correlation in error term}$, with the probability being less than the 5 percent of the level of significance; otherwise the alternative hypothesis is of $H_a = \text{there is autocorrelation or serial correlation in error term}$. The outputs revealed that difference at order 1 (AR1) and difference at order 2 (AR2) were present.

Table 4.5: Autocorrelation/serial correlation test

| Test order | Coefficient (t-Statistic) | | Prob. |
|------------|---------------------------|------|-------|
| | 1 | 2 | |
| AR(1) | 0.1 | 0.04 | 0.08 |
| AR(2) | 0.83 | 0.52 | 0.94 |

Source: Author's own computation (2023)

4.5 Empirical results and discussions

4.5.1 Results of the dynamic panel model

For efficiency and robust estimates, different dynamic panel estimation models were used to test the stability of the coefficients. This study opted to deploy two-step system GMM instead of difference GMM, as it is very powerful and flexible, and also avoids endogeneity. The embedded diagnostic tests support the feasibility and reliability of the adopted instrumental approach of GMM, which is a dynamic panel estimator (Arellano & Bover, 1995; Blundell & Bond, 1998). In employing two-step system GMM, the use of lagged values of both levels and differences is done until orthogonality is reached. **Table 4.7** presents the coefficients of the GMM estimator of the dynamic specification with fixed effects. This study is in line with the economic theories and studies by Razafindravonona (2021), Amel (2018), and Chaibi and Ftiti (2015). This section provides an interpretation of the GMM estimation results, and assesses the relationship between macroeconomic and bank-specific variables on credit risk, to confirm whether there is consistency with the predicted signs and anticipated hypothesis.

Table 4.6 denotes that the NPLs ratio is not only reactive to bank-specific factors, but rather to macroeconomic variables. The explanatory variables, including the lagged dependent variable (NPL ratio), were all statistically significant, except the liquidity ratio and real effective exchange rate (REER). The study assessed the relationship between the lagged NPLs ratio and NPLs, which had an anticipated and predicted positive effect. The results in table 4.6 reveal that the lag value for NPLs is positive and statistically significant, as shown by models 1, 2 and, 3; this implies that an increase in NPLs in the previous quarter is likely to increase NPLs in the next quarter, for which a coefficient of a 0.48 percent increase is obtained, thus signaling the ability to increase credit risk to the

next quarter. This is corroborated with previous studies by (Sorge & Virolainen, 2006) and (Razafindravonona, 2021). This confirms the relevance of stress tests undertaken in Tanzania with the assumption of an increase in aggregate NPLs, which may potentially lead to an increase in credit risk for the Tanzanian banking sector in the future (BOT (2019a); as such, this calls for policymakers to propose mitigation measures.

The relationship between the banking sector and credit risk is assessed based on the leverage ratio, liquidity ratio, return on assets (RoA), and bank size. The relationship between the leverage ratio and credit risk has a predicted effect of either positively or negatively testing the moral hazard hypothesis. The results from the GMM estimation depict that the leverage ratio was positive and statistically significant to credit risk, with coefficients of 0.1 percent as predicted. This signaled that a bank with a higher leverage ratio tends to take more exposure when lending, thus increasing its financial risk as well as its credit risk, which is corroborated by (Louzis et al., 2012). Similarly, bank size was reported as being positive and statistically significant to credit risk; this result is consistent with the predicted assumption, from the study by Chaibi and Ftiti (2015), and the diversification hypothesis that amplified the fact that the bigger the size of a bank, the larger its exposure. These results conformed the findings in the study by Razafindravonona (2021), who identified that the larger the bank, the higher the risk.

For this study, the findings show that there is a relationship between increased leverage ratios and bank size, in alignment with the findings by (Waithaka, 2013), who alluded that a well capitalised banking sector is able to maximize return and meet regulatory requirements, by expanding the diversifications of risky assets for different lending categories. Further, the results in this study reflect that larger banks in the Tanzanian banking sector maintain adequate capital, thus lower funding costs, compared to smaller banks whose capital is minimal; this, therefore, increases the cost of funding to finance loans, resulting in the creation of a higher potential for losses through default.

On the one hand, for the liquidity ratio, the GMM results reflected a positive coefficient of 0.01 percent for credit risk; although this is not statistically significant, it is partly supported by the increased ability of a bank to assess loans as well as meeting demand liabilities, as narrated by (Inshira & Jahfer, 2019) in their study. The results signal that the Tanzanian

banking sector has sufficient liquidity buffers that are able to meet the demand liabilities as well as facilitate lending in the economy.

On the other hand, the predicted return on assets (RoA) depicted a negative and statistically significant effect on credit risk, implying that the efficient utilisation of assets has a negative correlation to credit risk. This implies that the more efficient a bank is, the lower its potential for credit risk; this result is in line with the findings by (Ejoh et al., 2014) and the moral hazard hypothesis. Further, this result is aligned with the first objective of this study, which aimed at assessing banking sector resilience, enriching the agency theory, as well as asset and liability management theory, by attributing the significance of the efficient functioning of a bank in mitigating credit risk (Erwin et al., 2018). These results amplify the fact that the Tanzanian banking sector needs to increase its profitability levels to be able to absorb credit exposures, as profits are a resultant of both lending and prompt repayments, in line with modern portfolio theory (Kazan & Uludağ, 2014).

Macroeconomic variables, namely GDP, inflation rate, REER, oil price, and interest rate, also influence credit risk as depicted in Table 4.7. The results reveal that GDP is positive and statistically significant in influencing credit risk, which is not consistent with the hypothesis from the studies by (Ghosh, 2015) and (Bitar et al., 2018). However, the results are consistent with the findings in Chapter 3 of this study, which depicted that domestic GDP is not a major cause of credit risk, as more than 50 percent of the economy is financed by the informal financial sector. The inflation rate, on the other hand is expected to have a varied effect, either positive or negative (Chaibi & Ftiti, 2015), though this study's results reflected a negative and statistically significant influence on credit risk, with negative coefficients of -0.08 percent. Interest rates have a direct effect on the credit risk, thus the higher the interest rates, the higher the credit risk, which was confirmed by the findings of this study. The results reflected a positive and statistically significant influence, with a 0.07 percent coefficient. Meanwhile, the exchange rate (REER) had a negative coefficient of 3.15 percent, reflecting that it had no significant impact on credit risk, due to less exposure of banks to foreign denominated loans; this is in line with the findings by (Amel, 2018; Beck et al., 2015).

Table 4.6: Results of the estimation of dynamic panel model with fixed effects

| Dependent Variable: Non-Performing Loans | | | | | | | |
|--|---------------------------|-------|--------|------|--------------|------|-----------------|
| Estimation: Two System GMM | | | | | | | |
| Variables | Coefficient (t-Statistic) | | | | | | Predicted Signs |
| Specific to Bank | -1 | | -2 | | -3 | | |
| NLPs (-1) | 0.48** | 2.05 | 0.66** | 2.55 | 0.42* | 1.89 | + |
| Lev | 0.1 | 1.98 | 0.03 | 0.93 | 0.09* | 2.01 | -/+ |
| Liq | 0.01 | 1.01 | 0.004 | 0.34 | 0.01 | 1.34 | + |
| ROA | -0.73*** | -2.73 | | | - 0.07*** | 3.07 | |
| BAT | 0.0004* | 1.98 | | | | | + |
| Macroeconomic Variables | | | | | | | |
| GDP | 0.26** | 2.12 | 0.17 | 1.48 | 0.29** | 2.44 | - |
| Inf | -0.08 | -1.53 | -0.08 | 0.39 | .0.10* | 1.97 | -/+ |
| REE | -3.15 | 0.82 | -0.61 | 0.89 | 1.12 | 0.43 | -/+ |
| Int | 0.07** | 2.66 | 0.04* | 1.77 | 0.07** | 2.61 | + |
| Number of Instruments | 898 | | 898 | | 899 | | |

Absolute value of T-statistics in parenthesis. *** means p<1percent; ** means p<5percent; * means p<10percent.

Source: Author's calculation

4.5.2 Reaction of credit risk indicators to scenarios of macroeconomic shocks

This section presents a simulation of credit risk exposure to macroeconomic shocks for each individual bank, from the results obtained from the panel data estimates from the GMM output. This study conducted “baseline” and “adverse and plausible” scenarios. The baseline scenario was based on the current status as per Q3:2020, and pointed to a normal evolution of the economic situation without the GVAR model causing any shock. An adverse scenario assumed a hypothetical impact of the macroeconomic shocks on the banks' credit risk, whereby the simulation of the impulse response functions of the GVAR model followed a decrease or increase of one standard deviation of the variable considered for the shock (Razafindravonona, 2021).

In doing so, this study deployed an auxiliary model that included a vector of macroeconomic variables for all sampled banks, which is described as the macroeconomic scenarios simulating shocks from the GVAR model described in *Chapter 4*, and is denoted as W_t in the equation (2) below as follows:

$$NPLs_{it} = \alpha_i + \theta_{i,t}NPLs_{i,t-1} + \delta'X_{i,t} + \pi'W_t + \mu_i + \varepsilon_{i,t} \quad (4.4.2)$$

In line with the studies by (Amel, 2018) and (Razafindravonona, 2021), stress testing was conducted by considering the paths of macroeconomic factors as exogenous, implying that banks' profit/loss did not transmit to the economy at large. Nevertheless, in practice, expert judgment forms part of determining which macroeconomic variables go into a model.

The impact of individual banks' credit risk on macroeconomic shocks was assessed, based on four major adverse scenarios generated from the GVAR model obtained in Chapter 3; "*h+4*" and "*h+8*" were used, implying that forecasts were for every four and eight quarters, respectively. The following scenarios were adopted from Chapter 3 in this study, for addressing the NPLs for individual banks, which are designated as bank AA to AS. The following scenarios were designed in line with studies by (Razafindravonona, 2021):

- i. *Domestic GDP shock scenario*: in relation to the results of the generalised impulse response (GIRFs) of the GVAR model, assessing the behaviour of banks following the reduction of one standard deviation in local GDP.
- ii. *Agricultural commodities price shock scenario*: corresponding to the results of the generalised impulse response (GIRFs) of the GVAR model, following a negative shock of one standard deviation in the price of agricultural commodities.
- iii. *Oil price shock scenario*: corresponding to the results of the generalised impulse response (GIRFs) of the GVAR model, following an increase of one standard deviation in the oil price.

Generally, this study observed that the Tanzanian banking sector was more responsive to negative shocks in domestic GDP on individual banks, compared to what was observed in the aggregated bank effect of the credit risk stress tests in Chapter 3.

4.5.2.1 Negative shock scenario on domestic GDP

Table 4.8, depicts the results of shocks in domestic GDP on NPLs for individual banks. The results show that all banks had NPLs forecasts for both “ $h+4$ ” and “ $h+8$ ”. For the baseline scenario for this particular study, as reflected in the period of Q3:2020, only two foreign banks, AE and AS, and one domestic bank, AI, had NPLs level below the 5.0 percent acceptance level. This signals that these banks had an effective underwriting of credit and repayments of borrowers, while the remaining banks had ratios above the acceptable limit in Tanzania, as expressed in (Tanzania, 2020).

The adverse scenario of one negative shock in domestic GDP in the following four and eight forecasted quarters, was anticipated to exhibit an increase in the NPLs ratio for all 15 banks. The results portray a larger shock with a 3-7 percent anticipated increase in the NPLs ratio for banks AA, AG, and AL, which are foreign banks, and for AC, which is a domestic bank, thus reflecting the magnitude of exposure related to lending by foreign banks, which contribute to GDP growth in Tanzania (BOT, 2019a). The results of a domestic GDP shock increasing the NPLs ratio is in line with the findings by B. Amel, Youssef (2018), in Tunisia and Razafindravonona (2021) conducted in Madagascar, which attested to the significance of GDP growth in affecting the NPLs ratio among their banks. This signals the profound influence of shocks in the business cycle to the banking sector in Tanzania. The results amplified the theories of agency and portfolio that insist that efficiency of the banking sector results in risk exposures (Erwin et al., 2018). The Tanzanian banking sector is influenced by domestic GDP, thus warranting close monitoring of changes in the economy. From this study, the Tanzanian GDP reflected the effects it has on the performance of the banking sector.

4.5.2.2 Negative shock in the price of agricultural commodities

A negative shock variation from agricultural commodities in the GVAR model reflected a relatively different output from other studies (Amel, 2018; Razafindravonona). Table 4.8, shows the results of how changes in the price of agricultural commodities, reflected a decrease in NPLs in the fourth and eighth quarter, which was forecasted for all 15 banks from AA and AS. The decline in NPLs varied from 0.03 percent to 0.47 percent for the next four quarters, and from 0.09 percent to 1.01 percent for the following four quarters.

The results reveal that most banks in the Tanzanian economy were not sensitive to changes in global agricultural commodities, partly due to less financing of that segment of the economy by the banking sector. In addition, this signals that there was an inverse response compared to the results revealed by Razafindravonona (2021), which reflected the shocks on agricultural prices resulting from an increase in NPLs, and thus a slowdown in repayments. The results imply that the Tanzanian agriculture sector is not funded by the banking sector, that there is minimal commercial farming, and that there is more domestic funding of it, as attested by the findings of (BOT, 2021a-a).

4.5.2.3 Positive shock in the price of oil

Another scenario in the study was an increase in oil prices on the banking sector through credit risk. The results in Table 14 show that all the banks were expected to have an increased NPLs ratio due to a 1 percent shock in oil prices, with AA, AC, AD, AI, and AJ banks experiencing a more significant effect. The overall banking sector was prone to risk in case oil prices surged, as the study revealed the impact of the shock would result in an increase ranging from 0.38 percent to 2.87 percent for the next four quarters, and from 0.33 percent to 2.57 percent for the following four quarters. This portrays the magnitude of credit extension by these banks to the sectors that are reliant on oil price, such as trade, transport, and manufacturing. This is in line with studies that have attested to how net oil importing countries are affected by increases in oil prices, in sectors that need oil to function (Abdolshah et al., 2021; Messai & Gallali, 2018; Taskinsoy, 2018). The implication of oil price shocks may lead to an increase in credit risk exposures, due to challenges in repayments as a result of cash flow mismatches, which attributes for the impact that occurred in the Tanzanian economy in 2020 (BOT, 2021b-a). Further, oil price shocks may also lead to a substantial increase in the inflation rate of major food crops, which is attributed to a higher cost of transportation, thus leading to increased household repayments.

Table 4.7: Change of NPLs after macroeconomic scenarios

| Banks | Ownership | Baseline scenario | Adverse scenarios | | | | | |
|-------|-----------|-------------------|--------------------------------|-----------------|---|---------------|------------------------------------|-----------------|
| | | NPL (2020q3) | Negative shock to domestic GDP | | Negative shock in the price of agricultural commodities | | Positive shock in the price of oil | |
| | | | h+4 | h+8 | h+4 | h+8 | h+4 | h+8 |
| AA | Foreign | 15.59 | 20.62 (5.03) | 22.55 (6.96) | 15.35 0.24 | 15.07 0.52 | 18.46 (2.87) | 18.11 (2.52) |
| AB | Foreign | 8.6 | 11.37 (2.77) | 12.44 (3.84) | 8.47 0.13 | 8.31 0.29 | 10.18 (1.58) | 9.99 (1.39) |
| AE | Foreign | 2.05 | 2.71 (0.66) | 2.97 (0.92) | 2.02 0.03 | 1.98 0.07 | 2.43 (0.38) | 2.38 (0.33) |
| AF | Foreign | 7.39 | 9.77 (2.38) | 10.69 (3.30) | 7.28 0.11 | 7.14 0.25 | 8.75 (1.36) | 8.58 (1.19) |
| AG | Local | 13.3 | 17.59 (4.29) | 19.24 (5.94) | 13.1 0.20 | 12.86 0.44 | 15.75 (2.45) | 15.45 (2.15) |
| AI | Foreign | 4.8 | 6.35 (1.55) | 6.94 (2.14) | 4.73 0.07 | 4.64 0.16 | 5.68 (0.88) | 5.58 (0.78) |
| AJ | Local | 13.3 | 17.59 (4.29) | 19.24 (5.94) | 13.1 0.20 | 12.86 0.44 | 15.75 (2.45) | 15.45 (2.15) |
| AK | Foreign | 6.73 | 8.9 (2.17) | 9.73 (3.00) | 6.63 0.10 | 6.51 0.22 | 7.97 (1.24) | 7.82 (1.09) |
| AM | Local | 5.81 | 7.68 (1.87) | 8.4 (2.59) | 5.72 0.09 | 5.62 0.19 | 6.88 (1.07) | 6.75 (0.94) |
| AN | Foreign | 7.88 | 10.42 (2.54) | 11.4 (3.52) | 7.76 0.12 | 7.62 0.26 | 9.33 (1.45) | 9.15 (1.27) |
| AO | Foreign | 6.42 | 8.49 (2.07) | 9.29 (2.87) | 6.32 0.10 | 6.21 0.21 | 7.6 (1.18) | 7.46 (1.04) |
| AP | Local | 7.08 | 9.36 (2.28) | 10.24 (3.16) | 6.97 0.11 | 6.84 0.24 | 8.38 (1.30) | 8.22 (1.14) |
| AQ | Local | 5.12 | 6.77 (1.65) | 7.41 (2.29) | 5.04 0.08 | 4.95 0.17 | 6.06 (0.94) | 5.95 (0.83) |
| AR | Foreign | 5.66 | 7.49 (1.83) | 8.19 (2.53) | 5.57 0.09 | 5.47 0.19 | 6.7 (1.04) | 6.57 (0.91) |
| AS | Foreign | 2.72 | 3.6 (0.88) | 3.93 (1.21) | 2.68 0.04 | 2.63 0.09 | 3.22 (0.50) | 3.16 (0.44) |

Changes in the NPL ratio are expressed as a percentage. h indicates the horizon of quarters after 2020q3. The values in brackets are the changes from the initial value of the NPLs ratio in 2020q3.

4.5.1 Impact of credit risk on bank's capital position

This section provides insights into the impact of macro scenarios transmitted from NPLs shocks to capital position. The change in a bank's credit risk is expected to reflect in its capital adequacy ratios, adopting the approach by (Vuković, 2014), while taking into account several assumptions due to data constraints. Some of the assumptions adopted in this study considered that risk-weighted assets (RWA) would increase in a constant way by 4.8 percent, which is a ratio obtained from the variation in annual credit growth for a period of five years in Tanzania (BOT, 2021a-a). In addition, the total loans are assumed to be constant at the time of projection t , in relation to the average, based on other similar studies done by B. Amel, Youssef (2018) and Razafindravonona (2021). Further, this study also assumed that profit over the time horizon would be zero, implying that CAR would not increase as a result of profits (Rakotonirainy et al., 2020).

This study adopted the ratio of the capital adequacy ratio to reflect capital position, for which Tanzania stood at 10 percent and 12 percent for core capital and total capital, respectively (BOT, 2021b-a). Moving from the pre-stress test to the stress capital position, which was affected by macroeconomic shocks in Tanzania, the use of total loans observed in each of the 15 banks was used, in particular for the last quarter of the time horizon Q4:2020. Later, capital loss was computed, taking into account the difference between the pre- and post-stress NPLs ratios, as shown in Table 4.8 above, after applying the macroeconomic shocks through the GVAR analysis. Based on the prior assumptions, the capital loss is deducted from the existing capital, whereby the new absolute capital is obtained. The post-shock CAR ratio is computed using the new capital, constant RWA, and assumed 5.96 percent RWA, to assess the magnitude of loss in capital as a percentage (see Table 4.9). This assumption is in line with the studies by (Amel, 2018; Méndez-Marcano, 2021).

Table 4.8: The computation of the stressed CAR for each bank

| S/N | Particulars | Formula for each Bank |
|-----|---|--|
| A | Total loans (TL) | Absolute value in Q4:2020 |
| B | Difference in NPLs ratio before and after stress (in percent) | NPLs post-stress minus NPLs pre-stress |
| C | Loss of capital (LC) | $LC=(TL*(Value\ obtained\ in\ B))$ |
| D | Total capital (TC) | Absolute value in Q4:2020 |
| E | Constant risk-weighted assets (RWA) | Absolute value in Q4:2020 |
| F | 5.96 percent increase in risk-weighted assets (RWA) | 5.96 percent times E |
| G | Total capital after stress (TCAS) | $TCAS=TC\ minus\ LC$ |
| | CAR percent post-stress test (constant RWA) | $(G\ divided\ by\ E)\ times\ 100$ |
| | CAR percent post-stress test(5.96 percent RWA) | $(G\ divided\ by\ F)\ times\ 100$ |

Source: Author's own computations referencing (Vuković, 2014).

Table 4.9: The computation of the assumption for RWA

| Period | Credit to private sector growth (annual percentage) |
|----------------|---|
| 2020 | 4.9 |
| 2019 | 11.1 |
| 2018 | 4.9 |
| 2017 | 1.7 |
| 2016 | 7.2 |
| <i>Average</i> | <i>5.96</i> |

Source: Author's own computations referencing (BOT, 2021b-a; Rakotonirainy et al., 2020)

Table 4.10 reflects the results of the stress test using the sampled 15 banks, from which 10 are foreign and five are local banks; all of them taken together accounted for more than 70 percent of the total banking sector's assets, as of December 2020 (BOT, 2021b-a). Generally, the results note that the average computed CAR ratio pre-stress test for the 15 banks was 18.02 percent. The post-test results reveal an average of 12.37 percent, 13.80 percent, and 14.43 percent, based on a 4.8 percent increase in RWA for a GDP shock, oil price shock, and agricultural commodities shock, respectively. The results show

that the Tanzanian banking sector was more vulnerable to a negative shock in GDP compared to the other macroeconomic shocks applied in this study, namely price changes in oil and raw agriculture commodities, thus being in line with the business cycle theory and study by (Rakotonirainy et al., 2020). However, the Tanzanian banking sector in general was still resilient to shocks based on adverse and plausible scenarios. In addition, these findings are in line with the theories of modern portfolio and asset liability management, as formulated by (Başarı, 2016); Farayibi (2016), who also confirmed that the banking sector's capital position is vulnerable to macroeconomic factors and global shocks.

4.5.1.1 Impact of negative shock in domestic GDP on CAR ratio

Table 4.10 details the impact on capital of individual macroeconomic shocks. For this subsection, the results are based on a negative shock in domestic GDP. The pre-stress test in period q42020 on the CAR ratio was 18.02 percent, and the post-stress test results in the 8th quarter were an average of 14.29 percent and 12.37 percent for a constant RWA and 5.96 percent for an increase in RWA, respectively. Through this, the magnitude of change in capital between the pre- and the post-stress test, ranged from 0.44 percent to 8.88 percent for a constant RWA, and from 1.69 percent to 10.46 percent for a 4.8 percent increase in RWA.

The individual bank analysis revealed that the most resilient bank in Tanzania was bank AE, which already had a substantially high cushion of CAR ratio pre-stress of 24.49 percent, signaling that it had stringent internal capital compliance policies that addressed concerns in advance. On the other hand, the results revealed that four banks, namely AR, AA, AG, and AJ, registered the highest decline in CAR ratios compared to the other banks in the sample, implying that these banks had a potential of accumulation in NPLs due to their lending approach, sectors, and recovery measures in place.

On meeting the regulatory requirements set in Tanzania, of 10 percent and 12 percent on core capital and total capital, respectively, the post-stress test results for individual banks revealed that, based on a constant RWA, only bank AA's CAR was below core, while bank AR's was below total. The results were based on the assumption of a 4.8 percent increase in RWA, showing that banks AA and AR were below core, and that banks AN,

AO, and AQ failed to meet the total CAR requirement (table 4.10). This signals that, based on their pre-stress capital, these banks did not have enough cushion to safeguard against potential domestic shocks. Hence this warrants that policymakers continue monitoring these banks, to mitigate exposure in terms of the impact on individual banks, as it may otherwise lead to a spillover effect to other banks; this owes to the enhanced interconnectedness of the banking sector, in terms of placements, lending, and related customer effects (Hirtle et al., 2016). The results are completely in agreement with other similar studies like those by (Vuković, 2014) and (B. Amel, Youssef, 2018) on individual bank effect, where it was witnessed that GDP shocks have a significant impact on the banking sector in the economies which were studied, and it was proposed that policymakers continue interventions to ensure financial stability.

Despite the ratio of the total loans-to-GDP ratio in the Tanzania banking sector being less than 20 percent, as reflected by the World Bank indicators (WB, 2020) and BOT statistics ending 2020 (BOT, 2021a-a), there has been a growing increase in demand for economic activities to be facilitated with a formal lending structure; hence, this would lead to a projected increase in exposure of the banking sector to economic contributions. In addition, there is an indirect effect of transmission among sectors that are directly financed by the banking sector and the informal sector, as well as by the efforts of the Tanzanian Government to place the microfinance sector under the regulatory watch of the Bank of Tanzania (BOT, 2021c). All these efforts together substantiate the projected increase in exposure of the banking sector to the functioning of the economy. Nevertheless, the banking sector in Tanzania remains resilient to shocks emanating from domestic GDP, due to the prudential measures and rigorous supervisory approaches put in place by the Bank of Tanzania on capital restoration and planning (BOT, 2021b-a). These results are in line with the studies by Amel (2018); (Dua & Kapur, 2018), who attested that the banking sector in their countries also remained resilient to shocks with enough buffers in place.

4.5.1.2 Impact of a positive shock in the price of oil on the CAR ratio

Another topic in the assessment of the impact on capital of individual macroeconomic shocks, is to view how a positive shock in a change in oil prices will affect the Tanzanian banks' capital ratios. Table 17 reveals that the average CAR ratio post-stress test after an

oil price shock was 15.95 percent for a constant RWA and 13.80 percent for a 4.80 percent increase in RWA, with a magnitude of change of ranging from 0.36 percent to 6.22 percent, and from 2.65 percent to 8.17 percent, respectively.

Compared to the previous shock on domestic GDP, the impact on CAR originating from the oil price shock is slightly lower. Therefore, when analyzing individual banks, the results reveal that the most resilient banks to an oil price shock, regardless of the magnitude, were banks AE and AG, which provided the additional capital from the regulatory thresholds. On this point, all the banks met the regulatory requirement of a core of 10 percent, while for a 12 percent total core, bank AJ' s capital ratio stood at 11.99 percent. This signals that the exposure of the banking sector to positive shocks was still mitigated within the plausible and adverse scenarios, if banks had adequate capital positions. The results are in agreement with the empirical reviews done by (Razafindravonona, 2021) and (B. Amel, Youssef, 2018).

This also implies that the oil price transmission to various economic activities funded by the banking sector, bore little impact compared to the effect on domestic GDP. This is because activities with the highest lending were personal loans, with approximately 30 percent of the total Tanzanian banking sector lending as of 2020 (BOT, 2021c). However, given the growing interlinkages between economic activities and households, which are one of the key players insofar as economic contributions, there is a need for policymakers to continue monitoring the exposure of these banks to enhance the resilience of the Tanzanian financial sector at large.

4.5.1.3 Impact of a negative shock in the price of agricultural commodities on the CAR ratio

This sub-section focuses on an assessment of the impact on capital of a negative shock in the price of agriculture commodities. Table 4.10 details that the average CAR ratio post-stress test after an oil price shock, was 16.52 percent for a constant RWA and 14.43 percent for a 4.80 percent increase in RWA, with a magnitude of change ranging from 0.06 percent to 5.04 percent, and from 2.06 percent to 7.88 percent, respectively. The results from the impact on the CAR ratio of a negative shock in the price of agricultural commodities on individual banks, revealed that the banks that were the most resilient to

commodity price changes were banks AE and AR, which depicted high magnitudes of change, but still within the regulatory thresholds.

Only bank AA was affected by this shock, with a reduction in the CAR ratio of 11.01 percent, which is below the threshold of the total CAR requirement. However, this depicts the minimal exposure of the Tanzanian banking sector to changes in the prices of agricultural commodities, despite agriculture being the main contributing sector to GDP. In line with the findings revealed in Chapter 3 of this study on macro credit risk stress testing of the aggregate banking sector, the individual bank assessment also attests that commodity price shocks were not significant, compared to oil price and GDP shocks, to the Tanzanian economy. Similarly, studies done by (Razafindravonona, 2021) and (B. Amel, Youssef, 2018) also attested to the same, and revealed that the substantial effect of raw materials was minimal to the banking sector's performance.

Conversely, the impact on raw commodity prices would have been reflected more greatly if the exportation of commodities was done more substantially by the banking sector, which has not proven to be the case in Tanzania (IMF, 2018b). The financing of export-oriented agricultural commodities is not a top priority, due there being few participants embarking on such initiatives or contractual financing being done by international financiers (BOT, 2021c). However, this still warrants close monitoring given the rising demand for the exportation of raw materials, and government efforts in expanding the agricultural sector towards a commercial base.

Table 4.10: Impact of macro-economic shocks on CAR ratios

| Banks | Ownership | Pre-stress test CAR | Negative shock in domestic GDP | | Positive shock in the price of oil | | Negative shock in the price of agricultural commodities | | CCyB |
|----------------|-----------------|---------------------|--------------------------------|------------------------------|------------------------------------|------------------------------|---|------------------------------|-------------|
| | | | RWA constant | RWA increases by 4.8 percent | RWA constant | RWA increases by 4.8 percent | RWA constant | RWA increases by 4.8 percent | |
| AA | Foreign | 12.42 | 8.12 | 7.00 | 11.33 | 9.76 | 12.77 | 11.01 | 2.5 |
| AB | Foreign | 14.59 | 12.01 | 12.51 | 16.16 | 13.93 | 16.90 | 14.57 | 2.5 |
| AE | Foreign | 26.99 | 24.34 | 20.98 | 24.85 | 21.42 | 25.07 | 21.61 | 2.5 |
| AF | Foreign | 16.31 | 14.09 | 12.15 | 15.63 | 13.48 | 16.12 | 14.07 | 2.5 |
| AG | Local | 21.40 | 14.77 | 12.74 | 17.19 | 14.82 | 18.27 | 15.75 | 2.5 |
| AI | Foreign | 15.92 | 14.44 | 12.45 | 15.56 | 13.42 | 15.08 | 13.86 | 2.5 |
| AJ | Local | 16.71 | 10.63 | 9.16 | 13.91 | 11.99 | 15.38 | 13.26 | 2.5 |
| AK | Foreign | 18.51 | 16.31 | 14.06 | 17.94 | 15.46 | 18.28 | 16.10 | 2.5 |
| AM | Local | 17.62 | 15.49 | 13.35 | 16.70 | 14.40 | 17.26 | 14.88 | 2.5 |
| AN | Foreign | 17.35 | 12.80 | 11.04 | 14.63 | 12.61 | 15.45 | 13.32 | 2.5 |
| AO | Foreign | 16.42 | 13.13 | 11.32 | 14.47 | 12.48 | 15.08 | 13.00 | 2.5 |
| AP | Local | 16.93 | 15.04 | 12.96 | 16.57 | 14.28 | 16.25 | 14.87 | 2.5 |
| AQ | Local | 15.58 | 13.85 | 11.94 | 15.00 | 12.93 | 15.52 | 13.38 | 2.5 |
| AR | Foreign | 20.38 | 11.50 | 9.92 | 14.16 | 12.21 | 15.34 | 13.22 | 2.5 |
| AS | Foreign | 15.72 | 15.28 | 14.03 | 15.15 | 13.75 | 15.10 | 13.62 | 2.5 |
| Average | 15 banks | 17.52 | 14.12 | 12.37 | 15.95 | 13.80 | 16.52 | 14.43 | 2.50 |

Source: Author's own computations (2023)

These results show that, generally, the capital position of the overall banking sector in Tanzania is prone to shock in case a GDP impact occurs. This alludes to the fact that the transmission mechanism of the functioning of an economy stimulates lending in the economy, and that recessions also lead to a decline of the same. In the context of the Tanzanian economy, episodes of declining economic growth were witnessed and the banking sector's capital position was not reactive enough (BOT, 2019a) due to direct simulation, as opposed to stress testing linkage that takes into account other factors such as banking specific impacts. The empirical findings of this chapter on adverse and severe scenarios, relate to the fact that conducting stress testing to assess banking sector resilience for both aggregate and individual banks is paramount, in addition to the use of other risk management tools by banks to mitigate exposures before they materialise. Policymakers are at the forefront of the adoption of Basel II and III, where stress testing

was adopted as part of Internal Capital Adequacy Assessment Programs (ICAAP); this has made stress testing more regulatory compliant (Basel, 2014). The studies by Oyetade et al. (2021, 2022) also amplified the relevance of the adoption of the Basel requirements in maintaining additional buffers in ensuring the resilience of the banking sector, once shocks occur. However, efforts are required to extend the usage of stress tests to take account the interlinkages between the functioning of the economy, trading partners, global factors, as well as the banking sector's operations.

4.6 Chapter Summary

This chapter assessed stress testing and banking sector resilience for individual banks in Tanzania using three different steps. The first step was to estimate the relationship between credit risk, macroeconomic variables, and banking factors using a dynamic panel model GMM estimator. The GMM estimator deployed was compared to other models in the measuring of efficiency and robustness, and it proved to be very powerful and flexible, while also avoiding endogeneity. The second step involved subjecting the NPLs to three different scenarios and shocks, which were derived from the GVAR model results obtained in Chapter 3 for an analysis of individual banks. The third step consisted in assessing the resilience of these banks to adverse scenarios, in case they materialized, by looking at the reaction of NPLs as they were transmitted to the capital positions of banks. Diagnostic tests were conducted using instrument validity, the Hausman test for testing the appropriate model to be used, autocorrelation, heteroscedasticity, and cointegration.

The GMM estimator results revealed that most of the banking sector factors were in agreement with the prescribed theories, except for the leverage ratio that behaved in an inverse manner. However, the study revealed that the NPLs ratio was not only reactive to banking sector factors, but also to macroeconomic variables, although the relationship was not that significant. For the shock transmissions of NPLs, the results revealed that for the assessment of individual banks, the domestic GDP shock had a more significant effect on credit risk compared to the other applied scenarios related to agricultural commodities and oil prices.

On assessing the impact of the macroeconomic scenarios to the capital position of the Tanzanian banking sector, the study linked the results obtained in the GVAR model after NPLs shocks with banking sector factors, and computed post-stress test CAR ratios. The study amplified the interlinkage of the banking sector to foreign and global shocks, with a sample of 15 banks from the Tanzanian banking sector. The GMM model was adopted to assess the significance of macroeconomic factors on credit risk in Tanzania, and later extended the analysis to the shocks that were transmitted to the capital position of the chosen banks. The results revealed that the banking sector in Tanzania is more exposed to domestic GDP shocks compared to the other two shocks observed in this study, namely from the prices of oil and agricultural commodities. However, the results revealed that when plausible and adverse scenarios were applied to the Tanzanian banking sector, it remained resilient to the shocks; this was because the Bank of Tanzania was taking prudential and supervisory measures to ensure the stability of the financial sector. In the next chapter, this study will focus on how to relate credit risk and economic growth, by viewing their sector-wise impact.

CHAPTER 5: EFFECT OF CREDIT RISK TO REAL ECONOMIC GROWTH IN TANZANIA

5.1 Introduction

This chapter emphasizes the significance of credit risk in an economy, by focusing on the relationship between credit intermediation challenges and economic activities in Tanzania. The chapter aims to amplify on chapters 3 and 4 that concentrated on a simulation of credit risk and the banking sector, taking into account global transmissions in addition to domestic macroeconomic variables and banking-specific factors. The previous chapters viewed the impact of credit risk on aggregate and individual banks, while this chapter assesses credit risk by taking into account six major sectors that contribute to economic growth in Tanzania. Credit is the engine for an economy to move, hence the aspect of risks that materialize from its functioning have been discussed for a long time. In the global financial crisis of 2007/8, the major source of risk that triggered spillover effects to the entire economy originated from credit. Therefore, there was an urgent need to assess the interlinkages of credit beyond a normal bank's performance and expand the anticipated magnitude of the effect to the real economy.

Credit risk is defined as the potential that a bank borrower or counterparty will fail to meet their obligations in accordance with agreed terms (Ejoh et al., 2014). According to Al-Smadi and Ahmad (2009), credit risk is the situation where the promised cash flows held by financial institutions may not be paid in full, either through lending or investing in securities. Several studies show that credit risk is the major source of financial distress in many economies, and has a spillover effect, thus affecting the smooth operations of the financial sector (Huan et al., 2020; Tehulu & Olana, 2014).

Credit risk can be viewed through the lenses of interest spread exposure, default risk due to borrowers' inability to pay contractual payments, downgrade risk associated with ratings of issuers, or concentration due to too much exposure on either an industry or a sector's investors (Zamore et al., 2018). On that note, studies have modeled credit risk using either loan loss provisions or non-performing loans, to assess its impact on the banking sector or economy (B. Amel, Youssef, 2018; Askari et al., 2021b; Batalim, 2013; Ouma, 2016). Probability of default and expected default frequency have been applied as

measures for assessing credit risk (Almekhlafi et al., 2016; Garr & Awadzie, 2021; Kolapo et al., 2012; Pesaran & Schuermann, 2003; Zamore et al., 2018). This study adopted the use of the non-performing loans ratio as the proxy for credit risk. The NPLs ratio is the most preferred indicator to use as a proxy, and is related to when a borrower is in default and has not paid the monthly principal and interest repayments for a specified period (Dimitrios et al., 2016; Waqas et al., 2017). Non-performing loans occur when borrowers run out of money to make repayments on a loan, or get into situations that make it difficult for them to continue making repayments towards the loan (Memdani, 2017). Non-performing loans generally refer to loans which do not generate income for a relatively long period of time; that is, the principal and/or interest on these loans has been left unpaid for at least 90 days (Basel, 2004).

As the intermediation function of credit increases, different studies have been conducted to assess the relationship between credit risk and banking sector performance (Almekhlafi et al., 2016; Kolapo et al., 2012). Further, other researchers have focused on assessing the impact of economic growth as one of the determinants of credit risk in different economies (Ekanayake & Azeez, 2015; Garr, 2013; Huan et al., 2020; Kiemo et al., 2019; Louzis et al., 2012; Memdani, 2017; Waqas et al., 2017). On the other hand, few studies have assessed the relationship between credit risk and real economic growth (Ojima & Ojima, 2019; Prokopowicz, 2015), concentrating on an analysis of the aggregate sector; therefore, this study will add to the existing literature by conducting a sector-wise analysis in Tanzania.

Adding to the significance reached regarding credit in stimulating economic growth, this study assesses the systemic impact of credit risk to economic growth, by viewing the risk perspective from a sector perspective, which is paramount. Specifically, the study intends to view credit risk not in isolation from the factors that can affect its effective functioning, as well as to look at its impact on the real economy. In that context, the use of the ARDL model will suit this purpose in assessing the short- and long-run relationships (Alzyadat, 2021; Ogunmuyiwa et al., 2017; Owusu & Odhiambo, 2015).

Furthermore, the growing contribution of the banking sector to Tanzania's economic growth, representing 23.5 percent in 2020 (BOT (2021b-a), motivates the study to

diagnose further areas that can attract policy interventions. Moreover, this chapter complements the work undertaken in chapters 3 and 4 that focused on credit risk stress tests, moving from the impact of aggregate NPLs to individual banks' resilience, respectively. In doing so, this chapter expands and diagnoses credit risk in the banking sector in relation to economic growth by sector classification, in order to continue amplifying the significance of credit risk to the economy, which warrants policymakers' close monitoring, . The sectors considered in this study, as per the classification by the Tanzania National Bureau of Statistics, and which account for about 70 percent of Gross Domestic Product (GDP) in Tanzania⁷(NBS, 2020), include agriculture, mining and quarrying, manufacturing, construction, trade and repair, and transport and storage. Therefore, related NPLs by activity in the banking sector will also be considered to assess the relationship between credit risk and economic growth in Tanzania.

This objective further contributes to the studies already conducted on the relationship between credit risk and economic growth, by looking at the significance of each economic sector, while providing a more focused policy directive that includes credit risk exposures. On this point, the study firstly addresses the concern of whether there is a relationship between credit risk and economic growth, given that the credit-to-GDP ratio in developing economies like Tanzania, is small. Secondly, this study looks at whether this relationship is observed over short or long periods as well as whether it is asymmetric in nature. This study further contributes to existing policies by showing the significance of credit risk not being well managed in the growth of individual sectors in the country. In addition, the study expands on an assessment of the effects of the relationship between credit risk and economic growth, using the data from six major sectors in Tanzania as detailed in Figure 5.1.

⁷ The Tanzanian GDP considered is of mainland Tanzania, excluding Zanzibar, and contributes to about 90 percent of the total GDP (BOT. (2021b-a). *Annual Reports - For the Year Ended 30 June 2021*.

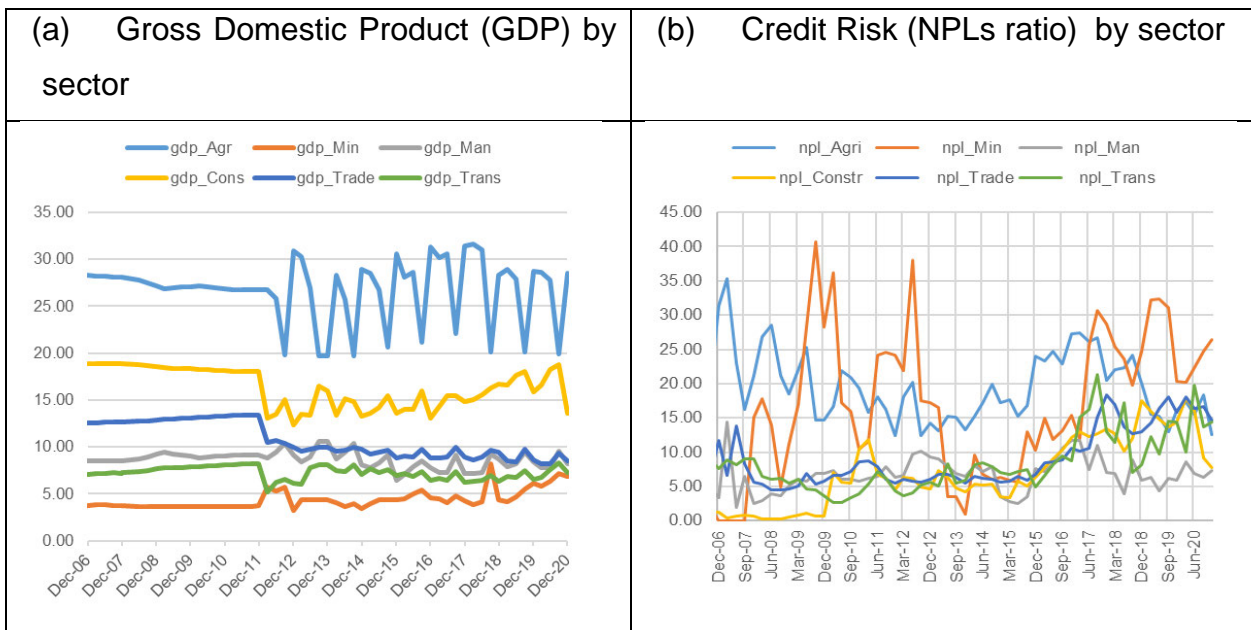


Figure 5.1: Sector wise analysis of Credit risk (NPLs ratio) and GDP (percent)

Source: Bank of Tanzania

5.2 Review of the literature on the effect of credit risk to real economic growth in Tanzania

The significance of credit risk to economic growth is still a subject that is not much researched. However, much research has been done on how economic growth is one of the determinants of credit growth and risk (Chaibi & Fiti, 2015; Ekanayake & Azeez, 2015; Garr, 2013; Huan et al., 2020; Ikram et al., 2016; Koju et al., 2018; Memdani, 2017; Nikolaidou & Vogiazas, 2017). Furthermore, researchers have viewed the relationship between credit risk and banking sector performance (Almekhlafi et al., 2016; Garr & Awadzie, 2021; Kolapo et al., 2012). However, few researchers have viewed credit risk in relation to economic growth (Ojima & Ojima, 2019). Based on the financial intermediation theories, works that have investigated the relationship between credit risk and economic growth, have shown that there is a slight impact of credit risk on economic growth (Ojima & Ojima, 2019). This section explores: the Bagehot theory on finance and growth; financial intermediation and economic development theories; works that have investigated the relationship between credit-related exposures; financial development in relation to

banking performance and economic growth, including the empirical literature that has been compiled on this topic.

5.3 Theoretical literature review on the effect of credit risk on real economic growth in Tanzania

The creation of theories on credit risk and economic growth took form after the global financial crisis of 2007/09, where the significance of credit was noted as a cornerstone of the challenges that affected the functioning of the banking sector as well as the economy (Aslanishvili, 2020; Pojatina, 2008). As reviewed in chapters 3 and 4, the relationship between credit risk and other factors is framed by a number of theories, which are rooted and have added to the Bagehot theory, and include finance and growth, financial intermediation, and economic development theories. The nexus between finance and growth can be traced back from the Bagehot theory in the 1870s, which viewed how different systems of credit basically differ according to their level of soundness, and concentrated on a wholesale money market, with the central bank providing a liquidity backstop (Bagehot, 1873). This theory viewed how financial aspects were linked to the economy, by pooling resources together and allocating them to more profitable areas (Rockoff, 2006). Further, the economy was expected to benefit from the spillover of this, and thus the function of the entity would spur economic growth (Rockoff, 2006). It is on this point that the theory of Bagehot alluded that financial systems play a crucial role in the economic growth of any economy (Stolbov, 2013).

On the one hand, some studies have viewed the Bagehot theory from the lender of last resort's view, and its major role in financial crises and mitigation measures (Freixas et al., 2000). On the other hand, studies have looked at the Bagehot theory as the cause for the existence of shadow banking, by viewing the funding of the money market in the capital market as a demonstration of how the existence of core holdings can pool credit and collapse the sector, using a structured model developed by (Mehrling et al., 2013). Levine (2005) shows how finance and growth theories are used to assess the interlinkage between the functioning of the financial system and economic growth, thus both financial intermediaries and markets matter for growth. On another note, Papaioannou (2007) has indicated how to link financial intermediation to economic growth, by using the theory of

finance and growth within a neoclassical growth framework on financial development, with a view of lowering the cost of capital, while raising total factor productivity, in advanced economies.

Subsequently, financial intermediation theory was developed from the finance and growth theory. Financial intermediation theory was brought into existence by Allen and Santomero (1997), who concentrated on the asset or liability side of the balance sheet. Haiss and Sümegi (2008) looked at financial intermediation theory, concentrating on insurance companies and how investments and premiums had a significant impact. Financial intermediation theory, as adopted by Tafirei (2016), observed the significance of both long-run relationships between banking developments and economic growth, where the stock exchange exhibited a negative impact on economic growth in Zimbabwe. Another study by Ojima and Ojima (2019) applied financial intermediation theory, by assessing the relationship between credit risk and economic growth in Nigeria, where an inverse relationship between the variables was found.

Further, Musau et al. (2018) confirmed the relationship between economic growth and credit risk, although depicting an important moderate effect, tied to financial intermediation theory supported by finance and growth theory. In his study, Mpeanin (2019) adopted the theory of financial intermediation, among other theories, to assess the impact of credit risk management on the financial performance of local banks in Ghana; this helped to amplify the relevance of credit risk management indicators, including cost-per-loan as well as non-performing loans, on banks' profitability. In another study by Akoto and Nabieu (2014), financial intermediation theory was adopted to assess the performance of financial intermediation and its impact on profitability in Ghanaian banking sector. Financial intermediation theory has been widely used, given the flexibility of its role, while having been observed to cater for various functions in the financial sector, specifically the banking sector (Awad & Al Karaki, 2019; Ho & Saadaoui, 2022; Joseph, 2020).

In the same context as finance and growth theory, economic development theory was an improvement on the Bagehot theory, that focused on development of the economy as a historical process of structural changes (Croitoru, 2012). Therefore, other than the theory of finance and growth, economic development theory has contributed to different schools

of thought related to the economic growth, providing a quantitative measure that emphasized the use of credit and role of the entrepreneur in development (Witt, 2016). Economic development theory argues that there is a distinction between the dynamic evolution of economic growth and financial development, where the role of innovation is significant in its contribution to business cycles, credit, and capitalism as a whole (Schumpeter & Backhaus, 2003). Similarly, Khan (2008) used the theory of economic development to assess the relationship between financial and economic development, where long- and short- run impacts were noticed in Pakistan. In addition, the study by Armeanu et al. (2015) adopted the theory of economic development to assess whether credit activity was important in generating and assimilating the impact of external shocks and factors which were difficult to intercept in the model.

In the studies by Croitoru (2012) and Fritsch (2017), it was noted that the equilibrium approach of neoclassical economics was not suitable in identifying and analysing the sources of economic development. Khan et al. (2019) also adopted the theory of economic development and cemented its significance, by assessing the relationship between financial development and economic growth, and found a potential relationship between the two factors. The existence of economic growth theory has not only supported development financing, but also studies like this one, where there is an interplay between financial development and economic growth. The theory of relationship goes beyond the relationship between credit and economic growth and performance, by rather viewing economic financial development in relation to economic growth. Since this study aims to assess how the previously mentioned relationship ultimately calls for policy implications, the significance of these theories is imperative (Fritsch, 2017; Mpeanin, 2019).

5.3.1 Empirical literature review on the effect between credit risk and real economic growth in Tanzania

Several studies have assessed how economic growth affects credit risk in different economies, using macroeconomic and banking sector determinants of credit risk (Abdolshah et al., 2020; Ahmed et al., 2021; Chaibi & Ftit, 2015; Koju et al., 2018; Memdani, 2017; Raiter, 2021). Further, other studies have adopted credit risk tests, as analyzed in Chapter 4 of this study, to assess the relationship between credit risk and

economic growth as one of the macroeconomic variables (Abdolshah et al., 2021; B. Amel, Youssef, 2018; Arestis & Jia, 2018; Batalim, 2013; Borio et al., 2014; Havrylchuk, 2010; Kattai, 2010; Pati, 2017; Rakotonirainy et al., 2020; Vazquez et al., 2012; Vuković, 2014). They all noted that economic growth had a significant impact on credit risk.

Beyond economic growth, other empirical studies have viewed the relationship between credit risk and credit risk management, and how this affects banking sector performance, especially profitability, among others factors (Almekhlafi et al., 2016; Garr & Awadzie, 2021; Kolapo et al., 2012). In this direction, Almekhlafi et al. (2016) investigated how the determinants of credit risk impacted bank performance in Yemen from 1998-2013, using panel data, fixed effect methods, and ordinary least squares (OLS). They concluded that credit risk management and its effect on banks' performance were similar across banks in Yemen, suggesting a causal relationship between credit risk and banks' performance. This was consistent with the findings of the study by Garr and Awadzie (2021), who analysed how credit risk affected banks' performance in Ghana, using unbalanced panel data of 16 banks from 1990 to 2018, together with the OLS method of estimation. The results revealed a significant negative impact on profitability in relation to credit risk, when using the provisions of loan loss as a proxy. They supported the relevance of effective credit management in the performance of the banking sector, and also amplified the need for the analysis of individual institutions.

On another note, Mpeanin (2019) also emphasized the need to strengthen the assessment of credit risk management on financial performance, using seven selected local banks in Zimbabwe from 2010 to 2016. He deployed a multivariate regression technique with descriptive statistics, and the results revealed that adequate capital and credit risk management indicators impacted local banks' profitability positively and negatively, respectively. Another study by Prokopowicz (2015) described the significance of the global financial crisis of 2007-09, and how it complemented to the enhancement of supervisory measures associated with credit risk management. This focused on additional restrictions in the provision of financial products, rather than on providing tools for a macro-prudential assessment, through surveillance and forward-looking tools for credit-related exposures (Prokopowicz, 2015).

Economic growth has also been associated with other financial intermediation functions, ranging from financial development, markets, to insurance, among others. To recap, empirical studies have provided evidence on how economic growth is impacted by financial development. In his study from Pakistan, Khan (2008) argued that there was a positive impact of financial development on economic growth, in both the long- and short-run, and called for continued liberalization to stimulate growth. According to Khan et al. (2019), it was noted that the indicators of financial development adopted for capital in the private sector as a share of GDP and broad money(M2), had policy implications and affected economic growth.

On a different note, some studies have assessed how the functioning of the financial sector can affect economic growth by adopting the financial intermediation theory that focused on the asset or liability side of the balance sheet concentration (Armeanu et al., 2015; Duican & Pop, 2015; Haiss & Sümegi, 2008; Joseph, 2020; Tafirei, 2016). Their studies revealed that the banking sector had a greater influence on economic growth other than the other financial sectors in the developing economies, while for emerging and developed economies the other financial sub-sectors have a greater linkage with economic growth more than the banking sector. Tafirei (2016) used ARDL and VECM approaches to assess how the banking sector and the stock market affected economic growth in Zimbabwe, for the period from 1988 to 2012. His results revealed that all banks were found to have a greater impact on economic growth than on stock markets, implying that policy-driven initiatives towards economic growth needed to be undertaken through bank-based systems rather than stock markets, given the significance of the former (Tafirei, 2016).

Haiss and Sümegi (2008) assessed the impact of insurance investment and premiums to economic growth for 29 European countries using cross-country panel data analysis, for the period from 1992 to 2005, while extending the interlinkage from the banking sector to the other financial sectors. Their study attested to the positive impact of life insurance on economic growth in most of the European countries, thus calling for more attention in considering the insurance sector in financial sector analysis and macroeconomic policy. In their study assessing the performance of the banking sector and its impact on

profitability in Ghana, Akoto and Nabieu (2014) used data for eight large banks for the period from 2004 to 2010, by deploying descriptive techniques and applying financial intermediation theory. Their study revealed that banks were able to mobilise more deposits and had a significant association with loans to a large extent, thus encouraging the government to put in place policies that motivated banks to mobilize deposits to generate loans (Akoto & Nabieu, 2014).

In assessing the relationships among various macroeconomic variables, different studies have adopted a range of methods, namely Johansen cointegration, vector autoregressive model (VAR) and vector error correction model (VECM), auto regressive distributive lag (ARDL), Non-linear auto regressive distributive lag (NARDL), and least square, among others (Awad & Al Karaki, 2019; Ghodsi, 2017; Musau et al., 2018). In a non-linear ARDL approach in the US, performed on a quarterly basis from 1975 to 2014, Ghodsi (2017) investigated the existence of linearity in the cointegration between house prices and fundamentals. He looked at both the short- and long-term impact of fundamentals on house prices, and found that fundamentals depicted short-term effects on house prices. On assessing estimates for short- and long-term relationships, Asteriou et al. (2021) deployed the asymmetric panel ARDL method on a selected panel of Asian countries for the period from 1980 to 2012, to examine the relationship between public debt and economic growth. Their result showed that an increase in government debt was negatively associated with economic growth in both the long run and short run, suggesting that public debt had a detrimental effect on economic growth.

Musau et al. (2018) assessed the relationship between credit risk and other financial dimensions, such as financial inclusion, on 43 commercial banks in the Kenyan banking sector from 2007 to 2015, using descriptive statistics and panel multiple regression analysis. Their study revealed that financial inclusion affected credit risk and that economic growth moderated the effect, thus calling for effective policies to both manage credit risk as well as to ensure financial inclusion.

A literature review on assessing the relationship between credit and economic growth, demonstrated the significance of diagnosing credit with a focus of its impact on the economy (Aslanishvili, 2020; Duican & Pop, 2015; Ho & Saadaoui, 2022; Joseph, 2020).

In amplifying this, Duican and Pop (2015) used a linear regression model to analyze the relationship between credit and economic growth in eight developing regions in Romania, from 2005 to 2014. Their results showed that credit could significantly influence the evolution of economic growth in Romania, thus encouraging banks to continue financing the economy through credit, as a significant way stimulate to growth in the country. Apart from credit risk, various studies have explored how credit has an impact on economic growth (Awad & Al Karaki, 2019; Chen et al., 2021; Ho & Saadaoui, 2022; Joseph, 2020). Joseph (2020) adopted the causality test and vector error correction in his study to assess the relationship between bank credit and economic growth in Tanzania, for the period from 1993 to 2017. His results revealed that there was no causal relationship between credit and economic growth in Tanzania, hence expansion of credit to facilitate the economy.

Similarly, in the study by Awad and Al Karaki (2019), the findings revealed that there was an insignificant contribution made by credit towards economic growth in Palestine. Their findings found that economic growth was a casualty of credit, owing to high risk in the production sector and more lending being targeted towards consumers.

Beyond credit, a few studies have also assessed the relationship between credit risk and economic growth, like Pojatina (2008), which investigated the relationship between credit risk, credit cycle, and economic cycle in the Croatian banking and economy, for the period from January 1995 and July 2005, using the least square method. The author noted that loans to corporates had a greater influence on economic growth than loans to households, over two periods of credit booms and one of credit bust, leading to potential threats to correct credit risk management in banks and the stability of the financial system. Another study by Ojima and Ojima (2019) also assessed how credit risk would affect economic growth in Nigeria, in which they realised that there was a relationship between credit risk and economic growth; as such, they recommended the Central Bank of Nigeria to contain default risk by reducing the interest rate. In summary, there is a need to assess the relationship between credit risk and economic growth, not only at the aggregate level, but also by sector and at individual bank level. Henceforth, this study intended to fill this gap, so that when policymakers make decisions on the impact of credit risk on economic

growth, a more detailed sector analysis can be considered to reveal exposures beyond aggregate value.

5.4 Methodology

Previous literature mentioned in this study assessed the impact of credit risk on economic growth, by using aggregate credit as well as individual bank credit, and adopting different methodologies such as economic growth models and VAR models (Banu, 2013; Ojima & Ojima, 2019; Olowofeso et al., 2015). Other studies deployed the ordinary least square (OLS) method, which was found to have limitations in assessing the long-run relationship between variables. However, there are techniques that are used to test the cointegration relationship between variables in time series, including the residual based Engel-Granger test and Johansen technique; these only apply to variables that are of the same order of integration, which may not be the case all the time (Tafirei, 2016). On this point, the existence of the autoregressive distributed lag (ARDL) approaches, initially introduced by Pesaran and Shin (1995) and later advanced by Pesaran et al. (2001), cater for variables at any order of integration, therefore giving flexibility of analysis. The approach considers the use of bounds testing for cointegration and includes variables which are not of the same order of integration, while other methods like the Johansen technique require that the economic variables under study be of the same order of integration. Therefore, there is the ability to find the power of and test the long-run relationships between credit risk and economic growth, as attested by different literature (Alzyadat, 2021; Busu, 2020).

In their study, Jareño et al. (2020) have shown the advantage of using the abovementioned method, as it accommodates small sample properties, therefore supporting analysis despite the stationarity of the variables. Further, this approach makes corrections for the problems of variable omission, serial correlation, and endogeneity, if appropriate lags are used (Jalil & Ma, 2008). The approach also takes into account the long-term estimates of the connectedness between variables. This method is employed to investigate whether a dynamic change exists in the economic growth of the major sector in Tanzania, due to a change in credit risk where NPLs are used as a proxy. The study will deploy the real gross domestic product (RGDP) at market price in reference to

economic growth as a dependent variable, and NPLs as a proxy for credit risk as one of the independent variable; additional control variables will be used, such as inflation rate and lending rate. Recent studies have adopted the autoregressive distributed lag (ARDL) approach to assess the relationship between time series variables, and to tackle the long-run estimation effect (Alzyadat, 2021; Marques et al., 2019; Ogunmuyiwa et al., 2017). In addition to the linear ARDL, the study employed the non-linear autoregressive lag model (NARDL) proposed by (Shin et al., 2014).

This study will use data for GDP and NPLs for six sectors, which sectors accounted for more than a 70 percent share of the total GDP by 2020. This data will be used to assess the short- and long-term relationships, as well as the positive and negative impact of credit risk on economic growth in Tanzania, for the period from Q2:2006 to Q4:2020, using a non-linear panel ARDL. This will support policy measures directed to banks and different sectors that contribute to the economy in Tanzania. This study will also add to the existing literature (Banu, 2013; Ojima & Ojima, 2019; Olowofeso et al., 2015), by using sector-wise data to link banking sector performance and economic growth in Tanzania.

5.4.1 Data variables and specification

This study employs quarterly time series data for economic growth (GDP), credit risk (CR), inflation rate (IR), real effective exchange rate (ER), trade openness (TO), and short-term interest rate (SR) in Tanzania, over the period from q22006 to q42020. A six data time series was employed, using six sectors from the Tanzanian economy. The choice of data was supported by the limited data availability, and the need to use sectors to take into account the comparability of the effects of individual sectors (Baltagi & Baltagi, 2008). The six sectors included agriculture (Agric), manufacturing (Man), mining and quarrying (Min), trade and repair (Trade), transport (Trans), and construction (Constr). These included having information and power properties of the testing procedures to reduce the collinearity, efficiency, and variability among the explanatory variables (Baltagi, 2008; Gujarat & Dawn, 2004). The variables GDP, CR, IR, ER, and SR were defined in chapters 3 and 4, but not TO. Trade openness (TO) is defined as the policy of economies that measures the extent to which a country is engaged in the global trading system (Keho, 2017; Ulaşan, 2015). The trade-to-GDP ratio is frequently used to measure the

importance of international transactions relative to domestic transactions (Bhagwati, 2014). Table 18 provides a summary of the data descriptions.

Table 5.1: Summary description of data variables

| Sno. | Variable | Proxy | Expected Sign | Source |
|------|-------------------------------|---|---------------|--|
| | Dependent Variables | | | |
| 1. | Economic growth (GDP) | GDP growth rate year-on-year change (percent) | | Tanzania's National Bureau of Statistics |
| | Independent Variables | | | |
| | Credit risk (CR) | (Non-performing loans/Gross loans)*100 (NPLs ratio) | (-) | Bank of Tanzania |
| | Inflation rate (IR) | Consumer price index (CPI) | (+) | Tanzania's National Bureau of Statistics |
| | Exchange rate (ER) | Real effective exchange rate | (-) | Bank of Tanzania |
| | Trade openness (TO) | ((Sum of import and exports)/GDP)*100 | (+) | International Monetary Fund (IMF) |
| | Short-term interest rate (SR) | Overnight interest rate | (-) | Bank of Tanzania |

Source: Author's own computation

5.4.2 Model specification

This study intends to employ an autoregressive distributive lag (ARDL) introduced by (Pesaran & Smith, 1995) and (Pesaran et al., 1999), to examine the short- and long-run

relationships. The ARDL model usually combines endogenous and exogenous variables, unlike a VAR model which is strictly for endogenous variables.

The first step before estimating the ARDL model was to conduct descriptive statistics on the distribution, central tendency, and dispersion of data to establish useful patterns of analysis. The following step is to test for stationary to assess whether the variables have the same order of integration, and to avoid the problem of spurious regression. In doing so, this study adopted two methods: The Augmented Dickey-Fuller (ADF) and the Phillip Peron (PP), to ascertain the order of integration that is appropriate for the ARDL modelling approach. The ADF test is preferred as it is more powerful and can handle more complex models than the Dickey-Fuller test (Mushtaq, 2011).

The procedure for the ADF test conducted in this study will follow Babatunde et al. (2017); Edoumiekumo and Opukri (2013) as follows:

$$\Delta Y_t = \alpha_0 + \alpha_{1t} + \beta Y_{t-1} + \sum_{l=1}^p \gamma_l \Delta Y_{t-l} + \mu_t \quad (5.2)$$

Where Y denotes the variable of interest and ΔY_t denotes the first difference of the time series data. l is the lag length and p represents the maximum lag length. t is the time period, β is the coefficient for Y_{t-1} , and μ_t is the error term. For the ADF test results, the hypothesis as stated $H_0: \beta = 0$ calls for rejecting the null hypothesis, signaling that variable Y is non-stationary, if β is significantly negative.

In addition, the use of the Philips-Perron (PP) test will be employed to cater for serial correlation and heteroskedacity in the error terms as shown below:

$$Y_t = h_1 + h_2 Y_{t-1} + h_3 \left(t + \frac{K}{2} \right) + \mu_t \quad (53)$$

Where h_1, h_2, h_3 are the coefficients of the regression, while K is the number of observations in the model. Using the PP test here, we assess the null hypothesis regarding whether the series is having unit root test against the alternative hypothesis.

Both the order of integration in the variables for the ADF and PP tests, are based on the test which includes both the intercept and time trend. In addition, the study used the

Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test to ascertain the order of integration that is appropriate.

The other step to be undertaken prior to ARDL model estimation is to determine the optimal lag length, which is usually done by three main criteria: the Aikake Information Criteria (AIC), as stated in Vrieze (2012); the Schwartz information criteria (SIC), as described in Vilsoet et al. (2011); and the Hannan Quinn criteria, as attested in (Mainassara & Kokonendji, 2016). The equations for undertaking these are the following:

$$AIC = -\frac{2l}{T} + 2m/T \quad (5.4)$$

$$SIC = -\frac{2l}{T} + (m \log T)/T \quad (5.5)$$

$$HQC = -\frac{2l}{T} + 2 \log(\log T)/T \quad (5.6)$$

In this study, T is the sample size, m is the number of parameters, and l is the log likelihood.

In assessing the information, the selection of AIC may lead to an inconsistent selection of the correct lag length, resulting in either under- or over-estimating the correct lag length. AIC selects the model that will predict the best values, while being less concerned with having too many parameters (Cavanaugh & Neath, 2019). On the other hand, the SIC is designed to select the true values of p and q (lag lengths). Further, SIC is order consistent and gives more parsimonious models when the sample size increases immensely, as the probability of selecting the right model tends towards to unity (Mainassara & Kokonendji, 2016).

After determining the optimal lag, the next step is to test co-integration among variables - a concept which generally mimics the existence of the long-run equilibrium relationship among variables. This usually gives an indication of convergence to some sort of equilibrium relationship among variables in the long run, though if all variables are integrated at order zero, then only the short-term relationship exists (Hashikutuva, 2017). If the variables are not of the same order and the order of integration is less than two, the use of the bound-testing procedure is adopted.

The procedure of the ARDL bounds test as proposed by (Pesaran et al., 1999), basically uses the results of standard F and T statistics to test the significance of the lagged levels of the variables in a univariate equilibrium correlation mechanism, to test the null hypothesis of “no cointegration”. In addition, Pesaran et al. (1999) presented two asymptotic critical values: the lower value and the upper value. The lower value assumes that all variables are I(0) while the upper value assumes that all variables are I(1). If the calculated test statistic exceeds the upper critical value, then the null hypothesis of “no cointegration” is rejected. If it is within the lower bound, the null hypothesis cannot be rejected. In a situation where a statistic falls within the respective bounds, the cointegration test is inconclusive (Oyelami & Ajeigbe, 2021).

After performing the bounds testing, the first step of the ARDL model requires the specification of a set of time series of both I(1) and/or I(0), as the ARDL (p, q) functional form model is established with x_t as an independent variable and y_t as a dependent one.

To assess the effect of credit risk on economic growth for the six sectors in Tanzania, the model for the ARDL approach is specified as follows:

$$\Delta \ln GDP_t = \alpha_0 + \sum_{i=1}^n k_{1i} \Delta \ln GDP_{t-i} + \sum_{i=0}^n w_i \Delta \ln CR_{t-i} + \sum_{i=0}^n m_i \Delta \ln X_{z_{t-i}} + \phi_1 \ln GDP_{t-1} + \phi_2 CR_{t-1} + \phi_3 X_{t-1} + \mu_t \quad (5.3.7)$$

Where: $\ln GDP$ is the natural log of gross domestic product, $\ln CR$ is credit risk, $\ln X$ is the vector of control variables (inflation, real effective exchange rate, short-term interest rate, and trade openness), k, w and m are the short-term coefficients, ϕ_1, ϕ_2, ϕ_3 are the coefficients to test for bound cointegration, i is the lag length, e_t and α_0 represent the error term at time t and intercept, respectively, and $j = 1, \dots, 6$, represents the six sectors of the Tanzanian economy.

In the presence of cointegration, ECM was estimated to capture short-term relationships and the speed of adjustments in terms of long-term equilibrium derived from equation (5.3.7), and the model is then specified as follows:

$$\Delta \ln GDP_t = \alpha_0 + \sum_{i=1}^n k_{1i} \Delta \ln GDP_{t-i} + \sum_{i=0}^n w_i \Delta \ln CR_{t-i} + \sum_{i=0}^n m_i \Delta \ln X_{z_{t-i}} + \phi \mu_{t-1} + \varepsilon_t \quad (5.3.8)$$

Where μ_{t-1} is the error correction term, k, w and m stand for short-term coefficients, and ε_t is the error term.

F and T statistics were used to test the significance of the lagged levels of the variables in a univariate equilibrium correlation mechanism, to test the null hypothesis of “no cointegration” (Oyelami & Ajeigbe, 2021). The F-test was used to test for cointegration as follows:

$$H_0, \text{ there is no co-integration: } \phi_1 = \phi_2 = \phi_3 = 0$$

$$H_1, \text{ there is a co-integration: } \phi_1 \neq 0, \phi_2 \neq 0, \phi_3 \neq 0$$

After estimating the ARDL model, testing for serial correlation and the bounds test approach ensured that the model was fit and stable for assessing the short- and long-term effects of credit risk to economic growth in Tanzania. However, the ARDL model has the limitation in identifying the relationships between the data variables which contain a unit root, as an issue of spurious correlation may occur, but cointegration and modelling variables have been argued to solve this problem (Hashikutuva, 2017). In addition to the ARDL model, the study deployed the non-linear autoregressive lag (NARDL) model as proposed by (Shin et al., 2014).

Moving from equation (5.3.7), the regression model for NARDL to measure the relationship between credit risk to economic growth, showed asymmetric short- and long-run relationships (Shin et al., 2014). The study adopted the NARDL and compared the results of the two models to determine the best estimates, in the same way as in the study by (Muzindutsi et al., 2020) and (Shin et al., 2014). In undertaking the NARDL model, we decompose the independent variable of credit risk into a positive and negative one, denoted by CR^+ and CR^- , respectively. The decomposed series appear as follows:

$$NEG(CR)_t = \sum_{s=1}^t \ln CR_s^- = \sum_{s=1}^T \text{Max} \Delta \ln CR_s, 0) \quad (5.3.9)$$

$$POS(CR)_t = \sum_{s=1}^t \ln CR_s^+ = \sum_{s=1}^T \text{Max} \Delta \ln CR_s, 0) \quad (5.3.10)$$

Equations (5.3.9) and (5.3.10) are included in equation (5.3.7), to form the NARDL model as follows:

$$\Delta \ln GDP_t = \alpha_0 + \sum_{i=1}^{n-1} k_{1i} \Delta \ln GDP_{t-i} + \sum_{i=0}^{n-1} (w_{1i}^+ \Delta \ln CR_{t-i}^+ + w_{2i}^- \Delta \ln CR_{t-i}^-) + \sum_{i=0}^n m_i \Delta \ln X_{t-i} + \phi_1 \ln GDP_{t-1} + \phi_2^+ \ln CR_{t-1}^+ + \phi_2^- \ln CR_{t-1}^- + \phi_3^+ X_{t-1} + \phi_3^- X_{t-1} + \mu_t \quad (5.3.10)$$

We decided to focus on credit risk, which is our core variable, and disregard the asymmetric effects of all other control variables. This was with the view of singling out the asymmetric effect of credit risk on economic growth. This also helped to make the estimation process manageable and avoid the proliferation of parameters.

From equation (5.3.10), the following hypothesis tests were used to test for the long-run relationship:

$$H_0: \phi_1^+ = \phi_2^+ = \phi_3^- = \phi_4^+$$

$$H_1: \phi_1^+ = \phi_2^+ = \phi_3^- = \phi_4^+$$

For the NARDL model, the error correction equation, which was estimated in the same way as was done for the ARDL model, is as follows:

$$\Delta \ln GDP_t = \alpha_0 + \sum_{i=1}^{n-1} k_{1i} \Delta \ln GDP_{t-i} + \sum_{i=0}^{n-1} (w_{1t}^+ \Delta \ln CR_{t-i}^+ + w_{2t}^- \Delta \ln CR_{t-i}^-) + \sum_{i=0}^n m_i \Delta \ln X_{t-i} + \gamma \mu_{t-1} + \varepsilon_t \quad (5.3.11)$$

Where the error correction term is μ_{t-1} and the speed of adjustment to long-run equilibrium is represented by γ . In estimating the models, diagnostic tests were conducted to establish model stability and efficiency.

Similarly, the immediate effect of the independent variables on the dependent variables was obtained for the short term by applying the Wald test. The Wald test was used with the following null hypothesis for the long term:

$$W_{GDP}^+ = W_{GDP}^-, W_{CR}^+ = W_{CR}^- \text{ and } W_X^+ = W_X^- \text{ while the short-term symmetries were tested as } \sum_{i=0}^{p-1} \phi_{GDP,i}^+ = \sum_{i=0}^{p-1} \phi_{GDP,i}^-, \sum_{i=0}^{p-1} \phi_{CR,i}^+ = \sum_{i=0}^{p-1} \phi_{CR,i}^- \text{ and } \sum_{i=0}^{p-1} \phi_{X,i}^+ = \sum_{i=0}^{p-1} \phi_{X,i}^- \quad (5.3.12)$$

Where GDP, CR, and X stand for the gross domestic product, credit risk, and control variables of this study, respectively.

This model was intended to assist in achieving the objective of assessing the short- and long-term impact of credit risk on real economic growth, looking at the six major sectors of economic growth in the Tanzanian economy. The next step entailed testing for serial correlation for both ARDL and NARDL in equation (5.3.6). If serial correlation was present, extra lagged variables would be included as measures to remove it. For a dynamic system to be stable, the roots obtained must lie inside a unit circle. Thereafter, the bounds test approach was performed, which entailed testing the null hypothesis that the parameters were equal to zero.

If parameters are equal to zero, it implies that there is no long-term relationship. Ideally, the null hypothesis should be rejected for a long-term relationship to exist. Assuming the results in the bounds test indicate the presence of cointegration, then the next step will entail estimating the long-run equilibrium between the variables, and lastly extract the long- and short-term effects. The aim is to measure the effect of credit risk on economic growth for a period of 14 years, assess the episodes with major changes, and find which sector witnessed the effects the most. The model will assist in selecting the threshold value endogenously (Gonzalez et al., 2017). The methodology described in Section 5.4 below was used to analyse data and extrapolate the results.

5.5 Empirical results and discussion

The results of the effect of credit risk on economic growth are presented in this section using selected sectors. Credit risk was measured using non-performing loans to capture the quality of assets, thus having a direct and indirect relationship with economic growth. With few studies viewing credit risk in relation to economic growth, most of the literature views that economic growth has an impact on credit risk given the performance effect described in Chapter 4. Most of the debate on the relationship between credit risk and economic growth is based on aggregate variables; as such, this study intended to explore the expanded relationship between the functioning of the key sectors of the economy and their contribution to the banking sector's exposure, as well as how their relationship in the

short and long term. In doing so, the sub-sections that follow will look at descriptive statistics, unit root tests, lag selection, and ARDL bounds testing.

The tests were chosen due to their robustness compared to time series tests, hence, avoiding wrong inferences and spurious regressions (Baltagi, 2008; Gujarat & Dawn, 2004). The application of the two tests provides room for cross-checking accuracy and comparing to ensure consistency.

5.5.1 Descriptive Statistics

Before conducting a unit root test, descriptive statistics are assessed as shown in appendices 11, 12 and 13. The statistics denote the mean, medium, maximum and minimum, standard deviation, skewness, kurtosis, and the Jarque-Bera test.

Appendix 11 details a descriptive analysis of the GDP ratio by sector, and reveals that agriculture had the highest average GDP ratio in the sample, followed by construction and trade, signaling that these were the main contributors of the economy in Tanzania. The distribution of the values in the series measured by kurtosis, imply that the curve is leptokurtic, as all values are positive, reflected by a distribution curve that is peaked. On the other hand, construction, trade, and transport show a normal distribution, but are platykurtic since their value is less than three. The degree of asymmetry of the series, as measured by skewness, denoted that GDP ratios for agriculture, manufacturing, construction, and transport had high values which were higher than the sample mean. For the Jarque-Bera test, the null hypothesis is that the distribution is normal, therefore since the GDP ratio for manufacturing and transport lie above the 5 percent level of significance, this portrays a normal distribution curve, while the other sectors are not normally distributed, as attested by the results of skewness and kurtosis.

On the other hand, *Appendix 12*, describes the data for credit risk with the NPLs ratio by sector as a proxy for this study. The results reveal that the NPLs ratio for agriculture has the highest mean, implying the highest average rate of exposure in line with the level of economic contribution, noted by GDP growth (*Appendix 14*). This reflects that despite agriculture being a high contributor to GDP, it is also a risky sector to lend to, given its high credit risk and repayment trends; this is attributed to challenges such as dependence

on weather conditions in developing economies like Tanzania. The distribution of the values in the series measured by kurtosis, imply that the curve is leptokurtic, as all values are positive, reflected by a distribution curve that is peaked. For skewness, all the sectors mirror a normal distribution, but they are platykurtic since they are less than three. For the Jarque-Bera test, as depicted by the probability, the null hypothesis is that the distribution is normal, therefore as the NPLs ratio for construction, manufacturing, and mining lie above the 5 percent level of significance, the results reveal a normal distribution curve; however, the other sectors are not normally distributed, as attested by the level of significance being below 5 percent.

Appendix 13 describes the data for the control variables, including exchange rate, inflation rate, interest rate, and trade openness. The standard deviation is observed to be highest in trade openness. For skewness, the distribution of the values in the series measured by kurtosis is leptokurtic, since all the values are positive, reflected by a distribution curve that is peaked. On the other hand, all the variables mirror a normal distribution, but they are platykurtic since they are less than three. For the Jarque-Bera test, the null hypothesis is that the distribution is normal, therefore for the real effective exchange rate and trade openness which lie above the 5 percent level of significance, the results reveal a normal distribution curve, while the inflation and interest rates are not normally distributed, as attested by the level of significance being below 5 percent.

5.5.2 Unit root test

In principle, the ARDL procedure does not require pre-testing for unit root, however, it is important to check the stationarity condition to ascertain that all variables are not integrated at order two, $I(2)$, or higher. This study conducted more than one unit root test, to ensure robustness, using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, to ascertain the order of integration that is appropriate for the ARDL modelling approach. The study assessed both intercept only, and trend and intercept in the unit root tests.

Appendices 14, 15, and 16 show the results of the unit root test for GDP and NPLs for the six sectors, as well as the control variables (inflation rate, exchange rate, short-term interest rate, and trade openness) in level and first difference. The results revealed that

the unit root test for GDP for the six selected sectors, had a mixture of both order zero $I(0)$ and order one $I(1)$, for both the ADF and PP unit root tests, thus the model was stationary as detailed in Appendix 14. In the case of the control variables, the results revealed that for the ADF test, the variables were stationary at first difference, while for the PP test, there were mixed results, as detailed in Appendix 15. For the NPLs by sector, the unit root test results revealed that there were mixed responses, though the manufacturing sector was stationary at level for both the ADF and PP tests.

Generically, the results showed a mixture of variables that were integrated of order zero $I(0)$ and order one $I(1)$, therefore the model was stationary. Being stationary reveals that the variable in the study had zero mean, constant variance, and the residuals were uncorrelated over time. Therefore, since $I(1)$ is the highest order of integration observed, this makes it possible to estimate ARDL cointegration. In undertaking the NARDL model estimations, unit root test results considered three tests, namely, the Augmented Dickey-Fuller (ADF), Phillips-Peron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests to ascertain the integration that was appropriate for the NARDL modelling approach. The results for unit root test are shown in Appendix 16 and Appendix 17 for the main and control variables, respectively. The results revealed that the highest order of integration observed was $I(1)$, making it possible to estimate NARDL cointegration.

5.5.3 Model selection and optimal lag length

Before running the ARDL and NARDL models, the model and lag selection criteria in this study were automatically generated from E-Views 12, using the five selection criteria: LR (sequential modified LR test statistic, with each test at 5% level); FPE (final prediction error); AIC (Aikake information criterion); SC (Schwarz information criterion); and HQ (Hannan-Quinn information criterion). The lag selection criteria for the individual sectors of agriculture, mining, manufacturing, construction, and trade and transport were observed to have a maximum lag length of 4, 4, 2, 4, and 3, respectively, as represented in Table 19. The NARDL model was found to be the superior model for all the sub-sectors presented. This was also considered a way of finding a balance between the two cases under fitting and overfitting (Cavanaugh & Neath, 2019).

Table 5.2: NARDL model selection

| Type | Agriculture | Mining | Manufacturing | Construction | Trade | Transport |
|------|--------------|--------------|---------------|--------------|------------|--------------|
| NAR | (4, 4, 1, 3, | (1, 1, 4, 0, | (2, 0, 0, 0, | (3,1,0,0,1 | (1,0,0,0,0 | (3, 0, 3, 0, |
| DL | 1, 4, 4) | 0, 0, 0) | 0, 2, 0) | ,0,1) | ,4,0) | 1, 0, 2) |

Source: Author's own computation (2023)

5.5.4 Long run ARDL and NARDL analysis

5.5.4.1 Bounds test for cointegration

In absence of the order I (2) of the variables, the cointegration test is usually conducted to determine the long run relationship among variables, using the ARDL bounds test. The results in *Table 5.3* results revealed that all the GDP ratios for the sectors were cointegrated, except for the transport sector, implying that there was a long-term relationship between credit risk and economic growth by sector classification in Tanzania. However, for the transport sector, this implied that there was no direct relationship between credit risk and economic growth, since part of the transport sector was not directly involved in the economy in the short run, due to its supporting nature. The F-statistics witnessed their highest GDP result for agriculture, with the general highest and lowest critical value at 5.0 percent being 3.7 percent and 2.6 percent, respectively. In addition, the F-statistics were higher than the lower and upper bounds for all six sectors in the study, thus signaling long –run cointegration among variables.

Table 5.3: Bound test for ARDL estimates

| Dependent variables | F-statistics | Lower critical value at 5 percent | Upper critical value at 5 percent | Cointegrated |
|---------------------|--------------|-----------------------------------|-----------------------------------|--------------|
| lnAGRIC | 10.56 | 2.62 | 3.73 | Yes |
| lnMin | 5.81 | 2.62 | 3.73 | Yes |
| lnMan | 7.99 | 2.62 | 3.73 | Yes |
| lnCon | 4.22 | 2.62 | 3.73 | Yes |
| Intrade | 5.88 | 2.62 | 3.73 | Yes |
| InTrans | 5.4 | 2.62 | 3.73 | No |

Source: Author's own computation (2023)

The results for the bounds test for the cointegration of the NARDL estimations, revealed that all the GDP ratios for the sectors were co-integrated, except for the trade sector, implying a long run relationship between credit risk and economic growth by sector in Tanzania. In Table 5.4, the results reveal that all the sectors have an F-statistic above the lower critical value, except for trade, with the highest F-statistics for the NARDL estimates witnessed in agriculture, thus signaling long-run cointegration among variables. For the NARDL estimates, the lowest and highest critical values were 2.66 percent and 3.79 percent, respectively.

Table 5.4: Bound test for NARDL estimates

| Dependent variables | F-Statistics | Lower critical value at 5 percent | Upper critical value at 5 percent | Cointegrated |
|----------------------------|---------------------|--|--|---------------------|
| InAGRIC | 16.75 | 2.62 | 3.79 | Yes |
| InMin | 4.45 | 2.62 | 3.79 | Yes |
| InMan | 16.55 | 2.62 | 3.79 | Yes |
| InCon | 5.55 | 2.62 | 3.79 | Yes |
| Intrade | 2.48 | 2.62 | 3.79 | No |
| InTrans | 7.34 | 2.62 | 3.79 | Yes |

Source: Author's own computation (2023)

5.5.5 Wald test

Table 5.5 depicts the results of the short- and long-term asymmetric effects of the relationship between the GDP variables and credit risk, by estimating the Wald test in order to have the best NARDL estimate. The results revealed that the sectors of agriculture, manufacturing, construction, and transport had a probability value of less than 5 percent, hence rejecting the null hypothesis; therefore, the sectors are asymmetric in nature and portrays that there is a linear relationship among the variables. This confirms the findings of the study conducted by (Qamruzzaman & Karim, 2020), who also

witnessed a long-term asymmetrical relationship between economic volatility, trade openness, and FDIs.

Table 5.5: Wald test results

| Dependent variables | NPL(POS) | NPL(NEG) | Wald test statistics value | Wald test prob. value |
|---------------------|----------|----------|----------------------------|-----------------------|
| lnAGRIC | 0.32*** | 0.23*** | -3.81420 | 0.00050 |
| lnMin | 0.04 | 0.03 | -1.48413 | 0.14490 |
| lnMan | 0.04 | 0.06 | 3.10168 | 0.00380 |
| lnCon | 0.12 | 0.41* | -94.47727 | 0.00000 |
| Intrade | -0.32 | -0.01 | -2.63267 | 0.01160 |
| InTrans | -0.22* | -0.18 | 3.20028 | 0.00270 |

Source: Author's own computation (2023)

5.5.5 Long run ARDL and NARDL estimates

Though the study revealed the presence of cointegration for most of the sectors, there is the need to estimate the long run ARDL, in order to calculate the elasticities. Thereafter, the study also estimated the short-run ARDL.

Table 5.6 shows that the results of the long run coefficients on the effect of credit risk on economic growth were mixed, with the agriculture, mining, and construction sectors being statistically significant. This implies that the performance of the banking sector's assets in terms of lending has a significant effect on the performance of economic growth; thus, there is the need for more close monitoring of these sectors, as they contributed greatly to the Tanzanian economy. These results are in line with the Bagehot and finance growth theories, which attest to the linkage and contribution of the financial system to economic growth. However, the results revealed that in the long run, the credit risk in the sectors of manufacturing, trade, and transport did not have a significant impact on economic growth, due to short-term transmission, given the nature of their economic activity (BOT, 2021a-a). These findings are at odds with previous literature such as Ojima and Ojima (2019), where the findings revealed that the impact of credit risk in the long run affected economic growth, thus being an inhibitor. In addition, in the long run, control variables exhibited positive coefficients, mainly interest rate, thus depicting how they influence economic growth for different sectors of the Tanzanian economy; this is due to variations in interest

rates and the way they are transmitted to economic activities. These results reveal the relevance of assessing credit on a more granular form, such as sector classification rather than aggregate analysis, to provide appropriate sector-specific policies for determining triggers and mitigation measures.

Table 5.6: Long-run ARDL model estimates

| Dependent variables | Constant | d.lnNPL | d.lnInf | d.lnExch | d.lnInt | d.lnopen |
|---------------------|----------|----------|---------|----------|----------|----------|
| ln_GDPAgric | 3.60*** | 0.07** | 0.05** | 0.187* | 0.02*** | -0.18*** |
| ln_GDPMin | 0.98 | 0.01*** | -0.29* | 0.42 | 0.12*** | -0.13 |
| ln_GDPMan | 1.02*** | -0.01 | -0.08 | 0.38 | -0.09*** | 0.38*** |
| ln_GDPCon | 3.61*** | -0.07*** | -0.11** | 0.35** | -0.08*** | -0.1 |
| ln_GDPtrade | 3.45 | 0.06 | 0.84** | -0.73 | 0.06 | -0.79 |
| ln_GDPTrans | -5.37 | 0.32 | -0.54* | 1.33 | -0.34* | 2.18* |

Source: Author's own computation (2023)

For the NARDL estimates, the variables are decomposed into negative and positive components to assess any non-linearity among the variables. *Table 5.7* suggests that a 1 percent positive increase in NPLs for the agricultural sector would lead to a 0.32 percent increase in the GDP ratio; however, for the trade and transport sectors, the GDP ratio would decline by 0.32 percent and 0.22 percent, respectively. This implies that lending in the banking sector is prominent for trade and transport, which has a direct transmission to the real economy, as these sectors' reliance on lending is from formal financial services, in contrast to the agricultural sector in Tanzania which is a vulnerable sector. This is in accordance with the study by (BOT, 2019a).

Taking into account a 1 percent negative effect of NPLs, the results were revealed to be statistically significant for agriculture and construction, with 0.23 percent and 0.41 percent, respectively, while trade and transport responded with a decline in the same way observed for a positive effect.

In this study, trade and transport showed negative coefficients in relation to credit risk, thus amplifying that these two sectors have an inverse relationship with GDP growth, in agreement with the study by (Ojima & Ojima, 2019). Generally, it is noticed that economic growth is greater with a positive rather than negative response from the NPLs ratio, which

aligns with the theoretical underpinnings of financial intermediation and the Bagehot theory.

Table 5.7: Long-run NARDL model estimates

| Dependent variables | NPL(POS) | NPL(NEG) | lnInf | lnExch | lnInt | lnopen |
|---------------------|----------|----------|-------|---------|---------|---------|
| lnAGRIC | 0.32*** | 0.23*** | 0.01 | 6.82** | 0.16*** | 0.08 |
| lnMin | 0.04 | 0.03 | 0.08 | 1.18 | 0.03 | -0.06 |
| lnMan | 0.04 | 0.06 | 0.01 | 2.65*** | 0.12*** | 0.05*** |
| lnCon | 0.12 | 0.41* | 0.29* | 2.64 | -0.19** | -0.05 |
| Intrade | -0.32 | -0.011 | -0.15 | 1.28 | -0.46 | -0.15 |
| lnTrans | -0.22* | -0.18 | -0.27 | 2.59 | -0.19** | 0.13 |

Source: Author's own computation

5.5.6 Short ARDL and NARDL error correction models

Updated E-views have an inbuilt capacity to accommodate the lag effect that may not affect the results. The results of estimating the short-run ARDL model are depicted in Table 5.8.

On this note, the results of the lag effect of the dependent variable GDP is statistically significant for the agriculture, manufacturing, and trade sectors, thus providing evidence that the capacity for error correction with adjustments is available in the model.

The results for the different sectors in the short run showed that lnGDP for construction and transport were statistically significant, and were therefore affected by credit risk. The remaining four sectors of agriculture, manufacturing, mining, and trade, did not show any sign of significance, thus implying that credit risk was not an influencing factor on lnGDP in the short run. Nevertheless, in the short run, the sectors exhibited levels of significance for the control variables of exchange rate (agriculture and manufacturing), interest rate (agriculture, manufacturing, mining, and trade) and for trade openness (mining, manufacturing, and transport). This implies that these variables depicted a significance to lnGDP for those sectors. The results for the lag of 1 and 2 standings for the previous one

and two quarters, respectively, revealed that only agriculture was significant at lag 1 and no sector was significant at lag 2 in relation to credit risk. However, during the lag 1 period, the control variables of inflation for construction and trade, exchange rate and interest rate for manufacturing, and trade openness for the mining sector, were statistically significant. For the lag 2 period, interest rate for the manufacturing and construction sectors, as well as impact of trade openness on the mining and manufacturing sectors, were significant.

Table 5.8: Short-run ARDL model estimates

| Dependent variables | Constant | Lag dep. | lnNP L | lnInf | lnExc h | lnInt | Inopen | Error-Correlation |
|---------------------|----------|----------|--------|---------|---------|---------|---------|-------------------|
| ln_GDPAgric | 9.44*** | -0.58*** | 0.05 | 0.05 | 0.66*** | -0.07** | -0.46 | -2.49*** |
| ln_GDPMin | 0.81 | -0.17 | 0.002 | 0.03 | 0.35 | 0.10*** | 0.25*** | -0.82*** |
| ln_GDPMan | 1.21* | -0.31*** | -0.01 | -0.08 | 0.69*** | 0.08*** | 1.07** | -1.34*** |
| ln_GDPCon | 3.28*** | -0.05 | 0.05** | 0.09 | -0.28 | -0.007 | -0.09 | -0.52*** |
| ln_GDPtrade | -1.04 | -0.26** | 0.04 | -0.02 | -0.16 | -0.03 | -0.21 | -0.39*** |
| ln_GDPTrans | -1.85*** | 0.18 | 0.11** | -0.09 | 0.03 | 0.07*** | -1.03* | -0.46*** |
| | | | (-1) | (-1) | (-1) | (-1) | (-1) | |
| ln_GDPAgric | | | 0.006* | -0.03 | | | -0.56 | |
| ln_GDPMin | | | | | | | 2.65*** | |
| ln_GDPMan | | | -0.01 | 0.03 | -0.62* | 0.14*** | -1.24 | |
| ln_GDPCon | | | | 0.19*** | 0.2 | | | |
| ln_GDPtrade | | | | 0.14*** | | | | |
| ln_GDPTrans | | | | | | | | |
| | | | (-2) | (-2) | (-2) | (-2) | (-2) | |
| ln_GDPAgric | | | - | | | | | |
| ln_GDPMin | | | 0.001 | -0.17 | | | 3.52** | |
| ln_GDPMan | | | | -0.01 | 0.49 | 0.05** | -2.63** | |
| ln_GDPCon | | | | | 0.4 | 0.07*** | | |
| ln_GDPtrade | | | | | | | | |
| ln_GDPTrans | | | | | | | | |

Source: Author's own computation (2023)

The NARDL results for short run estimates are depicted in *Table 5.9*, with credit risk having a positive relationship with the agriculture and transport sectors. This suggests that a 1 percent positive increase in NPLs in the short run would lead to a 0.89 percent and 0.14 percent increase for agriculture and transport, respectively; this is evidence that there was a direct effect of the impact of repayments of loans on economic growth for these particular sectors. For the effect of a 1 percent negative decrease in NPLs, positive coefficients were witnessed in agriculture and manufacturing, with the remaining sectors revealing negative coefficients, implying that the response is non-linear for these two sectors compared to the others. The lag of GDP depicted negative coefficients for all sectors, except for the manufacturing sector. For the error correction model, all the sectors denoted negative coefficients, except for mining. This implies that in the short run, a 1 percent increase in credit risk is expected to reduce economic growth, in line with economics theory and the finance growth theory that attest to the linkage and contribution of the financial system to economic growth.

Table 5.9: Short-run NARDL model estimates

| Dependent variables | Lag_d ep | NPL(P OS) | Lag 1 (POS) | NPL(N EG) | Lag 1 (NEG) | Inl nf | InExc h | InInt | Inop en | Err- Corr |
|---------------------|------------------|--------------|----------------|--------------|----------------|---------------|------------------|------------------|-----------------|------------------|
| In_GDPA gric | - 0.81** * | -0.091 | 0.64* | 0.38* | 0.21* | 0.0 4 | 24.75 *** | - 0.29* * | -2.77 | - 2.78** * |
| In_GDPM in | - 0.59** | -0.04 | 0.042* | -0.02 | 0.075** | 0.0 8 | 0.87 | 0.02 | -0.05 | 0.75** * |
| In_GDPM an | 0.71** * | 0.083* | | 0.062* | | 0.1 | - 9.52* ** | -0.06 | 0.18 | - 1.77** * |
| In_GDPC on | -0.28 | 0.07* | | -0.35** | 0.56*** | - 0.0 4 | 2.33 | - 0.10* * | - 0.39* * | - 0.52** * |
| In_GDPtr ade | - 0.40** * | -0.05* | | - 0.082** | | - 0.0 2 | 0.22 | - 0.08* ** | -0.02 | -0.18 |
| In_GDPT rans | - 0.38** | -0.074* | -0.134* | -0.07* | | - 0.0 4 | 1.06 | - 0.08* ** | 0.15 | -0.41 |

Source: Author's own computation (2023)

5.5.7 Diagnostic tests

Before proceeding with the use of the ARDL and NARDL estimation results, it is important to check for the validity and reliability of the model. Generally, diagnostic test results have confirmed that the model is free from serial correlation, residuals are normally distributed, and models are free from homoscedasticity. Besides these, Ramsey's Regression Equation Specification Error Test (RESET) test has also attested to the validity of the model's construction. The CUSUM and CUSUM of the square test have revealed that empirical models are stable.

5.5.7.1 Model validity tests

Validity tests for the ARDL and NARDL models in this particular study will consider serial correlation, heteroscedasticity, and the Regression Equation Specification Error Test (RESET) tests. These are performed to confirm the validity of the data used for the variables in the model.

The first validity test is the assessment of serial correlation, a situation where the residuals are correlated, and if correlated, the estimations are biased and inconsistent. Two approaches of conducting serial correlation are the Durbin-Watson (DW) test and the Breusch-Godfrey test or the Lagrange multiplier (LM). Given the limitation of the DW test, as it cannot consider higher orders when the lagged dependent variable is used as a regressor, the only method that is available for the ARDL model is the LM test. The Breusch-Godfrey test or LM test is used when different lags of the residuals are correlated with the hypothesis of H_0 : no serial correlation in the model; or H_1 : there is serial correlation in the model. The results shown in *Table 5.10* for the ARDL model estimates call for a rejection of the null hypothesis and acceptance of the alternative hypothesis, hence the series are stationary compared to the serial correlation. The study tested for serial correlation using the Breusch-Godfrey test and the results are presented in *Table 5.10*, which contains all the diagnostic tests of the study. The test reports that all six sectors and the aggregate result reject the null hypothesis, as the p-values are above the 5 percent significance level. This implies that in the study there is serial correlation in the estimated model. On the other hand, the NARDL model estimates in *Table 5.11* revealed that agriculture, manufacturing, and trade had values below the 5 percent significance

level, therefore the series were not stationary, implying that there is no serial correlation for these sectors.

The second validity test is to assess the heteroscedasticity of the model. In doing so, the study adopted the use of the autoregressive conditional heteroscedasticity (ARCH) test, a statistical model used to analyse volatility in time series in order to forecast future volatility. The rule states that null hypothesis must be rejected if the probability is less than 5 percent significance. *Table 5.10* shows the results of the test probability when the aggregate is at 0.01, therefore accepting the null hypothesis which signals heteroscedasticity. However, for individual sectors, such as agriculture and construction which have less than a 5 percent significance, the test fails to reject the constancy of variance, thus these sectors demonstrate homoscedastic. For NARDL estimates, *Table 5.11* reveals that agriculture and transport have a significance level below 5 percent, thus these sectors are homoscedastic.

The third validity test is the RESET test, a general specification test for the linear regression model. More specifically, the study adopted the Ramsey RESET test to assess whether non-linear combinations of the fitted values helped to explain the response variable. Further, the test basically used the powers of the predicted values of the dependent variable to check if the model had omitted a variable or not. *Table 5.10* for the results of the ARDL model estimates, reveals that other than construction, all the other sectors had a p-value above the 5 percent significance level. Therefore, there are no specification errors in all the other sectors except for construction. On the other hand, in *Table 5.11*, the NARDL model estimated that the Ramsey RESET test revealed that all sectors have a p-value less than 5 percent, except the manufacturing sector; therefore, this implies that there are specification errors in all these sectors.

Table 5.10: Results for ARDL and NARDL model for validity tests

| Test Method | Serial Correlation | | Heterodescacity | | RESET test | |
|-------------|-------------------------|-------|-----------------|-------|-------------|-------|
| | Breusch Goffrey-LM Test | | ARCH test | | Ramsey test | |
| | F.Stat | Prob. | F.Stat | Prob. | F.Stat | Prob. |
| ln_GDPAgric | 0.23 | 0.15 | 0.006 | 0.01 | 0.26 | 0.61 |
| ln_GDPMin | 0.31 | 0.19 | 0.57 | 0.86 | 1.9 | 0.16 |
| ln_GDPMan | 0.47 | 0.62 | 1.02 | 0.46 | 1.12 | 0.29 |

| | | | | | | |
|-------------|-------|------|------|------|------|------|
| In_GDPCon | 0.8 | 0.45 | 2.2 | 0.02 | 4.1 | 0.04 |
| In_GDPtrade | 0.004 | 0.99 | 0.93 | 0.55 | 0.92 | 0.36 |
| In_GDPTrans | 0.4 | 0.66 | 1.44 | 0.2 | 0.38 | 0.7 |

Table 5.11: Results for NARDL model for validity tests

| Test | Serial Correlation - Breusch Groffrey-LM Test | | Heterodescacity - ARCH test | | RESET test-Ramsey test | |
|-------------|---|-------|-----------------------------|-------|------------------------|-------|
| | F.Stat | Prob. | F.Stat | Prob. | F.Stat | Prob. |
| In_GDPAgric | 0.697 | 0.226 | 1.330 | 0.258 | 5.26 | 0.00 |
| In_GDPMin | 0.856 | 0.321 | 1.415 | 0.200 | 7.15 | 0.00 |
| In_GDPMan | 0.233 | 0.793 | 1.541 | 0.160 | 1.24 | 0.31 |
| In_GDPCon | 0.496 | 0.902 | 1.116 | 0.030 | 7.99 | 0.00 |
| In_GDPtrade | 1.250 | 0.200 | 2.116 | 0.096 | 5.08 | 0.00 |
| In_GDPTrans | 0.901 | 0.279 | 0.996 | 0.435 | 5.01 | 0.00 |

Source: Author's own computation (2023)

5.5.7.2 Model stability tests

Another test for estimating the ARDL and NARDL models is to conduct a stability test. A stability test is used to assess whether or not the model revealed structural changes over the study period, and whether it can be used for reliable predictions. The test also assists in assessing adequacy before making a forecast, by checking the model's stability and performing a diagnostic of residual performance. To check the stability in the long run of the ARDL error-correct model and the accuracy of the estimated model, CUSUM is adopted for this study. The results in the graphs in Figure 5.21 show the six sectors, which all lie statistically within the 5 percent critical bounds, confirming that all coefficients in the model are stable.

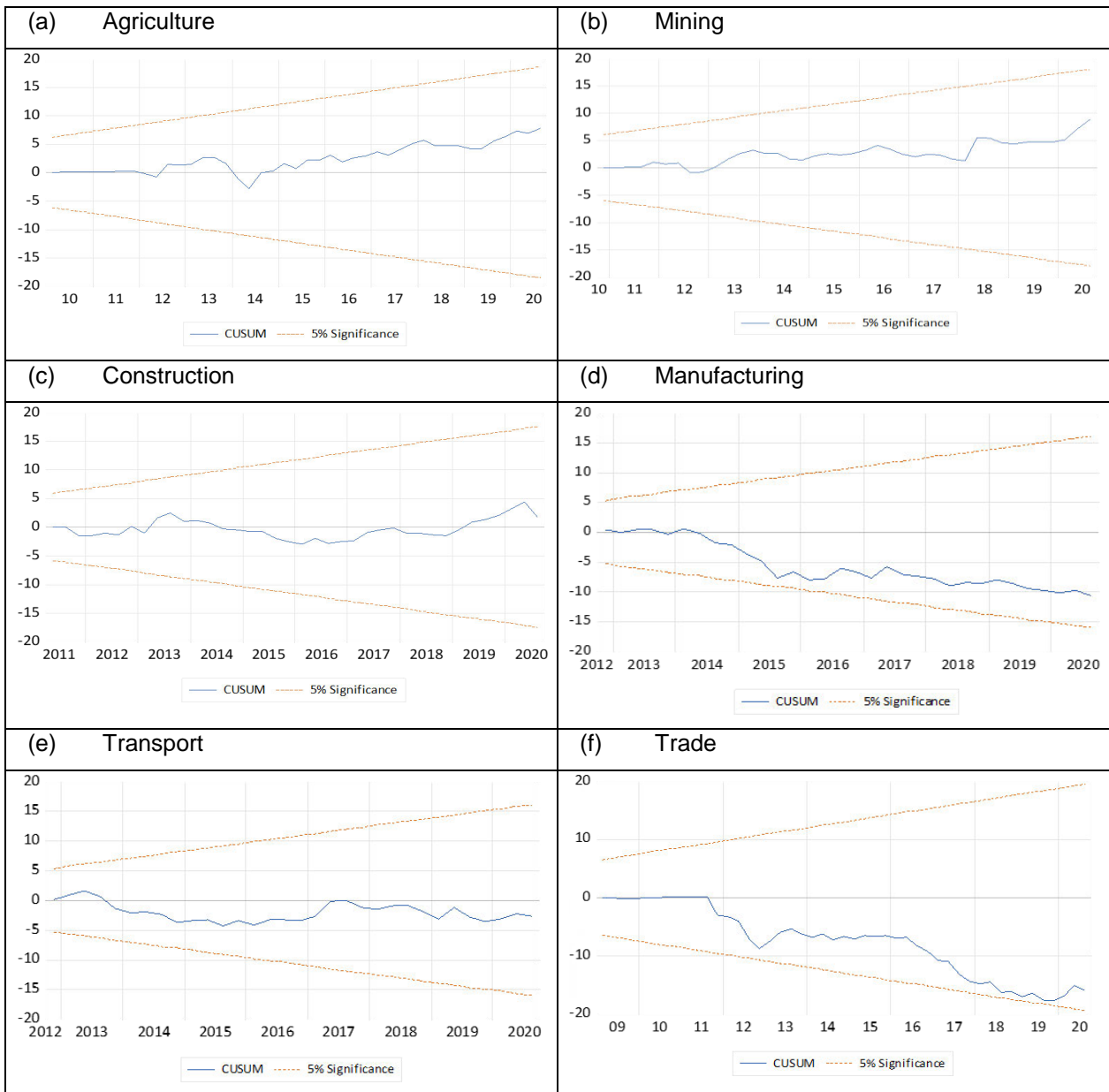


Figure 5.2: Results for CUSUM test for ARDL model estimates

Source: Author's own computation (2023)

Similarly, the CUSUM test was also performed for NARDL model estimates to estimate the stability of the model. Notably, the results of the graphs in Figure 22 depict that all six sectors statistically lie within the 5 percent critical bounds, confirming that all the coefficients in the model are stable. Therefore, one can confidently conclude that the relationship between credit risk and economic growth in Tanzania is of a long run nature, as attested by both the ARDL and NARDL estimation models.

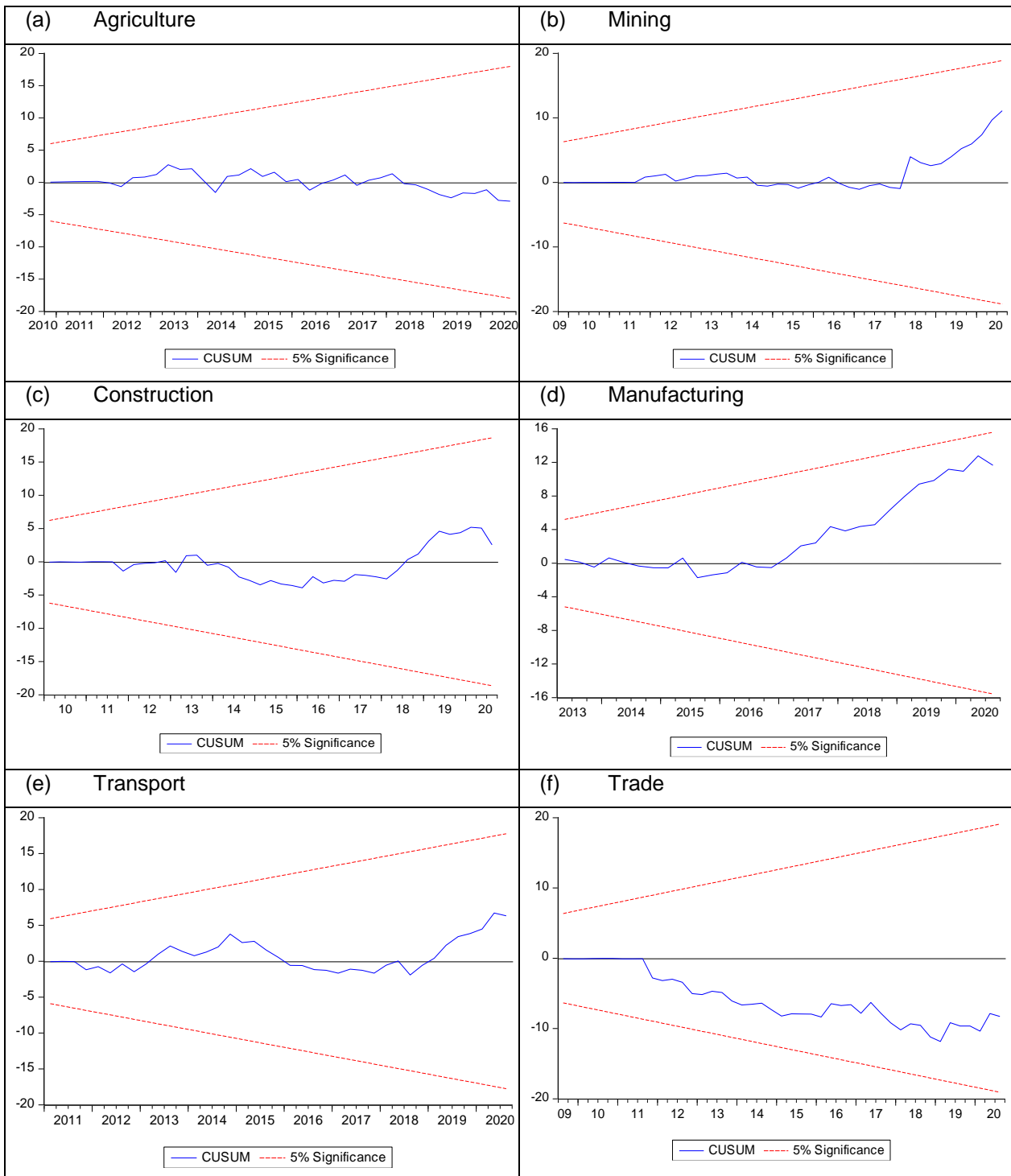


Figure 5.3: Results for CUSUM test for NARDL model estimates

Source: Author's own computation (2023)

5.6 Chapter Summary

This chapter focused on the effect of credit risk on economic growth, by looking at the six key sectors of agriculture, manufacturing, mining, trade, transport, and construction in Tanzania. The study covered a period from the second quarter of 2006 to the fourth quarter of 2020, assessing which sectors were more significant in the short and long run in relation to credit risk and economic growth. As research requires one to conduct preliminary tests before performing an empirical analysis, the study conducted unit root tests using ADF, PP, and KKPS tests to check the stationarity of data for both intercept and trend, for the ARDL and NARDL models. Non-performing loans were used as a proxy for credit risk in this study while GDP was used as a proxy for economic growth; the control variables included inflation rate, exchange rate, short-term interest rate, and trade openness. This chapter adopted both the ARDL and NARDL models for assessing the short-run and long-run effect of credit risk on economic growth, based on theoretical and empirical literature. In addition, the study established the efficiency and stability of the model using standard diagnostics, which confirmed its overall significance.

The bounds test revealed that there was a long-run relationship between these two factors, as attested by the cointegration results, except for the manufacturing and trade sectors in the ARDL and NARDL models, respectively. This implies that despite GDP being one of the determinants of credit risk, as observed in *Chapter 4*, the assessment of the effect of credit risk on GDP can assist policymakers in understanding the second round effect and how the performance of the banking sector can influence the Tanzanian economy. Therefore, this assessment broadens the literature on assessing both credit risk and economic growth, not based on aggregate relationships but rather on sector impact. This will assist in proposing sector-wise policies to mitigate exposures, with different magnitudes and resource allocations for effective supervision, financial stability, and economic growth in Tanzania. Although this research has tried to look at the issue sector wise, there is still room for more research to further analyse the results and observations made in this study.

CHAPTER 6: MACRO CREDIT STRESS TESTS AND MACRO-PRUDENTIAL POLICY

6.1 Introduction

Previous chapters have shown the significance of stress testing, as well as the relationship between credit risk and economic growth in developing countries like Tanzania. On the one hand, chapters 3 and 4 explored the significance of stress testing, by relating global transmissions and trading partner implications to the banking sector around credit-associated exposure as well as capital adequacy. The results of stress testing showed that Tanzanian banks were exposed to foreign transmission, given that Tanzania is an open economy; however, the capital adequacy buffers were sufficient to contain the impact, hence provided resilience. On the other hand, Chapter 5 explored the relationship between credit risk and economic growth using six major sectors, to examine the possibility of the second round effect that credit exposure may have on economic growth in Tanzania. The results showed that credit risk was not directly related to economic growth in Tanzania, as most of the sectors were not financed by the formal banking system. To draw from the previous chapters, this chapter aims to assess the interrelationship between macro stress tests and macro-prudential analysis.

Macro-prudential tools, with stress testing forming one of them, gained traction after the global financial crisis of 2008/09, with the intention to enhance the assessment of financial stability (Berezina et al., 2019). Across the globe, several central banks including the Reserve Bank of Australia, Federal Reserve, Bank of England, Reserve Bank of South Africa, and European Central Bank, among others, adopted these tools, with the IMF and BIS doing enormous work in developing and proposing macro-prudential frameworks to complement the micro-prudential assessment (Claessens, 2014; Constâncio, 2016b; Górnicka et al., 2020; Kohn, 2020; Selialia et al., 2010). While prudential regulations target individual banks, assuming the impact of one bank is exogenous to the interaction among banks, macro-prudential regulations, on the other hand, assess the systemic risk of the financial system as a whole (Arnold et al., 2012).

A macro-prudential assessment of banks, non-banks, and real economy sectors, involves policy measures/tools for which assist in evaluating the health and soundness of the financial system (Claessens, 2014). More specifically, bank-related macro-prudential

tools can either be qualitative or quantitative, with the former data being submitted by banks while the latter is obtained from sentiment surveys. Jayaram and Gadanez (2016) found that the presence of macro-prudential frameworks was much very focused on banks, where financial stability measurements were related to financial cycle dynamics, systemic risk, market dynamics, as well as policy choices. They further amplified that the choice of a macro-prudential tool depended on the type of shocks and imbalances, with some financial ones originating domestically while others mitigated vulnerabilities from global factors that were assessed, hence giving relevance to the suitability of the indicator (IMF, 2011; Jayaram & Gadanez, 2016).

Basically, there are a number of macro-prudential instruments that have been developed and applied to contain systemic risk, and address the pro-cyclical build-up of both excessive leverage and volatile funding, ranging from broad-based buffers, sectoral tools, and liquidity (Auer et al., 2022; Behn et al., 2013). Studies have looked at the existence of countercyclical capital buffers (CcyB) as a macro-prudential tool that is suitable for addressing pro-cyclical challenges in banks and associating credit with economic growth (Drehmann & Tsatsaronis, 2014; Jokivuolle et al., 2015). Recent studies have sought to assess how different macro-prudential tools interact among each other, as part of enhancing financial sector assessment, due to the growing global integrations (Chavaz et al., 2019; Constâncio, 2016b; Kohn, 2020). Specifically, stress testing has been assessed to discover how to calibrate macro-prudential policy tools like countercyclical buffers (Chavaz et al., 2019; Kohn, 2020).

Countercyclical capital buffers have been established to address the regulatory gaps observed during the global financial crisis of 2008/09, and to preserve the resilience of the banking sector, by taking into account financial cycles to avoid disruptions to credit supply, thus protecting the real economy (Repullo & Saurina Salas, 2011; Vasylyeva et al., 2014). Given the dynamic nature of the buffers, regulators call for banks to build a capital buffer during periods of excessive credit growth to cushion against the impact of adverse shocks to lending, thus gradually releasing credit to support the continued functioning of the real economy (Bonfim & Monteiro, 2013; Burra et al., 2015; Stojkov, 2020).

Drawing from the previous chapters, which established stress scenarios for both domestic and global transmission, this chapter intends to: extend the assessment of resilience of the 15 banks that were studied; establish a countercyclical capital buffer (CcyB); and finally assess the linkage between credit and GDP using a CcyB, with Tanzania representing developing economies. Further, **this study intends to show the need to relate business cycle variations through stress tests, and to determine time-varying capital requirements, by establishing a countercyclical buffer**. It also intends to contribute to the existing, nascent literature on stress testing and macro-prudential tools. In doing so, this study has adopted the use of countercyclical buffers using Basel III, to mitigate the procyclicality of bank capital and gauge the effectiveness of macro-prudential policies in decision-making, by using the case of Tanzania. This was done in order to identify the reference benchmark for the CcyB, and use the stress tests results as an indicator of systemic risk to determine when the appropriate time was to release the CcyB to support the economy (Górnicka et al., 2020).

The rest of this chapter derives both the empirical and theoretical literature review in Section 6.2, the methodology adopted including data descriptions, source, and models to be used for analysis are presented in Section 6.3, while Section 6.4 presents the empirical results and summary.

6.2 Literature review on macro credit stress tests and macro-prudential policy

Financial stability efforts to safeguard the banking sector as well as the financial system at large, have been enormous in recent years with a great emphasis on implementing macro-prudential policy tools and instruments (Claessens, 2014; Górnicka et al., 2020; Jayaram & Gadanecz, 2016). The area of macro-prudential policy tools and analysis, as well as associating these with stress tests, is a grey area and there have been few studies conducted by policymakers and academicians delving into the significance of cyclical behaviour for systemic risk assessment (Chavaz et al., 2019; Kohn, 2020). In relation to the theories associated with relating macro-prudential policy tools with the performance of the banking sector, studies conducted in this area have alluded to the fact that effective systemic risk assessment is important to curb spillover effects, by maintaining buffers during good times that can cushion the potential risks during crises (Burra et al., 2015;

Holmsen, 2014; Kenç, 2016; Schoenmaker & Wierts, 2016; Yandari & Sudaryati, 2018). This section explores various theories that underline this thought, including the empirical literature that has been compiled in this area.

6.2.1 Theoretical literature review on macro credit stress tests and macro-prudential policy

The macro-prudential aspects discussed here are drawn from the review discussed in chapters 3 and 4, where macro stress testing and banking resilience were associated to the existence of various theories, including arbitrage pricing and agency theories. The major concern of these theories was whether risk aspect could be influenced by the level of oversight. Therefore, to amplify that, the extension of macro-prudential policy tools is the aim of this study. Macro-prudential policies have been adopted in different jurisdictions, with the intention of controlling credit growth in aggregate or main economic sectors to ensure financial stability, and also to support the co-existence of economic and financial cycles (Kenç, 2016). With the growing interlinkages and financial transmissions, several measures have been taken towards addressing crisis management by critically identifying systemic institutions, proposing mitigation of systemic crises by curbing the credit cycle, as well as conducting tests determining the fragility of the system and risk of contagion.

Following the impact of the growing interlinkages between credit and GDP, macro-prudential policy has become a significant way to secure buffers to ensure resilience before exposure materialises. It is worth noting that the emergence of macro-prudential regulations, policies, and tools together are utilized in crisis prevention and mitigation, to ensure the financial stability of an economy. Potentially, as macro-prudential policy focuses on mechanisms to curb the spillover effects of financial crises, and propose mitigation measures in due course; on a side note, the thinking around the macro-prudential theory comes from Minsky's theory and financial investment. Based on these theoretical underpinnings, the interactions between macro-prudential tools focus on ensuring financial stability, and are important to identify the interlinkages between credit and GDP, and gain the potential benefits derived from each one. To anchor this, this chapter will refer to the theories that relate to how stress tests are associated with other macro-prudential policy tools, specifically countercyclical buffers.

Minsky's theory goes relates to the fragility of the financial system and proposed the need to devise approaches to stabilization policy as well as reforms to financial arrangements (Minsky, 1975). He described the fundamentals required to distinguish between robust and fragile financial structures, based on hedge, speculative, and Ponzi finance by economic actors, and based on that, provided a roadmap to the reforms needed to prevent periodic recurrences of crises (Minsky, 1975). This theory, in the study by Minsky (1977), continued to build on the concept of the financial instability hypothesis, drawing from Keynes' theory, by viewing financial crisis as a systemic risk and not an occurrence, and pointing to the role of financial decisions in sophisticated capitalist economies.

In the same light, Minsky (1980) continued to amplify the Minsky theory by recognizing banking as a pervasive phenomenon that cannot be controlled by only legislations, but rather viewing the behaviour of the capitalist economy at large. Further, the existence of the financial instability hypothesis derived from Minsky's theory, which expanded on the Keynesian and standard theories, underscored the behaviour of government dynamics; this was done by assessing the interventions taken in monetary and fiscal policy in a complex financial system, with the anticipation that crisis may occur (Knell, 2015).

In a study by Taylor and O'Connell (1985), it was noted that Minsky's ideas on financial crises were influential, and were supported by the existence of other reviews in late 1970s, although citations of his work were few, as most it was not formally elaborated and scarcely noticed in the textbooks at that time. In the same review, Taylor and O'Connell (1985) underscored a crisis by adopting a model that focused on assessing the anticipated occurrence of debt deflation macroeconomic events that may lead to the dampening of expected profits.

In another study by Wolfson (2002), Minsky's theory of financial crises was adopted and expanded upon beyond the context of the domestic economy, by taking into account the international setting and investigating the dynamics of the global economy in light of financial crises. In the wake of the global financial crisis of 2008/09, the adoption of Minsky's theory shed light on the rise and fall of the shadow banking system, where the loopholes in regulations originated from credit booms, in turn leading to a deepening of the systemic crisis (McCulley, 2009). After that global crisis, the existence of Minsky's

theory was referenced in association with business cycles, which have ultimately permitted financial crises to take place over long durations, reflecting the longer phase of the cycle (Palley, 2011). Recent studies have adopted Minsky' theory, with a view of assessing the causality links on how financial cycles cause business cycles in the UK economy; the results found that the cycles observed change over time with contemporary financial cycles being longer than their historical counterparts (Porada-Rochoń & Škare, 2020). In another study, Akaev and Sadovnichii (2020) adopted a model to predict financial instability using Minsky's theory for the US economy, in order to compare the impact of the short-term dynamics during the COVID-19 pandemic to those of the financial and economic crisis of 2007/09.

Macro-prudential theory goes way back to the early 1970s and its later use became significant after the global financial crisis of 2007-09, by building on global efforts on the assessment of systemic risk and proposing mitigation measures for financial crises (Clement, 2010). Studies focusing on macro-prudential theories have been widely adopted at international fora, including those involving the IMF, BIS, as well as central banks, which are focused on enhancing the surveillance of financial stability (Burra et al., 2015). A review by Kenç (2016) on macro-prudential theory, focused on how to control credit growth in an aggregate or major economic sector, which usually began in the advanced economies and later spilled over into the emerging market economics that were faced with excessive capital inflows.

Holmsen (2014) argued that the existence of macro-prudential theory focuses on the risk that comes out of banks, while traditional banking regulations focus on the risk that goes into banks; thus this theory aims at strengthening the resilience of the financial system, while helping to curb financial vulnerabilities that build up in the economy. In another study that amplified the relevance of macro-prudential theory, Schoenmaker and Wierds (2016) argued for the development of a framework for measuring and addressing financial imbalances, where the financial cycle was the key variable for measuring financial imbalances. Farhi and Werning (2016) revealed the use of the theory of macro-prudential policies for nominal rigidities in the goods and labor markets.

As macro-prudential policy is a wide-ranging phenomenon, this study aims to focus on the adoption of countercyclical capital buffer (CCyB) associated with assessing the credit-to-GDP gap, which aims to safeguard financial stability by retaining additional capital in times of excess credit growth, and secure it for times of distress (Andaiyani et al., 2021; Wezel, 2019). In relation to this, the pecking order theory, in addition to the existing Minsky and macro-prudential theories, is important, as a CCyB is a type of additional capital policy that functions as a buffer to anticipate losses in the event of excessive credit growth (Andaiyani et al., 2021).

Pecking order theory originates from the idea of capital structure, which describes a hierarchy of financing choices that a firm makes due to information asymmetries; as a result of adverse selection, firms prefer internal to external finance (Myers, 1984; Yıldırım & Çelik, 2021). Since equity is rarely issued, Myers (1984) introduced the idea of internal to external funds, where there is debt to equity if external funds are needed, thus the debt ratio reflects the cumulative requirement for external financing, moving from simple to asymmetric information models. The use of pecking order theory for the selection of funding projects in an economy, with the existence of macro-prudential bank capital regulation in a competitive financial system, revealed how risk-shifting activities become less profitable (Harris et al., 2014).

Macro-prudential oversight analysis has revealed the usage of the pecking order theory in Turkey, where the credit market responded to a persistence in uncertainty with a more pronounced effect on private rather than public firms (Yarba, 2017). The relevance of the assessment of macro-prudential policies became significant after the 2007-09 financial crisis, as highlighted by Yandari and Sudaryati (2018), in relation to pro-cyclical action having a considerable influence on the asymmetry of income-smoothing information. In another study, the pecking order theory was adopted for the development of the macro-prudential regulatory framework of Basel III in the Swiss banking system, whose effectiveness and efficiency of financial regulations fosters financial system resilience. Osina (2018) examined the effectiveness of capital controls and macro-prudential policies to manage the volume of international capital flows; the results were in line with the pecking order theory on capital flows, and with the riskiness of different asset classes.

Bjørland and Kockerols (2020) adopted the use of pecking order theory in the development of a stress test framework on macro-prudential contagion in the Norwegian banking sector, assessing the direct and indirect contagion effect of fire sales, in which the contagion losses were highly correlated with losses in covered bonds.

6.2.2 Empirical literature review on macro credit stress tests and macro-prudential policy

Moving from the theoretical to the empirical review, there are a few studies that have assessed the relationship between stress testing and macro-prudential tools, mainly focusing on amplifying the significance of macro-prudential interactions for financial stability (Arnold et al., 2012; Kenç, 2016; Noyer, 2014). Specifically, Górnicka et al. (2020) concentrated on simulating bank credit losses for stress-testing purposes, and calibrating borrower-based macro-prudential tools, which incorporated the housing and economic cycles;. In another study, Constâncio (2016b) noted that the emergence of macro-prudential policy has brought advancement to stress testing beyond the normal results for individual banks, by integrating more realistic dynamic features, contagion effects, and the real economy, so as to enhance the use of macro-prudential policy. The objective of this study was to assess how macro credit risk stress tests related to macro-prudential policy tools, specifically countercyclical capital buffer. In relation to this, some studies have assessed the impact of countercyclical buffer policies on the banking sector's performance, besides its credit growth (Vasylyeva et al., 2014).

Andaiyani et al. (2021) assessed the impact of countercyclical buffer policies on the profitability of regional development banks in Sumatra, Indonesia, by employing a dynamic panel model with generalized methods of moments (GMM) on a quarterly frequency, from Q1:2005 to Q2:2017. The results revealed that the increased capital by using the CCyB had no significant effect on the selected banks' profitability, but rather brought an increase in the amount and cost of loans to companies (Andaiyani et al., 2021).

Another study by Behn et al. (2013) drew on the setting of Basel III /CRD IV countercyclical capital buffers (CCyBs), which embedded credit, other domestic and global financial factors, as well as banking sector variables, using data for 23 EU member

states from Q2:1982 to Q3:2012 with a multivariate early warning model framework. Behn et al. (2013) assessed this to predict vulnerable states of the economy in EU member states, in order to increase the resilience of the banking sector and its ability to absorb shocks arising from financial and economic stress. Osina (2018) reviewed the effective calibration of capital flow regulations to country-specific circumstances, using a sample of 112 countries from 2000 and 2016, to link global governance indicators and patterns of gross capital flows; the study noted that, reserve requirement ratios and concentration limits were the most effective macro-prudential policies for managing countries' exposures to global liquidity fluctuations.

Empirically, different studies have assessed countries' banking systems by relating macro stress testing to macro-prudential policy, in the context of macro-prudential stress testing frameworks (Andersen et al., 2019; Bjørland & Kockerols, 2020; Buncic & Melecky, 2013; Taskinsoy, 2019). In this vein, the study by Bjørland and Kockerols (2020) developed a macro-prudential stress testing framework for the Norwegian banking system, to assess contagion effects on how losses could be amplified beyond the stress scenarios on a normal stress test. The study covered 22 banks during Q2:2019, and for the quantification of contagion-driven systemic risk, Monte-Carlo simulation model were adopted, revealing that losses were high when banks ran quickly into funding problems (Bjørland & Kockerols, 2020). Arnold et al. (2012) assessed the different mechanisms used to measure systemic risk, banking crises, as well as challenges encountered. Further, on a macro-prudential perspective, the study analyzed the emergence of countercyclical capital buffers related to the financial cycle and macro-stress tests, and monitored the financial system and broader economy, as well as the emergence of liquidity regulation, in view of capital adequacy standards (Arnold et al., 2012).

The European Central Bank has done extensive work on exploring the principles behind the effective implementation of macro-prudential policy, with emphasis on the importance of pre-emptive and countercyclical, financial cycles, and borrower-based tools; it was found that stress tests should have a macro-prudential dimension, and that monetary policy should be complemented by a macro-prudential policy (Constâncio, 2016a). Anderson (2016) analyzed the perspectives of policymakers and academics regarding

how to use stress tests for macro-prudential policies, through dynamic provisioning and a cap on the loan-to-value ratio for mortgage loans. The scenarios that supervisors imposed on the banks were specified in a set of hypothesized paths for a relatively small number of macroeconomic variables (Anderson, 2016). In a different vein, Borio et al. (2014) macro stress tested the macro-prudential framework to detect for vulnerabilities in the financial system ahead of a crisis.

This study assessed the relationship between stress tests and macro-prudential tools using a countercyclical capital buffer (CCyB) as a proxy. The main objective of the CCyB is to strengthen the resilience of the banking system, by gradually increasing banks' capital buffers during periods of rising systemic risk, thereby supporting the flow of credit during periods of financial stress (Van Oordt, 2020). Kohn (2020) argued that there was a need to ensure that banks had enough capital for the continuity of credit extension to customers, in order to support economic growth even after a severe shock. Further, the study focused on a review of how the Bank of England had adopted countercyclical capital buffers and stress tests as key inputs in assessing the level of risk and capital required, with a view of protecting and enhancing the resilience of the UK financial system (Kohn, 2020).

In a similar study to the one just mentioned, Chavaz et al. (2019) designed a framework to associate how CCyB and stress tests had been applied in action to deliver countercyclical capital and other macro-prudential judgments and policies. This was drawn using two scenarios that depicted severity in the annual cyclical scenario for 2018 and a worst-case, no-deal Brexit scenario; the results revealed that the major UK banks remained resilient, as the losses originating from shocks were absorbed by existing capital buffers (Chavaz et al., 2019).

On another note, Van Oordt (2020) applied the long-term exposure covariance using data from Q1:1990 to Q4:2016 from 124 banks in six advanced economies, namely: Australia, Canada, the Euro area, Japan, the United Kingdom, and the United States. This aimed at calibrating the magnitude of the countercyclical capital buffer (CCyB) using market-based stress tests. Meanwhile, Vickers (2019) established the countercyclical capital buffer using a set of simple and composite indicators for the financial cycle and systemic risk in

the Czech economy, estimating credit losses in the event of adverse shocks and stylized facts about the financial cycle.

Generally, the theories and empirical literature relating stress testing with macro-prudential tools, specifically countercyclical buffers, are still a new area of research. The interplay between these supplements existing systemic risk assessments. It must be noted that policy makers adopt stress testing as an effective tool, it is imperative to extend its function beyond just looking at banking sector performance, but rather also gauging established capital ratios owing to shocks. Given the complexity of macro-prudential analysis, few studies have been carried out in the African context with a standalone focus, rather than with interrelated functions. Therefore, this study aims to fill this gap by using Tanzania as a proxy to establish countercyclical capital buffers using the Basel approach, in order to both guide and assess when they should be used, in case the stress test shocks materialise. There is the need to maintain capital buffers in good times as well, to ensure the resilience of the Tanzanian banking sector in case a crisis does occur.

6.3 Methodology

The objective of this chapter is to analyse the relationship between stress tests and macro-prudential policy tools in the banking sector, with the aim of improving macro-prudential analysis in order to derive evidence-based policies. This study intends to first establish the countercyclical capital buffer (CCyB) using the methodology for credit-to-GDP gap, based on banking sector credit data from Q2:2006 to Q4:2020, at a quarterly frequency. Given the constraint of having limited data, the use of the BIS' guide with the credit-to-GDP gap will add substance to the implications of the CCyB, since the stressed conditions relate to the impact of credit risk on the banking sector's performance. Previous literature has reviewed the implementation of the CCyB and its consequences, proposing indicators that are best suited to detect systemic risk (Behn et al., 2013; Burra et al., 2015). For calibration of the CcyB, studies denote several approaches and an indicator base selection ranging from one to 25 indicators (BCBS, 2017; Supervision, 2009). This study opts to adopt the credit-to-GDP gap ratio, a lead indicator as an early warning signal for determining financial distress, as proposed in the study by (BCBS, 2010), since it has

been identified as a powerful predictor of banking crises in several studies. In addition, the credit-to-GDP gap ratio usually normalizes with the size of the economy, thus providing a deeper financial aspect (Drehmann & Tsatsaronis, 2014) To establish and determine the periods of credit growth, and develop a reference benchmark to assess when it is appropriate to release the CcyB, using the stress test results obtained in Chapter 4.

Later, the build-up of systemic risk using the results observed of the macro credit risk stress test in Chapter 3, will be used to identify episodes when banks would react and when the central bank would release the CcyB, in relation to a deviation in the core capital, conservation buffer, and the CcyB reference benchmark. In Tanzania, the core capital was 10 percent), the regulatory capital was 12 percent), and the conservation buffer was 2.5 percent (Tanzania, 2020).

6.3.1 Model specification for macro credit stress tests and macro-prudential policy

This section explains the model adopted when calibrating the countercyclical capital buffer for Tanzania, establishing that a bank would need to adjust its capital if its capital threshold was below the reference CcyB. This study adopted the credit-to-GDP gap methodology proposed at Basel III, which computes the gap between the credit-to-GDP ratio and its long-term trend, in order to calibrate the CcyB for Tanzania (BCBS, 2010; Kohn, 2020). The introduction of countercyclical capital buffers tends to cater for rising economic cycles, in order to minimize capital erosion and ensure continuity of credit provision in times of downturns (Kohn, 2020). To establish the credit-to-GDP ratio gap, the Basel Committee for Banking Supervision (BCBS) proposed the trend-removal statistical technique.

First of all, this study will calculate the CcyB buffer using the BIS 2010 approach:

Calculate the credit-to-GDP ratio.

$$Ratio_t = Credit_t / GDP_t \times 100 \quad (6.1)$$

GDP_t represents nominal, domestic GDP; $Credit_t$ represents aggregate private sector credit, and t is time on a quarterly basis.

Calculate the credit-to-GDP gap.

$$GAP_t = Ratio_t - Trend_t \quad (6.2)$$

$Ratio_t$ represents the number obtained from equation (6.1), and $Trend_t$ represents the sustainable average of the credit-to-GDP ratio.

The main advantage of the approach is its relatively low data requirement, as it is only dependent on the time series of the credit-to-GDP ratio. The trend is given by the solution of the following optimization problem.

On estimating the trend for computing the credit-to-GDP gap, there are several statistical methods that can be used, including the one-sided Hodrick Prescott (HP) filter which is proposed for this study (Drehmann & Tsatsaronis, 2014). The advantage of the HP filter is its simplicity of use, however, its weak link to economic theory may lead to statistical and economic challenges (Hájek et al., 2016).

Establishing the CcyB buffer using the computed credit to GDP gap:

L – the lower threshold

H - the upper threshold of the buffer guide

As per the BCBS (2010) the following is adopted.....:

$$\left(\frac{Credit_t}{GDP_t} \times 100 \right) - Trend_t < 2percent \quad \text{When } L=2$$

$$\left(\frac{Credit_t}{GDP_t} \times 100 \right) - Trend_t > 10 percent \quad \text{When } H=10$$

Obtain the reference benchmark.

Computation of the time when the bank can release a CcyB, using the stress test results obtained in paper one, based on capital adequacy levels in a severe scenario.

If Capital after Stress Test_t < 10 percent, then release CcyB

6.3.2 Data description

The credit-to-GDP gap is a proxy determining the CcyB, when most of the risks originated from credit exposures. The data is obtained from the Bank of Tanzania's publications,

ranging from Q2:2006 to Q4:2020 for gross loans on a quarterly basis. The GDP data is obtained from the National Bureau of Statistics on a quarterly basis (Behn et al., 2013; Bonfim & Monteiro, 2013; Burra et al., 2015; Stojkov, 2020).

6.4 Interpretation of results

The section aims to provide a detailed analysis of the results and an interpretation of them, beginning with a descriptive analysis, followed by setting the countercyclical buffer and the buffer guide in relation to stressed capital for each bank, as obtained in Chapter 4.

6.4.1 Setting the countercyclical buffer

Figure 6.1 reflects how a positive gap may indicate excessive credit growth, when using the countercyclical capital buffer (CcyB) described in the BIS 2010 approach. The BCBS suggests that a credit-to-GDP gap of between 2 and 10 percent should correspond to a buffer of between 0 and 2.5 per cent in risk-weighted assets (BCBS, 2010).

The CcyB developed in this study, as shown in *Figure 6.1*, revealed that during the month of March 2009, and from March 2011 to September 2018, the buffer was above 10 percent of the core capital requirement, implying that Tanzania's banking sector would have to set an excess of 2.5 percent capital in case of the adoption of Basel III. Thus, this reflects that the Tanzanian economy witnessed a growing credit growth, and lending terms tended to get easier during that period (BOT, 2010b, 2019a). In Tanzania, banks already hold an additional buffer, namely a conservation buffer of 2.5 percent, on top of its 10 percent and 12 percent of core and total capital requirements, respectively (BOT, 2021c).

The behaviour of the credit-to GDP gap observed in *Figure 22* is positive, despite the times of depression experienced around the globe, among others the financial crisis of 2007-09. This implies that despite the challenges, the Tanzanian banking sector still had enough capital to absorb shocks, as well as minimal global interactions in the sector. This is quite different from the study by Kohn (2020) who established a countercyclical buffer in the UK, and noted the negative gap during the times of the global financial crisis and Brexit, given the global interactions of the UK's banking sector. This study adopted one indicator for setting the countercyclical buffer, in contrast to other preferred empirical

studies, which propose that policymakers use several indicators that influence credit growth to make decisions, as highlighted by (Van Norden, 2011).

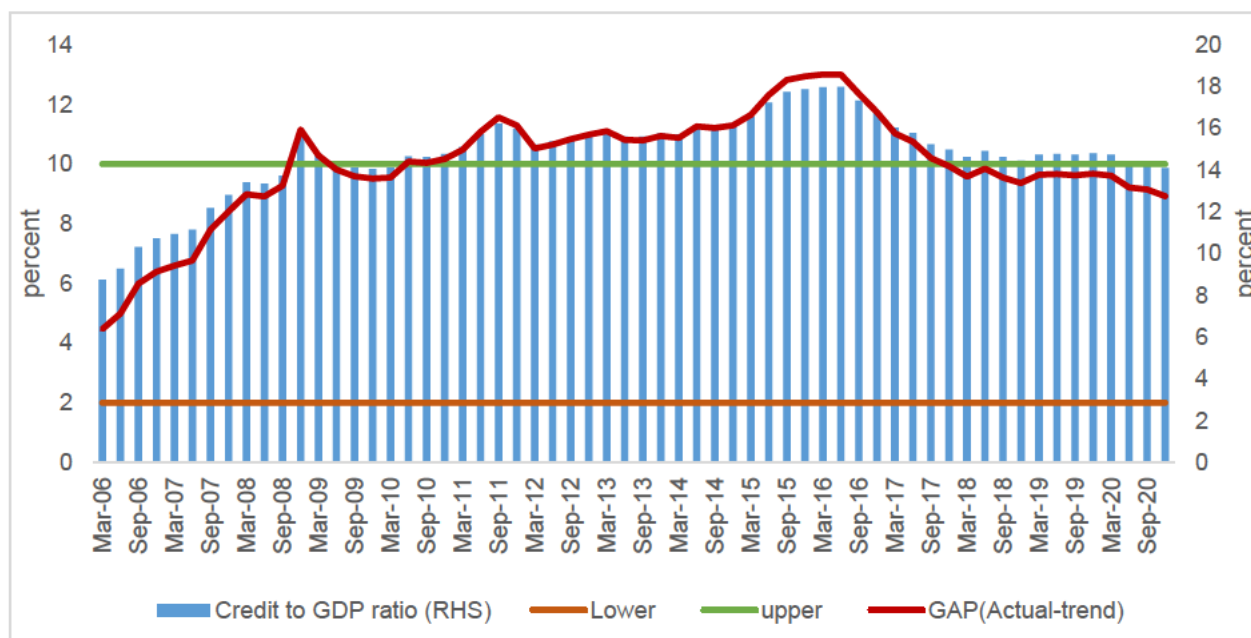


Figure 6.1: Credit to GDP gap and the buffer guide

Source: Author's own computation using BIS guide 2010

6.4.2 Stress test results in comparison to releasing the CCyB

At an individual bank level, drawing from the results in Chapter 4 on stress tests of the selected 15 banks, the study observed that since Tanzania had existing capital adequacy requirements of core and total capital requirements of 10 percent and 12 percent, respectively. In addition, there is an additional conversation buffer of 2.5 percent for risk-weighted assets, then during periods of credit growth, an additional CcyB would be seen as viable by certain banks. Based on these results, which show a positive credit-to-GDP gap, using the stressed test scenarios derived from the output obtained in chapter 4.

From the stress tests obtained in Table 17 in Chapter 4, the activation of CcyB in 2020, based on three scenarios, had the following effects, when a negative shock to GDP was applied, the activation of CcyB had an aggregate effect on capital adequacy requirements; however, individual banks were affected differently, with banks AA, AJ, and AR being

below the 10 percent core capital requirements. For the stress test results of a positive shock in the oil price, only bank AA was below the 10 percent mark after the stressed scenario, thus activation of the CcyB would be necessary. In the third scenario of a negative shock on the price of agricultural commodities, with a 16 percent increase in RWA, all the banks had capital ratios above the 10 percent capital adequacy, therefore, no bank would be subjected to activation of the CcyB in case it was adopted. This result is in line with the study by Brasliš and Arefjevs (2014) compared the CcyB obtained from different countries, and revealed how the two different indicators of credit-to-GDP gap and credit growth were adopted.

6.5 Chapter Summary

This chapter focused on designing the countercyclical buffer using the BIS 2010 buffer guide, and later establishing during which period it would have been necessary to release it, in case it existed in Tanzania. The CcyB was expected to help maintain the supply of credit to the economy and dampen the downswing of the financial cycle. The study adopted the credit-to-GDP gap as the indicator for the computation of the buffer guide. The data for the study was from the second quarter of March 2006 to the fourth quarter of September 2020. The results of the buffer guide depicted a positive gap. The positive gap showed that even during the global crisis of 2008/09, the potential of having negative recessions was not witnessed in the Tanzanian economy.

The results further revealed how the established countercyclical capital buffer could have been released by individual banks, if the banking sector adopted CcyB based on the stress test results observed in Chapter 5. Therefore, it is recommended for policymakers to review the buffer gap based on the amount of credit growth exposure, instead of using an aggregate buffer. Notably there are few studies that have done research in the area of countercyclical capital buffers and stress tests, thus this study adds to the existing literature by linking the findings observed in Chapter 4 to the design of a countercyclical capital buffer in this chapter.

CHAPTER 7: SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The main aim of this study was to assess how macro credit risk stress tests for individual banks by sector classification effect a bank's resilience, real economic growth, and the usage of macro-prudential tools. Given the significance of credit risk as the major source of risk in the banking sector, several studies modelled credit risk in isolation from other risk factors, including liquidity, contagion, interest, and foreign exchange risks, to effectively assess its implication on the banking sector performance. However, no empirical study has been done in Tanzania expounding on individual banks' or sector-wise exposure to credit risk in the banking sector, as well as economic growth implications. Thus a study on the area of credit risk on both systemic impact as well as economic growth implications was relevant, given the significance of credit in the banking sector. In addition, this study also drew on the need to integrate macro-prudential tools using macro stress tests and countercyclical buffers. Further, the study concentrated on credit in the banking sector and real economy, thus, probing policymakers to extend concentration to the complete financial stability rather than only using the normal supervisory and compliance tools of risk management.

To achieve this aim, this study had three specific objectives, which are to: assess the impact of macro credit risk stress tests on the banking sector's resilience in Tanzania; evaluate the effect of banks' credit risk to real economic growth by sector in Tanzania; and to analyze the implication of the stress test results in influencing macro-prudential policy decisions in Tanzania. This study was structured into seven chapters, where Chapter 1 focused on the introduction, statement of the problem, objectives, contributions, and the conceptual framework of the study. Chapter 2 focused on the review of the financial sector and the banking sub-sector in Tanzania. Chapters 3 and 4 aimed at attaining the first objective of the study, namely of assessing the impact of macro-credit risk stress tests on the banking sector's resilience in Tanzania. Chapter 5 analyzed the effect of credit risk on real economic growth in Tanzania. Chapter 6 proposed the adoption of a countercyclical capital buffer, and assessed the implications of the stress test results obtained in Chapter 4; specifically, it assessed how they deviated from the buffer, when

the buffer would be required, and by which specific banks in Tanzania. *Chapter 7* contains the conclusion of this study as well as recommendations.

The rest of this chapter details: a summary of findings, namely objective, achievement, and key conclusions; recommendations; limitation of the study; and areas for further research.

7.2 Summary of the findings

This study aimed to explore the relationship between macro-prudential tools, banking sector resilience, and economic growth in Tanzania. To do so, the study used stress tests and a countercyclical buffer as types of macro-prudential tools. In order to effectively achieve the objectives, the study was divided into three main parts, divided into eight detailed chapters. The first part included the introduction in *Chapter 1*, and the financial sector, banking sub-sector, and overview of stress testing in Tanzania in *Chapter 2*. The second part covered the main section of the thesis, detailing the objectives from chapters 3 to 6: Chapter 3 assessed the macro-credit risk stress tests; *Chapter 4* viewed the relationship between stress tests and banking sector resilience; *Chapter 5* assessed the relationship between credit risk and economic growth; and Chapter 6 viewed the relationship between stress tests, economic growth, and countercyclical buffers. The third part of the thesis is *Chapter 7*, which is the final chapter of the study, and summarises the entire study, as well as providing the conclusion, policy recommendations its limitations, and further areas for research.

The motive behind the study in Chapter 1 was to draw the point of how important credit risk assessment is for effective financial stability and economic growth. Through this, this chapter looked at the key drivers that guided the study, the contributions and significance to the growing literature in the area of stress tests, and countercyclical buffers and economic growth in developing economies like Tanzania. Chapter 2 brought on board the structure of the financial sector in relation to reforms that have occurred in Tanzania over the years. Further, the chapter dissected the different types of banks in the Tanzanian economy, and also related how much the banking sector has been contributing to economic growth, thus signaling its relevance. The chapter also amplified how the Tanzanian banking sector was fairing in relation to the other EAC partner states. In

addition, *Chapter 2* also brought into focus the evolution of stress tests and different initiatives towards enhancing their conduct, from a global and individual point of view.

Chapter 3 adopted the GVAR model to conduct macro credit risk stress testing in the Tanzanian banking sector, due to its growing exposures and interlinkages with the global economy, thus pointing to the importance of assessing the magnitude of their effect on the banking sector and the need to propose mitigation measures. The choice of the GVAR model was motivated by the need to accommodate both domestic and global variables in relation to countries that have a high trading relationship with Tanzania, to uncover how the performance of their economies would transmit to the Tanzanian banking sector through credit exposure.

Chapter 4 was motivated by the need to further explore the relationship between stress tests and banking sector resilience at an individual bank level, by looking at banking sector-specific variables. This chapter adopted the dynamic panel model approach, especially the GMM model for modelling NPLs, to link credit risk with economic and banking sector variables. This was adopted to avoid bias in fixed effect panel econometric models, in order to get a more efficient estimation. Drawing from the stress test framework for macro credit risk proposed in *Chapter 3*, using the GVAR model, macroeconomic scenarios were used. Further, to assess the reaction of credit risk to macroeconomic shocks, this study adopted the GVAR model results obtained in *Chapter 3* for these shocks, and integrated the banking-specific variables to assess their impact. The end result of the chapter was how each individual bank was affected by macroeconomic shocks, by using the stressed NPLs' relationship to capital adequacy. This will support specific bank measures with different responses, based on the magnitude of exposure, to support existing supervisory tools for onsite and offsite surveillance. This chapter brought on board bank resilience, which is the ultimate goal of banks for risk management, through using stress tests to detect early warning signals.

Chapter 5 continued to amplify the significance of assessing credit risk in different dimensions, from the banking sector level in terms of performance, to sectoral analysis. This chapter evaluated the relationship between credit risk and economic growth using both the ARDL and NARDL models, and detailing both short- and long-run relationships

using the six major sectors of the Tanzanian economy. For a long time, studies like Ojima and Ojima (2019) have viewed how economic growth affected credit risk; however, little has been done on how credit risk can be a source of challenges for economic growth, specifically by conducting sector-wise comparability.

Finally, *Chapter 6* established the relationship between stress tests, economic growth, and the countercyclical capital buffer, where the CcyB was developed following the BIS 2010 approach using the credit-to-GDP gap indicator. This chapter aimed at determining the appropriate mitigating pro-cyclicality of bank capital, and gauging the effectiveness of macro-prudential policy in decision-making, using the case of Tanzania.

7.3 Objective, achievement and key conclusions

Fundamentally, this study has attempted to address the identified research gaps as outlined in the three specific objectives. Objective one aimed at assessing the impact of macro credit risk stress tests on banking sector resilience in Tanzania. The second objective aimed to evaluate the effect of bank credit risk on real economic growth by sector in Tanzania. The last objective sought to analyze the implication of the stress test results in influencing macro-prudential policy decisions in Tanzania. The Tanzanian financial sector has been dominated by the banking sector since the colonial era, and accounts for about 70 percent of total financial assets. Despite the different challenges encountered during the period under review, including the global financial crisis of 2008/09, two regime changes, as well as the COVID-19 pandemic, the Tanzanian banking sector has continued to exhibit resilience with high capital adequacy ratios above the regulatory requirement, and has maintained liquidity ratios above the 20.0 percent minimum requirement. However, the analysis noted the concern of the quality of assets remaining above the acceptable level of 5.0 percent for the past ten years, hence warranting monitoring.

Objective one explored the impact of macro credit risk stress testing on banking sector resilience in Tanzania, by associating global and banking sector-specific effects. This was achieved by first conducting a macro credit risk stress test using the GVAR model to capture domestic, foreign, and global transmissions in Chapter 3. The findings depicted that the Tanzanian banking sector was more responsive to changes in the inflation rate

compared to GDP in the domestic economy, as forecasted for the next 40 months. This was supported by the lag effect in the reaction of GDP as well as the purchasing power of customers. Oil price was a major global shock that affected credit risk, as Tanzania is an oil importing country, and as such, there was a substantial spillover effect due to rising prices affecting major sectors of the economy, thus increasing the consumer prices. Later, the relationship between macro credit risk stress tests and banking sector resilience was explored using 18 commercial banks in the Tanzanian economy, with banking-specific factors being considered in Chapter 4. The findings revealed that the banking sector in Tanzania was more exposed to domestic GDP shocks compared to the other two shocks observed in this study, namely the change in prices in oil and agricultural commodities. However, the results revealed that based on the plausible and adverse scenarios applied, the Tanzanian banking sector was still resilient to shocks, as the Bank of Tanzania was taking prudential and supervisory measures to ensure stability of the financial sector.

Objective two, on the other hand, evaluated the effect of bank credit risk on real economic growth, concentrating on the six major economic sectors of agriculture, manufacturing, mining, trade, transport, and construction in Tanzania. The results implied that despite GDP being one of the determinants of credit risk, as observed in Chapter 3, an assessment of the effect of credit risk on GDP could assist policymakers in understanding the second round effect, regarding how the performance of the banking sector can influence the economy in Tanzania. Therefore, this assessment broadens the literature on assessing both credit risk and economic growth, not based on aggregate relationship but rather on sector impact. Chapter 5 assessed that there was a long-run relationship between these two factors, as attested by the cointegration results, except for the manufacturing sector.

It was found that, for both the ARDL and NARDL estimation results in the long run, there was a significant effect of credit risk witnessed on economic growth, which was mainly observed in agriculture, mining, and construction. Meanwhile, in the short run, the construction and transport sectors were statistically significant with a negative and positive coefficient, respectively. These results amplify that policymakers need to conduct more sector-specific policy assessments and propose sector-specific tools, rather than

aggregate sector tools since the effect was different in the various sectors of the economy, to support economic growth and mitigate credit risk exposures as well.

Objective three dealt with the interplay between the macro credit stress tests, economic growth, and macro-prudential policy, with particular interest in the banking sector. In Chapter 6, a countercyclical capital buffer was designed using the BIS guide of 2010, with the credit-to-GDP gap as the proxy indicator. The study witnessed that the credit cycles were all on the positive side, between the 2 percent and 10 percent thresholds, thus implying that there was no need to release a CcyB since the economies were not substantially affected by the crises. The study also reflected that the banking sector analysis on the selected macro scenarios outlined in *Chapter 4*, the banks with capital ratios below the 10 percent of the core capital requirement retained the CcyB, would be required to release the capital buffer, so as to continue operations and ensure resilience of the banking sector. Thus, this calls for the policymakers in Tanzania to adopt the CcyB, even at a small magnitude, to secure those banks whose capital ratios are below the threshold, during times when stressed scenarios materialise.

The implications of the results denote that regulatory authorities need to pay close attention to domestic exposures as well as the transmission of global shocks, given the growing interlinkages among economies globally. The contagion effect is a key area that needs to be studied more deeply, looking at internal banks' operations linked to the domestic effect, and then at the foreign exposures that directly or indirectly hinder the stability of an economy through spillover effects. Regulators should encourage bank stress tests, shifting from the aggregate exposure of the banking sector to individual banks, so as to devise bank-specific mitigation and restoration plans. Policymakers should also diagnose risk exposure from specific sectors, relating the anticipated NPLs with the GDP of an economy, since as was observed, not at all times did GDP affect NPLs; there could, however, be a second round effect of the NPLs resulting in a slowdown in economic growth in the country.

7.4 Recommendations

Based on the conclusion of the results linked to the objectives, the study recommends the enhancement of the assessment of banking sector resilience and the provision of mitigation measures in advance, to contain anticipated exposures ensuring financial stability. The purpose of stress tests is to ensure that banks have enough capital in case adverse and plausible scenarios materialise, by assessing the resilience of the existing banking sector's structures to macroeconomic shocks. However, this poses the question of what the impact of global shocks and banking sector-specific variables is on the resilience of the banking sector, especially for banks in developing economies like Tanzania.

The assessment conducted in Chapter 4 revealed that banking sector resilience depends not only on external macroeconomic factors, but rather on internal operating bank specific-factors that have a significant impact; therefore, these should be considered when designing stress testing. The study therefore recommends that while conducting various stress tests, it is imperative for central banks to view global transmissions as they may have a greater impact on a bank's position, than the domestic and bank-specific factors.

Credit risk should be analysed from an individual bank to a sector-specific perspective. The involvement of foreign and global transmissions is vital to deduce the external exposures beyond the banking sector, which may directly or indirectly affect the functioning of the banking sector at large, in case these exposures materialise. Central banks should always compare their assessments to those of peers, since the performance of one can hinder the other. Based on the findings in *Chapter 5*, this study also recommends that policymakers indulge in sector-specific analysis and assess how the banking sector relates to economic growth, in order to establish the magnitude of impact and set sector-specific policies. The implementation of BASEL II and III is imperative to developing countries like Tanzania, so as to maintain excess capital to cushion against potential risks in case crisis occurs. This study revealed the significance of the adoption of a countercyclical buffer, which maintains capital when the credit cycle is booming in the economy, and utilises it during the challenges. The findings of Chapter 6 recommend that the policy makers in Tanzania consider designing a countercyclical buffer, despite the

transmissions in the aggregate banking sector still have a slight impact on the performance, to have buffers in case of extended impact.

7.5 Limitation of the study

Like any other research, this study experienced a number of constraints. The area of stress testing is still new especially in developing countries like Tanzania, thus there was the challenge of limited data for the banking sector, especially when conducting individual bank analyses. This study deployed secondary data, which was at a point being reflected, as banks' operations were inconsistent during the review period. Further, the economy is still financed by the informal sector, thus the relationship assessment left a huge segment of the exposure uncovered.

Macroeconomic statistics keep varying, in particular GDP, due to change in policies and computational arrangements, leading to shifts in trends during different periods, due to the adjustments. The sectors used for computing GDP and lending by the banking sector were not aligned with each other, leading to a need to combine sectors in order to have consistence. Tanzania has not adopted Basel II with a specific countercyclical buffer, therefore the selected indicator may have left out key components from a prudential point of view.

7.6 Areas for further research

As this study was trying to enrich the literature on stress testing, with a specific focus on developing economies like Tanzania, it was not able to explore the entire banking sector or establish the bank-specific effects of global transmissions on credit risk. In addition, this study was a quantitative analysis, therefore there is room for research to blend this with qualitative information to enrich the analysis of specific issues that are not captured by numbers, yet have an impact on the banking sector. There is also a need to view a cross country comparison of the performance of stress tests in regional blocks, to relate how the Tanzanian banking sector is performing in relation to its peers regionally.

Further studies can also consider exploring forward-looking stress tests on individual banks that are inclusive of the entire sector. Since financial stability is a broad area, further areas of research could be to design stress tests for other financial sectors, including the

insurance, microfinance, and pension sectors, to assess the magnitude of exposures as well as to expand stress tests to be more comprehensive and system wide.

Appendices

Diagnostic Test

Appendix 1: Descriptive statistics for domestic variables

| REAL GDP | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
|--------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|---------------|--------------|
| | | | | | | - | | | |
| CHINA | 11.825 943 | 11.900 153 | 12.094 041 | 11.311 444 | 0.223 194 | 0.6878 51 | 2.289 099 | 17.8553 18 | 0.0001 33 |
| | | | | | | - | | | |
| EURO | 12.029 424 | 12.034 103 | 12.073 139 | 11.932 363 | 0.028 019 | 0.8999 80 | 3.701 807 | 28.6966 06 | 0.0000 01 |
| | | | | | | - | | | |
| INDIA | 11.187 169 | 11.187 708 | 11.381 225 | 10.782 566 | 0.144 368 | 0.5429 37 | 2.463 915 | 10.8705 01 | 0.0043 60 |
| | | | | | | - | | | |
| KENYA | 9.6797 46 | 9.7087 71 | 9.9298 87 | 9.2705 19 | 0.179 070 | 0.3492 14 | 2.082 856 | 9.65649 8 | 0.0080 01 |
| SOUTH AFRICA | 10.486 431 | 10.492 855 | 10.584 931 | 10.363 229 | 0.054 656 | 0.0471 10 | 1.919 508 | 8.42955 9 | 0.0147 76 |
| | | | | | | - | | | |
| TANZANIA | 9.5167 87 | 9.5791 77 | 9.7169 22 | 9.1769 58 | 0.158 447 | 0.5993 43 | 2.227 570 | 15.0636 34 | 0.0005 36 |
| | | | | | | - | | | |
| UAE | 10.449 561 | 10.476 568 | 10.552 604 | 10.247 320 | 0.084 439 | 0.8395 95 | 2.508 145 | 22.9894 61 | 0.0000 10 |
| USA | 12.151 329 | 12.144 855 | 12.253 221 | 12.048 322 | 0.062 942 | 0.1936 31 | 1.644 629 | 14.4666 02 | 0.0007 22 |

| INFLATION | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|--------------|
| | | | | | | - | | | |
| CHINA | 2.0354 46 | 2.0452 11 | 2.1161 64 | 1.9401 05 | 0.048 111 | 0.3372 99 | 2.005 902 | 10.4909 02 | 0.0052 71 |
| | | | | | | - | | | |
| EURO | 2.0183 17 | 2.0237 00 | 2.0580 21 | 1.9689 86 | 0.024 723 | 0.2331 71 | 1.965 962 | 9.28618 5 | 0.0096 28 |
| | | | | | | - | | | |
| INDIA | 2.0818 00 | 2.1181 99 | 2.2807 03 | 1.8302 40 | 0.136 283 | 0.4003 16 | 1.775 985 | 15.6736 93 | 0.0003 95 |
| | | | | | | - | | | |
| KENYA | 2.0953 07 | 2.1184 68 | 2.3098 08 | 1.7877 61 | 0.150 548 | 0.4711 41 | 2.124 595 | 12.1416 90 | 0.0023 09 |
| | | | | | | - | | | |
| SOUTH AFRICA | 2.0646 87 | 2.0676 73 | 2.2197 16 | 1.8754 10 | 0.102 443 | 0.1877 64 | 1.853 936 | 10.5119 92 | 0.0052 16 |
| | | | | | | - | | | |
| TANZANIA | 2.1058 80 | 2.1485 63 | 2.2905 44 | 1.8425 66 | 0.144 253 | 0.4144 82 | 1.734 814 | 16.7845 65 | 0.0002 27 |
| | | | | | | - | | | |
| UAE | 2.0146 35 | 2.0109 35 | 2.0718 13 | 1.9392 69 | 0.038 532 | 0.5935 04 | 2.519 495 | 12.2113 66 | 0.0022 30 |

| USA | 2.0240 39 | 2.0288 80 | 2.0770 54 | 1.9587 56 | 0.032 066 | - 0.1750 20 | 2.007 127 | 7.95061 8 | 0.0187 73 |
|----------------|--------------|--------------|--------------|--------------|--------------|-------------------|--------------|----------------|--------------|
| EXCHANGE RATE | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
| CHINA | 0.1009 48 | 0.1036 53 | 0.1178 82 | 0.0838 10 | 0.008 584 | 0.4968 76 | 2.328 892 | 10.5918 50 | 0.0050 12 |
| EURO | 0.8523 33 | 0.8524 25 | 0.9669 59 | 0.7766 49 | 0.043 794 | 0.3580 46 | 2.506 275 | 5.50539 9 | 0.0637 56 |
| INDIA | 0.0123 07 | 0.0115 61 | 0.0162 41 | 0.0094 78 | 0.001 970 | 0.4390 91 | 1.810 489 | 16.0435 76 | 0.0003 28 |
| KENYA | 0.0078 22 | 0.0075 32 | 0.0100 29 | 0.0062 77 | 0.000 962 | 0.7908 40 | 2.430 912 | 21.1634 05 | 0.0000 25 |
| SOUTH AFRICA | 0.0696 00 | 0.0658 82 | 0.1140 55 | 0.0394 80 | 0.018 286 | 0.2974 17 | 1.955 442 | 10.4818 09 | 0.0052 95 |
| TANZANIA | 0.0004 11 | 0.0004 05 | 0.0005 87 | 0.0003 05 | 0.000 083 | 0.3260 17 | 1.763 161 | 14.2705 99 | 0.0007 96 |
| UAE | 0.1847 30 | 0.1827 88 | 0.2021 31 | 0.1663 88 | 0.009 710 | 0.0835 40 | 1.657 593 | 13.2806 76 | 0.0013 07 |
| USA | 0.6784 22 | 0.6712 89 | 0.7423 27 | 0.6110 60 | 0.035 659 | 0.0835 40 | 1.657 593 | 13.2806 76 | 0.0013 07 |
| NOMINAL S RATE | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
| CHINA | 0.0544 79 | 0.0535 00 | 0.0747 00 | 0.0435 00 | 0.009 709 | 0.3232 92 | 2.050 220 | 9.57568 5 | 0.0083 30 |
| EURO | 0.0257 76 | 0.0300 94 | 0.0481 45 | 0.0005 53 | 0.015 013 | 0.1627 73 | 1.451 801 | 18.3050 82 | 0.0001 06 |
| INDIA | 0.1057 25 | 0.1025 00 | 0.1400 00 | 0.0800 00 | 0.013 737 | 0.7782 10 | 2.671 082 | 19.0395 88 | 0.0000 73 |
| KENYA | 0.1485 44 | 0.1401 00 | 0.2034 00 | 0.1175 00 | 0.021 681 | 0.8801 21 | 2.905 808 | 23.5291 24 | 0.0000 08 |
| SOUTH AFRICA | 0.1032 12 | 0.1000 00 | 0.1550 00 | 0.0700 00 | 0.019 218 | 1.1426 70 | 3.972 989 | 47.3389 86 | 0.0000 00 |
| TANZANIA | 0.1598 60 | 0.1599 00 | 0.1865 00 | 0.1413 00 | 0.009 941 | 0.2700 50 | 2.520 646 | 3.72924 4 | 0.1549 55 |
| UAE | 0.0162 86 | 0.0103 70 | 0.0514 81 | 0.0003 70 | 0.008 368 | 1.4160 67 | 5.736 015 | 119.337 404 | 0.0000 00 |
| USA | 0.0435 24 | 0.0325 00 | 0.0825 00 | 0.0325 00 | 0.016 346 | 1.4181 50 | 3.669 295 | 64.7827 24 | 0.0000 00 |
| NON PERFORMING | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
| CHINA | 0.0233 41 | 0.0160 97 | 0.0536 11 | 0.0067 61 | 0.015 404 | 0.7217 46 | 2.016 905 | 22.6830 06 | 0.0000 12 |
| EURO | 0.0471 01 | 0.0491 13 | 0.0843 48 | 0.0159 48 | 0.020 689 | 0.1656 84 | 1.826 320 | 10.7497 72 | 0.0046 31 |
| INDIA | 0.0539 28 | 0.0401 31 | 0.1134 70 | 0.0218 41 | 0.031 260 | 0.6097 99 | 1.749 082 | 22.5876 32 | 0.0000 12 |

| | | | | | | | | | |
|-----------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|--------------|
| KENYA | 0.0915 36 | 0.0873 03 | 0.2584 38 | 0.0416 88 | 0.041 916 | 1.1844 43 | 4.980 076 | 73.4854 70 | 0.0000 00 |
| SOUTH AFRICA | 0.0367 87 | 0.0365 77 | 0.0622 74 | 0.0086 02 | 0.013 626 | 0.1381 21 | 2.667 275 | 1.26204 6 | 0.5320 47 |
| TANZANIA | 0.0824 88 | 0.0792 63 | 0.1262 85 | 0.0573 74 | 0.017 346 | 0.5410 47 | 2.091 495 | 14.7219 35 | 0.0006 36 |
| UAE | 0.0543 72 | 0.0544 16 | 0.0916 66 | 0.0188 32 | 0.015 758 | 0.3996 10 | 3.099 127 | 4.97879 4 | 0.0829 60 |
| USA | 0.0233 45 | 0.0162 41 | 0.0571 93 | 0.0069 59 | 0.015 487 | 0.7628 40 | 2.140 451 | 22.8605 13 | 0.0000 11 |

Source: Author's Own computation from GVAR

Appendix 2: Descriptive statistics for foreign variables

| REAL GDP | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
|--------------|-----------|-----------|-----------|-----------|-----------|----------|----------|-------------|-------------|
| | | | | | | - | | | |
| CHINA | 11.922872 | 11.924044 | 11.997160 | 11.796459 | 0.046740 | 0.247235 | 2.616510 | 2.789168 | 0.247936 |
| | | | | | | - | | | |
| EURO | 11.850181 | 11.879495 | 12.014096 | 11.561751 | 0.128868 | 0.483866 | 2.068261 | 13.258163 | 0.001321 |
| | | | | | | - | | | |
| INDIA | 11.686854 | 11.720584 | 11.810599 | 11.447117 | 0.097319 | 0.643906 | 2.421119 | 14.848291 | 0.000597 |
| | | | | | | - | | | |
| KENYA | 11.471225 | 11.512713 | 11.624536 | 11.148620 | 0.127055 | 0.717137 | 2.487319 | 17.354793 | 0.000170 |
| | | | | | | - | | | |
| SOUTH AFRICA | 11.788869 | 11.822721 | 11.926224 | 11.499990 | 0.111221 | 0.695535 | 2.587714 | 15.771838 | 0.000376 |
| | | | | | | - | | | |
| TANZANIA | 11.320932 | 11.361147 | 11.490129 | 10.968488 | 0.138244 | 0.688845 | 2.437067 | 16.534621 | 0.000257 |
| | | | | | | - | | | |
| UAE | 11.643729 | 11.666439 | 11.795462 | 11.330864 | 0.118577 | 0.611985 | 2.473743 | 13.215272 | 0.001350 |
| | | | | | | - | | | |
| USA | 11.836945 | 11.877267 | 11.976935 | 11.529740 | 0.115463 | 0.790134 | 2.759705 | 19.267371 | 0.000065 |

| INFLATION | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
|--------------|----------|----------|----------|----------|-----------|----------|----------|-------------|-------------|
| | | | | | | - | | | |
| CHINA | 2.026311 | 2.033556 | 2.084227 | 1.951189 | 0.037978 | 0.269890 | 1.923125 | 10.514466 | 0.005210 |
| | | | | | | - | | | |
| EURO | 2.033260 | 2.041151 | 2.105862 | 1.941668 | 0.047307 | 0.295323 | 1.938194 | 10.712469 | 0.004719 |
| | | | | | | - | | | |
| INDIA | 2.026558 | 2.031447 | 2.084132 | 1.950256 | 0.038893 | 0.322902 | 2.008239 | 10.168322 | 0.006194 |
| | | | | | | - | | | |
| KENYA | 2.039638 | 2.050247 | 2.125338 | 1.925563 | 0.060136 | 0.355907 | 1.887288 | 12.727836 | 0.001723 |
| | | | | | | - | | | |
| SOUTH AFRICA | 2.032576 | 2.041742 | 2.101880 | 1.942216 | 0.047071 | 0.336200 | 1.910312 | 11.938997 | 0.002556 |
| | | | | | | - | | | |
| TANZANIA | 2.045233 | 2.058146 | 2.147060 | 1.908772 | 0.071685 | 0.382169 | 1.899890 | 13.109614 | 0.001423 |
| | | | | | | - | | | |
| UAE | 2.046693 | 2.063094 | 2.152570 | 1.911365 | 0.071729 | 0.357804 | 1.830794 | 13.723370 | 0.001047 |
| | | | | | | - | | | |
| USA | 2.030449 | 2.038872 | 2.096095 | 1.947839 | 0.043179 | 0.326343 | 1.931611 | 11.401114 | 0.003344 |

| EXCHANGE RATE | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
|----------------|----------|----------|----------|----------|-----------|----------|----------|-------------|-------------|
| | | | | | | - | | | |
| CHINA | 0.667304 | 0.669021 | 0.681610 | 0.646053 | 0.007517 | 0.786268 | 3.180159 | 19.104046 | 0.000071 |
| EURO | 0.373324 | 0.368247 | 0.406410 | 0.335557 | 0.018993 | 0.050698 | 1.679286 | 12.717356 | 0.001732 |
| | | | | | | - | | | |
| INDIA | 0.453531 | 0.454190 | 0.460102 | 0.441262 | 0.004608 | 0.788441 | 2.959860 | 18.860221 | 0.000080 |
| KENYA | 0.278049 | 0.277349 | 0.289410 | 0.271655 | 0.003974 | 0.498963 | 2.517481 | 9.091624 | 0.010612 |
| SOUTH AFRICA | 0.436528 | 0.435173 | 0.466088 | 0.419192 | 0.010243 | 0.559329 | 2.781732 | 9.752132 | 0.007627 |
| TANZANIA | 0.193571 | 0.193385 | 0.198660 | 0.189904 | 0.002078 | 0.166411 | 2.075071 | 6.902225 | 0.031710 |
| UAE | 0.326605 | 0.326086 | 0.342121 | 0.317209 | 0.005236 | 0.601305 | 2.994380 | 10.975491 | 0.004137 |
| USA | 0.439507 | 0.438459 | 0.486598 | 0.410649 | 0.017603 | 0.382985 | 2.460900 | 6.400405 | 0.040754 |
| NOMINAL S RATE | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
| CHINA | 0.041086 | 0.038031 | 0.069674 | 0.023007 | 0.011796 | 1.045588 | 3.121748 | 33.351881 | 0.000000 |
| EURO | 0.052900 | 0.049059 | 0.080111 | 0.040768 | 0.010500 | 1.399434 | 3.643778 | 62.914235 | 0.000000 |
| INDIA | 0.041131 | 0.039621 | 0.060929 | 0.024988 | 0.009047 | 0.655308 | 2.525439 | 14.512725 | 0.000706 |
| KENYA | 0.057356 | 0.056771 | 0.078251 | 0.041511 | 0.009007 | 0.584465 | 2.553720 | 11.663862 | 0.002932 |
| SOUTH AFRICA | 0.047822 | 0.048556 | 0.067664 | 0.030671 | 0.010405 | 0.232833 | 1.894058 | 10.418385 | 0.005466 |
| TANZANIA | 0.063851 | 0.064370 | 0.085956 | 0.047318 | 0.008960 | 0.518251 | 2.559917 | 9.409894 | 0.009050 |
| UAE | 0.065706 | 0.064700 | 0.089037 | 0.049097 | 0.010861 | 0.618302 | 2.349217 | 14.505510 | 0.000708 |
| | | | | | | - | | | |
| USA | 0.044384 | 0.047018 | 0.066040 | 0.025787 | 0.011517 | 0.006649 | 1.659457 | 13.033089 | 0.001479 |
| NON PERFORMING | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
| | | | | | | - | | | |
| CHINA | 0.036648 | 0.036785 | 0.055311 | 0.014269 | 0.013101 | 0.147743 | 1.669564 | 13.493247 | 0.001175 |
| EURO | 0.026892 | 0.021398 | 0.053150 | 0.010448 | 0.012591 | 0.709911 | 2.183629 | 19.965653 | 0.000046 |
| INDIA | 0.035202 | 0.031534 | 0.053929 | 0.014787 | 0.012811 | 0.177733 | 1.593476 | 15.338966 | 0.000467 |

| | | | | | | | | | |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|--------------|
| | | | | | | - | | | |
| KENYA | 0.0389 47 | 0.0402 98 | 0.0510 18 | 0.0179 53 | 0.009 624 | 0.8680 76 | 2.783 837 | 23.1168 11 | 0.0000 10 |
| | | | | | | - | | | |
| SOUTH AFRICA | 0.0371 28 | 0.0378 79 | 0.0538 56 | 0.0153 70 | 0.012 122 | 0.2739 86 | 1.813 832 | 12.4128 33 | 0.0020 16 |
| | | | | | | - | | | |
| TANZANIA | 0.0424 04 | 0.0456 07 | 0.0518 51 | 0.0213 17 | 0.008 452 | 1.2802 54 | 3.483 755 | 51.7672 61 | 0.0000 00 |
| | | | | | | - | | | |
| UAE | 0.0402 96 | 0.0434 45 | 0.0521 25 | 0.0183 97 | 0.010 020 | 1.1223 32 | 2.980 817 | 38.2173 99 | 0.0000 00 |
| | | | | | | - | | | |
| USA | 0.0368 93 | 0.0378 34 | 0.0562 74 | 0.0133 88 | 0.013 911 | 0.1541 73 | 1.624 212 | 14.4651 48 | 0.0007 23 |

Source: Author's Own computation from GVAR

Appendix 3: Descriptive statistics for global variables

| Statistics | Mean | Median | Maximum | Minimum | Std. dev. | Skewness | Kurtosis | Jarque-Bera | Probability |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|--------------|
| | | | | | | - | | | |
| OIL PRICE | 1.840 590 | 1.836 830 | 2.1232 96 | 1.323 046 | 0.152 710 | 0.3572 45 | 2.663 589 | 4.57217 3 | 0.1016 64 |
| RAW MATERIAL PRICE | 1.941 004 | 1.919 706 | 2.1289 16 | 1.849 297 | 0.058 270 | 1.1759 82 | 4.063 519 | 51.1347 00 | 0.0000 00 |
| | | | | | | - | | | |
| METAL PRICE | 1.929 660 | 1.931 865 | 2.1012 66 | 1.704 408 | 0.090 446 | 0.2628 14 | 2.635 984 | 2.92914 6 | 0.2311 77 |

Source: Author's Own computation from GVAR

Appendix 4: Unit root tests for the foreign variables at the 5 percent significance level

| Foreign Variables | Statistic | Critical Value | CHINA | EURO | INDIA | KENYA | SOUTH AFRICA | TANZANIA | UAE | USA |
|-------------------|-----------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| ys (with trend) | ADF | -3.45 | - 3.118 1 | - 0.601 4 | - 2.031 6 | - 1.444 1 | - 2.237 2 | - -0.8897 | - 0.972 8 | - 2.543 4 |
| ys (with trend) | WS | -3.24 | - 2.225 4 | - 0.224 2 | - 0.838 5 | - 0.029 8 | - 0.217 8 | - 0.3392 | - 0.476 1 | - 0.012 4 |
| ys (no trend) | ADF | -2.89 | - 1.891 7 | - 2.278 5 | - 2.555 3 | - 2.409 4 | - 2.698 3 | - -2.1755 | - 1.911 2 | - 2.829 7 |
| ys (no trend) | WS | -2.55 | - 0.138 0 | - 0.364 5 | - 0.756 9 | - 0.712 4 | - 1.200 5 | - 0.6529 | - 0.836 1 | - 1.302 6 |
| Dys | ADF | -2.89 | - 3.658 1 | - 2.181 8 | - 3.467 5 | - 2.671 7 | - 3.013 0 | - -2.5547 | - 3.133 6 | - 3.106 8 |
| Dys | WS | -2.55 | - 3.009 3 | - 1.451 3 | - 3.355 9 | - 1.861 1 | - 2.232 2 | - -1.1101 | - 0.229 2 | - 2.518 5 |
| DDys | ADF | -2.89 | - 11.80 47 | - 11.78 13 | - 11.87 03 | - 11.82 55 | - 11.85 62 | - 11.731 9 | - 11.52 87 | - 11.87 90 |
| DDys | WS | -2.55 | - 11.97 79 | - 11.95 83 | - 12.05 07 | - 12.00 01 | - 12.03 32 | - 11.890 4 | - 11.63 56 | - 12.05 83 |
| Dps (with trend) | ADF | -3.45 | - 2.122 4 | - 2.079 3 | - 1.894 2 | - 0.488 3 | - 1.062 3 | - -0.8196 | - 0.963 2 | - 1.329 5 |
| Dps (with trend) | WS | -3.24 | - 1.561 0 | - 1.305 8 | - 1.171 8 | - 0.048 0 | - 0.501 5 | - -0.3505 | - 0.582 8 | - 0.822 8 |
| Dps (no trend) | ADF | -2.89 | - 1.665 0 | - 2.023 6 | - 2.203 3 | - 3.155 3 | - 2.611 3 | - -2.9669 | - 2.792 0 | - 2.391 0 |
| Dps (no trend) | WS | -2.55 | - 1.872 8 | - 2.198 3 | - 1.660 3 | - 1.611 4 | - 1.724 7 | - 1.6916 | - 1.646 8 | - 1.690 9 |
| DDps | ADF | -2.89 | - 7.478 3 | - 8.586 6 | - 7.366 7 | - 7.363 0 | - 4.640 2 | - -7.3205 | - 7.352 7 | - 4.823 3 |
| DDps | WS | -2.55 | - 7.529 4 | - 8.706 1 | - 7.493 7 | - 7.508 3 | - 4.610 1 | - -7.3954 | - 7.403 2 | - 4.722 9 |
| DDDps | ADF | -2.89 | - 8.431 3 | - 10.11 49 | - 10.09 65 | - 11.81 65 | - 11.31 69 | - 11.650 4 | - 10.78 97 | - 11.60 73 |
| DDDps | WS | -2.55 | - 8.575 4 | - 10.17 56 | - 9.967 5 | - 12.25 91 | - 11.14 78 | - 12.272 9 | - 11.20 26 | - 11.35 76 |
| eps (with trend) | ADF | -3.45 | - 2.154 8 | - 3.371 6 | - 2.325 2 | - 3.310 1 | - 3.396 7 | - -3.1276 | - 3.239 3 | - 3.493 2 |

| | | | | | | | | | | |
|-------------------|-----|-------|-----------------|-----------------|-----------------|------------------|-----------------|---------|-----------------|------------------|
| eps (with trend) | WS | -3.24 | - 2.388 6 | - 2.361 5 | - 2.545 3 | - 2.832 7 | - 2.722 2 | -2.7520 | - 2.843 6 | - 2.638 8 |
| eps (no trend) | ADF | -2.89 | - 2.149 2 | - 1.574 2 | - 1.978 4 | - 2.859 2 | - 2.597 0 | -3.0579 | - 2.634 9 | - 2.353 9 |
| eps (no trend) | WS | -2.55 | - 2.389 6 | - 1.882 4 | - 2.143 5 | - 2.820 0 | - 2.623 2 | -2.7966 | - 2.730 8 | - 2.439 8 |
| Deps | ADF | -2.89 | - 6.676 5 | - 5.545 5 | - 6.858 8 | - 8.362 2 | - 8.235 4 | -6.5145 | - 8.377 1 | - 8.159 0 |
| Deps | WS | -2.55 | - 6.844 5 | - 5.541 7 | - 7.026 4 | - 8.490 7 | - 8.366 2 | -6.6773 | - 8.506 0 | - 8.289 8 |
| DDeps | ADF | -2.89 | - 9.255 6 | - 9.030 1 | - 9.219 1 | - 9.867 7 | - 9.747 7 | -9.7625 | - 9.791 5 | - 9.668 0 |
| DDeps | WS | -2.55 | - 9.430 3 | - 9.122 2 | - 9.334 2 | - 10.05 83 | - 9.939 3 | -9.8979 | - 9.990 3 | - 9.854 1 |
| rs (with trend) | ADF | -3.45 | - 2.085 5 | - 2.029 9 | - 2.129 5 | - 3.447 5 | - 3.377 6 | -3.6664 | - 3.402 0 | - 3.131 2 |
| rs (with trend) | WS | -3.24 | - 2.298 4 | - 2.210 3 | - 2.348 7 | - 2.674 1 | - 2.588 9 | -2.5971 | - 2.857 3 | - 2.169 3 |
| rs (no trend) | ADF | -2.89 | - 1.401 6 | - 1.754 6 | - 0.954 5 | - 0.687 7 | - 0.775 9 | -0.6367 | - 0.949 1 | - 0.640 4 |
| rs (no trend) | WS | -2.55 | - 0.602 1 | - 1.120 6 | - 0.723 2 | - 0.976 2 | - 0.920 7 | -1.0137 | - 1.178 1 | - 0.969 0 |
| Drs | ADF | -2.89 | - 5.933 6 | - 5.989 7 | - 6.148 7 | - 6.047 6 | - 5.952 0 | -6.6350 | - 6.866 5 | - 5.893 6 |
| Drs | WS | -2.55 | - 5.571 9 | - 5.842 4 | - 5.861 9 | - 6.030 4 | - 5.729 2 | -6.7176 | - 6.956 8 | - 5.708 9 |
| DDrs | ADF | -2.89 | - 9.203 7 | - 9.646 7 | - 9.751 9 | - 9.315 2 | - 8.551 9 | -9.3867 | - 9.335 4 | - 11.12 33 |
| DDrs | WS | -2.55 | - 9.367 9 | - 9.715 7 | - 9.920 2 | - 9.522 8 | - 8.743 8 | -9.6031 | - 9.553 6 | - 11.29 38 |
| npls (with trend) | ADF | -3.45 | - 2.231 1 | - 3.396 1 | - 2.997 5 | - 2.583 3 | - 2.279 6 | -3.2539 | - 2.114 1 | - 2.145 4 |
| npls (with trend) | WS | -3.24 | - 1.904 7 | - 3.042 9 | - 2.929 3 | - 2.652 6 | - 2.050 2 | -3.1065 | - 2.337 7 | - 1.775 0 |
| npls (no trend) | ADF | -2.89 | - 2.417 4 | - 2.982 8 | - 2.843 9 | - 2.840 9 | - 2.391 7 | -2.4262 | - 2.471 5 | - 2.149 7 |

| | | | | | | | | | | |
|-----------------|-----|-------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| npls (no trend) | WS | -2.55 | - 2.123 7 | - 2.969 0 | - 2.893 3 | - 2.596 8 | - 2.055 2 | -2.6341 | - 1.805 4 | - 1.777 4 |
| Dnpls | ADF | -2.89 | - 2.847 7 | - 2.328 3 | - 2.685 1 | - 3.453 0 | - 3.215 8 | -3.9027 | - 3.812 8 | - 3.314 7 |
| Dnpls | WS | -2.55 | - 2.886 0 | - 2.422 4 | - 2.283 9 | - 2.922 4 | - 3.172 1 | -2.6262 | - 3.686 1 | - 3.367 2 |
| DDnpls | ADF | -2.89 | - 13.82 95 | - 12.62 13 | - 14.32 84 | - 11.25 48 | - 11.51 68 | - 11.616 0 | - 11.61 34 | - 11.81 06 |
| DDnpls | WS | -2.55 | - 13.98 18 | - 12.76 27 | - 14.47 97 | - 11.40 84 | - 11.68 65 | - 11.782 9 | - 11.78 63 | - 11.98 65 |

Source: Author's own calculation from GVAR

Appendix 5: Unit root tests for the domestic variables at the 5 percent significance level

| Domestic Variables | Statistic | Critical Value | CHINA | EURO | INDIA | KENYA | SOUTH AFRICA | TANZANIA | UAE | USA |
|--------------------|-----------|----------------|---------|---------|---------|---------|--------------|----------|---------|---------|
| y (with trend) | ADF | -3.45 | 1.9910 | 3.5596 | 1.1845 | 1.9182 | 1.7769 | -2.2139 | 1.9462 | 2.3446 |
| y (with trend) | WS | -3.24 | 0.0564 | 2.2751 | 0.2362 | 0.4289 | 1.5936 | -1.4240 | 1.7778 | 2.5120 |
| y (no trend) | ADF | -2.89 | 3.6688 | 3.6151 | 1.5662 | 2.3122 | 2.0184 | -2.8032 | 2.4580 | 1.2534 |
| y (no trend) | WS | -2.55 | 0.8453 | 2.0848 | 0.8104 | 1.1702 | 1.5405 | 0.5314 | 1.1097 | 0.7761 |
| Dy | ADF | -2.89 | 2.4188 | 4.2856 | 4.1075 | 3.8323 | 2.9493 | -3.7535 | 3.8478 | 1.9642 |
| Dy | WS | -2.55 | 2.2834 | 4.0491 | 1.0512 | 2.6854 | 2.6283 | -3.8953 | 4.0042 | 1.8227 |
| DDy | ADF | -2.89 | 11.9037 | 11.8978 | 11.3886 | 11.8074 | 11.6523 | 11.8489 | 11.8759 | 11.5255 |
| DDy | WS | -2.55 | 12.0825 | 12.0775 | 11.4300 | 11.9706 | 11.8223 | 12.0189 | 12.0551 | 11.6999 |
| Dp (with trend) | ADF | -3.45 | 2.5189 | 2.6585 | 1.0137 | 1.4996 | 1.1155 | -0.7370 | 1.0718 | 3.9546 |
| Dp (with trend) | WS | -3.24 | 2.3062 | 2.2104 | 1.1000 | 1.1165 | 0.5210 | -0.9855 | 1.1121 | 3.5116 |
| Dp (no trend) | ADF | -2.89 | 1.5978 | 1.6728 | 1.8984 | 1.5838 | 2.6129 | -1.7785 | 1.9954 | 0.8896 |
| Dp (no trend) | WS | -2.55 | 1.4906 | 1.4230 | 2.2627 | 2.3199 | 2.0211 | 1.2952 | 0.4024 | 1.6377 |
| DDp | ADF | -2.89 | 8.0733 | 8.4994 | 6.8642 | 6.0471 | 8.9276 | -7.0073 | 5.9460 | 7.5083 |
| DDp | WS | -2.55 | 8.2038 | 8.6136 | 6.9993 | 5.8192 | 9.0152 | -7.0717 | 6.0884 | 7.5867 |
| DDDp | ADF | -2.89 | 10.5228 | 10.1055 | 9.6570 | 9.4319 | 9.7508 | -8.6104 | 10.7559 | 10.9639 |
| DDDp | WS | -2.55 | 10.4850 | 10.2823 | 9.7050 | 7.8917 | 9.8764 | -8.7534 | 10.9604 | 11.1195 |

| | | | | | | | | | | |
|------------------|-----|-------|------------------|------------------|------------------|------------------|------------------|-------------|-----------------|-----------------|
| ep (with trend) | ADF | -3.45 | - 1.727 8 | - 3.465 6 | - 2.624 0 | - 2.980 3 | - 3.375 7 | -3.2327 | - 3.294 1 | - 3.294 1 |
| ep (with trend) | WS | -3.24 | - 1.916 4 | - 2.768 6 | - 2.819 9 | - 3.054 9 | - 2.615 3 | -2.8845 | - 2.143 3 | - 2.143 3 |
| ep (no trend) | ADF | -2.89 | - 1.648 3 | - 2.142 1 | - 1.222 3 | - 1.476 1 | - 2.276 4 | -1.7519 | - 1.651 7 | - 1.651 7 |
| ep (no trend) | WS | -2.55 | - 0.756 6 | - 2.350 4 | - 0.243 0 | - 0.455 4 | - 0.009 4 | 0.3803 | - 1.905 4 | - 1.905 4 |
| Dep | ADF | -2.89 | - 5.502 4 | - 8.243 9 | - 8.465 4 | - 6.849 5 | - 6.578 0 | -7.4314 | - 5.539 2 | - 5.539 2 |
| Dep | WS | -2.55 | - 5.662 4 | - 8.374 5 | - 8.586 5 | - 7.000 9 | - 6.635 4 | -7.2396 | - 5.547 7 | - 5.547 7 |
| DDep | ADF | -2.89 | - 13.20 64 | - 9.596 1 | - 10.72 06 | - 11.43 24 | - 11.25 79 | -9.5778 | - 9.031 5 | - 9.031 5 |
| DDep | WS | -2.55 | - 13.07 47 | - 9.775 3 | - 10.79 73 | - 11.50 62 | - 10.74 16 | -9.8049 | - 9.148 4 | - 9.148 4 |
| r (with trend) | ADF | -3.45 | - 2.973 4 | - 3.299 2 | - 3.133 2 | - 1.768 4 | - 2.686 8 | -2.7946 | - 2.547 3 | - 2.155 0 |
| r (with trend) | WS | -3.24 | - 2.807 7 | - 2.079 2 | - 2.693 4 | - 1.782 7 | - 2.705 9 | -2.9838 | - 2.647 5 | - 1.841 2 |
| r (no trend) | ADF | -2.89 | - 1.617 8 | - 0.295 0 | - 1.589 6 | - 1.623 2 | - 1.893 3 | -2.2461 | - 2.549 0 | - 2.448 2 |
| r (no trend) | WS | -2.55 | - 1.878 7 | - 0.641 4 | - 1.879 5 | - 1.755 1 | - 2.141 5 | -2.0606 | - 2.642 4 | - 1.436 5 |
| Dr | ADF | -2.89 | - 4.731 1 | - 6.841 8 | - 8.433 3 | - 5.819 6 | - 4.058 9 | 11.188 4 | 6.200 2 | 4.914 4 |
| Dr | WS | -2.55 | - 4.862 4 | - 6.645 8 | - 8.564 4 | - 5.958 8 | - 4.226 0 | 11.326 4 | 6.369 3 | 4.727 0 |
| DDr | ADF | -2.89 | - 11.69 50 | - 10.48 77 | - 9.864 1 | - 9.067 2 | - 8.349 2 | 11.428 3 | 14.11 90 | 9.070 5 |
| DDr | WS | -2.55 | - 11.85 22 | - 10.65 78 | - 10.04 53 | - 9.259 7 | - 8.419 1 | 11.411 1 | 14.32 16 | 8.990 3 |
| npl (with trend) | ADF | -3.45 | - 3.027 6 | - 1.527 0 | - 2.165 4 | - 3.132 9 | - 3.024 2 | -3.5069 | - 2.848 5 | - 3.312 2 |
| npl (with trend) | WS | -3.24 | - 2.457 0 | - 1.410 5 | - 1.550 9 | - 0.922 2 | - 2.916 1 | -3.7008 | - 2.564 7 | - 2.786 0 |

| | | | | | | | | | | |
|----------------|-----|-------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|-----------------|
| npl (no trend) | ADF | -2.89 | - 2.337 7 | - 1.744 9 | - 1.051 7 | - 1.766 5 | - 3.009 9 | -2.3881 | - 2.326 1 | - 2.637 6 |
| npl (no trend) | WS | -2.55 | - 2.372 0 | - 1.405 6 | - 1.425 6 | 0.578 9 | 2.794 5 | -2.2190 | - 2.886 7 | - 2.661 6 |
| Dnpl | ADF | -2.89 | - 2.148 0 | - 3.617 5 | - 3.627 0 | - 3.785 6 | - 2.565 2 | -5.6413 | - 3.700 1 | - 1.824 9 |
| Dnpl | WS | -2.55 | - 2.353 6 | - 3.748 7 | - 3.653 7 | - 1.496 3 | - 2.295 9 | -5.7850 | - 1.130 3 | - 2.119 0 |
| DDnpl | ADF | -2.89 | - 11.62 55 | - 11.90 03 | - 11.86 92 | - 11.79 23 | - 11.44 81 | - 13.576 5 | - 14.35 06 | - 5.660 2 |
| DDnpl | WS | -2.55 | - 11.79 87 | - 12.07 96 | - 12.04 94 | - 11.96 15 | - 11.60 71 | - 13.744 4 | - 14.48 92 | - 5.813 3 |

Source: Author's own calculation from GVAR

Appendix 6: Unit root test for the global variables at the 5 percent significant level

| Global Variables | Test | Critical Value | Statistic |
|-------------------------|-------------|-----------------------|------------------|
| poil (with trend) | ADF | -3.45 | -3.427598 |
| poil (with trend) | WS | -3.24 | -3.379056 |
| poil (no trend) | ADF | -2.89 | -2.876533 |
| poil (no trend) | WS | -2.55 | -3.044176 |
| Dpoil | ADF | -2.89 | -8.010653 |
| Dpoil | WS | -2.55 | -8.148683 |
| DDpoil | ADF | -2.89 | -9.399436 |
| Dpoil | WS | -2.55 | -9.592881 |
| pmat (with trend) | ADF | -3.45 | -2.569868 |
| pmat (with trend) | WS | -3.24 | -1.751858 |
| pmat (no trend) | ADF | -2.89 | -2.278185 |
| pmat (no trend) | WS | -2.55 | -1.899637 |
| Dpmat | ADF | -2.89 | -5.603753 |
| Dpmat | WS | -2.55 | -5.540148 |
| DDpmat | ADF | -2.89 | -8.529679 |
| Dpmat | WS | -2.55 | -8.902597 |
| pmetal (with trend) | ADF | -3.45 | -3.144173 |
| pmetal (with trend) | WS | -3.24 | -3.18533 |
| pmetal (no trend) | ADF | -2.89 | -2.888951 |
| pmetal (no trend) | WS | -2.55 | -3.096091 |
| Dpmetal | ADF | -2.89 | -5.771268 |
| Dpmetal | WS | -2.55 | -5.424473 |
| DDpmetal | ADF | -2.89 | -10.20359 |
| Dpmetal | WS | -2.55 | -10.23965 |

Source: Author's own calculation from GVAR

Appendix 7: Choice criteria for selecting the order of the VARX* models together with corresponding residual serial correlation F-Statistics

| Country/ Region | p | q | AIC | SBC | logLi k | Fcrit_0. 05 | y | Dp | ep | r | npl | |
|--------------------|---|---|-------|-------|------------|----------------|--------|-------|-------|-------|-------|-------|
| CHINA | 1 | 1 | 4851. | 4669. | 4966. | F(4, | 2.4319 | 1.043 | 1.795 | 1.465 | 1.896 | 2.495 |
| | | | 644 | 015 | 644 | 150) | 65056 | 795 | 914 | 229 | 888 | 699 |
| CHINA | 2 | 1 | 4848. | 4626. | 4988. | F(4, | 2.4340 | 0.176 | 0.838 | 3.294 | 4.304 | 1.513 |
| | | | 474 | 143 | 474 | 145) | 65136 | 194 | 339 | 772 | 042 | 45 |
| EURO | 1 | 1 | 4226. | 4044. | 4341. | F(4, | 2.4319 | 3.846 | 4.211 | 0.497 | 2.433 | 0.250 |
| | | | 877 | 249 | 877 | 150) | 65056 | 406 | 473 | 282 | 37 | 262 |
| EURO | 2 | 1 | 4222. | 4000. | 4362. | F(4, | 2.4340 | 0.955 | 3.321 | 0.659 | 1.256 | 0.215 |
| | | | 838 | 508 | 838 | 145) | 65136 | 382 | 924 | 741 | 838 | 61 |
| INDIA | 1 | 1 | 4475. | 4293. | 4590. | F(4, | 2.4319 | 0.467 | 1.158 | 1.308 | 0.107 | 1.299 |
| | | | 911 | 283 | 911 | 150) | 65056 | 097 | 992 | 072 | 973 | 936 |
| INDIA | 2 | 1 | 4474. | 4252. | 4614. | F(4, | 2.4340 | 0.637 | 0.716 | 1.907 | 0.662 | 0.442 |
| | | | 378 | 047 | 378 | 145) | 65136 | 766 | 314 | 12 | 579 | 327 |
| KENYA | 1 | 1 | 4412. | 4229. | 4527. | F(4, | 2.4319 | 2.013 | 3.555 | 2.849 | 0.913 | 2.284 |
| | | | 34 | 711 | 34 | 150) | 65056 | 253 | 2 | 997 | 011 | 011 |
| KENYA | 2 | 1 | 4439. | 4216. | 4579. | F(4, | 2.4340 | 0.608 | 0.065 | 2.496 | 1.162 | 1.016 |
| | | | 048 | 718 | 048 | 145) | 65136 | 949 | 427 | 949 | 106 | 53 |
| SOUTH AFRICA | 1 | 1 | 4351. | 4168. | 4466. | F(4, | 2.4319 | 0.490 | 1.659 | 3.879 | 3.814 | 0.908 |
| | | | 118 | 49 | 118 | 150) | 65056 | 859 | 981 | 07 | 302 | 275 |
| SOUTH AFRICA | 2 | 1 | 4362. | 4140. | 4502. | F(4, | 2.4340 | 0.724 | 1.495 | 5.167 | 2.509 | 0.978 |
| | | | 702 | 372 | 702 | 145) | 65136 | 665 | 53 | 306 | 703 | 603 |
| TANZANI A | 1 | 1 | 4917. | 4734. | 5032. | F(4, | 2.4319 | 0.306 | 8.254 | 3.934 | 0.197 | 28.38 |
| | | | 048 | 419 | 048 | 150) | 65056 | 747 | 618 | 437 | 342 | 233 |
| TANZANI A | 2 | 1 | 4969. | 4747. | 5109. | F(4, | 2.4340 | 0.145 | 0.706 | 3.418 | 0.039 | 14.41 |
| | | | 557 | 226 | 557 | 145) | 65136 | 036 | 357 | 082 | 326 | 053 |
| UAE | 1 | 1 | 4359. | 4176. | 4474. | F(4, | 2.4319 | 0.309 | 0.432 | 0.352 | 31.77 | 12.82 |
| | | | 494 | 865 | 494 | 150) | 65056 | 974 | 112 | 799 | 08 | 044 |
| UAE | 2 | 1 | 4421. | 4198. | 4561. | F(4, | 2.4340 | 0.950 | 0.548 | 1.291 | 13.67 | 1.042 |
| | | | 064 | 733 | 064 | 145) | 65136 | 04 | 022 | 671 | 297 | 861 |
| USA | 1 | 1 | 4816. | 4633. | 4931. | F(4, | 2.4319 | 7.908 | 8.689 | 0.470 | 3.596 | 32.86 |
| | | | 541 | 912 | 541 | 150) | 65056 | 612 | 393 | 407 | 891 | 561 |
| USA | 2 | 1 | 4911. | 4688. | 5051. | F(4, | 2.4340 | 1.819 | 0.802 | 1.031 | 0.995 | 9.077 |
| | | | 111 | 781 | 111 | 145) | 65136 | 607 | 651 | 015 | 759 | 485 |

Source: Author's own calculation from GVAR

Appendix 8: Choice criteria for selecting the order of the weak exogeneity regressions together with corresponding residual serial correlation F-statistics

| Country/Region | p* | q* | AIC | SBC | logLik | F-statistic | Fcrit_0.05 | ys | Dps | eps | rs | np | po | ml | pm | etal |
|--------------------|----|----|------|------|--------|-------------|------------|----|-----|-----|----|----|----|----|-----|------|
| CHINA | 1 | 1 | 6059 | 5856 | 6187 | F(4,1 | 2.43 | 5. | 3. | 2. | 2. | 3. | 1. | 1. | 0.2 | |
| | | | .15 | .24 | .15 | 56) | | 84 | 14 | 23 | 55 | 89 | 73 | 54 | 2 | |
| CHINA | 1 | 2 | 6030 | 5727 | 6222 | F(4,1 | 2.43 | 1. | 2. | 1. | 1. | 1. | 1. | 0. | 1.3 | |
| | | | .82 | .00 | .82 | 47) | | 24 | 80 | 83 | 23 | 86 | 83 | 46 | 6 | |
| CHINA | 2 | 1 | 6033 | 5768 | 6201 | F(4,1 | 2.43 | 1. | 3. | 3. | 1. | 2. | 2. | 1. | 0.5 | |
| | | | .92 | .08 | .92 | 50) | | 57 | 68 | 98 | 69 | 58 | 36 | 03 | 5 | |
| CHINA | 2 | 2 | 6027 | 5660 | 6259 | F(4,1 | 2.44 | 1. | 2. | 2. | 1. | 1. | 2. | 1. | 1.8 | |
| | | | .34 | .23 | .34 | 42) | | 23 | 98 | 55 | 59 | 65 | 03 | 53 | 4 | |
| EURO | 1 | 1 | 6151 | 5961 | 6271 | F(4,1 | 2.43 | 6. | 5. | 0. | 0. | 3. | 2. | 1. | 0.2 | |
| | | | .83 | .60 | .83 | 57) | | 17 | 06 | 69 | 97 | 92 | 33 | 00 | 6 | |
| EURO | 1 | 2 | 6141 | 5850 | 6325 | F(4,1 | 2.43 | 2. | 1. | 0. | 0. | 1. | 1. | 0. | 1.0 | |
| | | | .28 | .12 | .28 | 48) | | 61 | 39 | 93 | 98 | 05 | 15 | 36 | 1 | |
| EURO | 2 | 1 | 6118 | 5864 | 6278 | F(4,1 | 2.43 | 5. | 8. | 1. | 0. | 2. | 3. | 1. | 0.3 | |
| | | | .01 | .82 | .01 | 51) | | 39 | 69 | 55 | 30 | 25 | 06 | 22 | 1 | |
| EURO | 2 | 2 | 6142 | 5788 | 6366 | F(4,1 | 2.43 | 1. | 0. | 1. | 0. | 0. | 1. | 0. | 0.7 | |
| | | | .86 | .40 | .86 | 43) | | 76 | 88 | 48 | 67 | 68 | 27 | 45 | 0 | |
| INDIA | 1 | 1 | 6151 | 5948 | 6279 | F(4,1 | 2.43 | 4. | 2. | 0. | 1. | 9. | 2. | 1. | 0.1 | |
| | | | .70 | .79 | .70 | 56) | | 06 | 51 | 65 | 70 | 49 | 50 | 28 | 4 | |
| INDIA | 1 | 2 | 6130 | 5826 | 6322 | F(4,1 | 2.43 | 2. | 3. | 2. | 0. | 2. | 2. | 0. | 1.4 | |
| | | | .29 | .47 | .29 | 47) | | 52 | 66 | 47 | 45 | 34 | 29 | 54 | 1 | |
| INDIA | 2 | 1 | 6095 | 5829 | 6263 | F(4,1 | 2.43 | 2. | 2. | 0. | 1. | 7. | 3. | 1. | 0.4 | |
| | | | .70 | .86 | .70 | 50) | | 35 | 03 | 47 | 18 | 98 | 01 | 40 | 6 | |
| INDIA | 2 | 2 | 6108 | 5741 | 6340 | F(4,1 | 2.44 | 2. | 3. | 1. | 0. | 2. | 1. | 0. | 1.9 | |
| | | | .48 | .36 | .48 | 42) | | 44 | 20 | 27 | 44 | 01 | 43 | 42 | 7 | |
| KENYA | 1 | 1 | 6134 | 5918 | 6270 | F(4,1 | 2.43 | 6. | 3. | 0. | 4. | 5. | 1. | 1. | 0.9 | |
| | | | .52 | .93 | .52 | 55) | | 63 | 40 | 78 | 87 | 85 | 40 | 30 | 9 | |
| KENYA | 1 | 2 | 6099 | 5782 | 6299 | F(4,1 | 2.43 | 1. | 3. | 1. | 0. | 3. | 2. | 1. | 1.2 | |
| | | | .26 | .78 | .26 | 46) | | 01 | 40 | 19 | 74 | 66 | 34 | 34 | 5 | |
| KENYA | 2 | 1 | 6079 | 5801 | 6255 | F(4,1 | 2.43 | 6. | 4. | 0. | 4. | 3. | 1. | 1. | 0.2 | |
| | | | .80 | .30 | .80 | 49) | | 47 | 34 | 90 | 99 | 96 | 94 | 72 | 9 | |
| KENYA SOUTH AFRICA | 2 | 2 | 6085 | 5706 | 6325 | F(4,1 | 2.44 | 1. | 5. | 0. | 0. | 1. | 2. | 1. | 1.0 | |
| | | | .78 | .00 | .78 | 41) | | 82 | 19 | 69 | 63 | 38 | 27 | 30 | 8 | |
| SOUTH AFRICA | 1 | 1 | 5945 | 5755 | 6065 | F(4,1 | 2.43 | 5. | 6. | 0. | 3. | 3. | 2. | 1. | 0.1 | |
| | | | .29 | .06 | .29 | 57) | | 61 | 28 | 95 | 99 | 20 | 55 | 75 | 6 | |
| SOUTH AFRICA | 1 | 2 | 5908 | 5617 | 6092 | F(4,1 | 2.43 | 1. | 7. | 2. | 1. | 2. | 2. | 0. | 1.0 | |
| | | | .16 | .00 | .16 | 48) | | 95 | 59 | 08 | 04 | 68 | 43 | 96 | 6 | |
| SOUTH AFRICA | 2 | 1 | 5906 | 5653 | 6066 | F(4,1 | 2.43 | 3. | 3. | 1. | 3. | 1. | 2. | 2. | 1.5 | |
| | | | .29 | .11 | .29 | 51) | | 56 | 79 | 14 | 04 | 64 | 35 | 05 | 8 | |
| SOUTH AFRICA | 2 | 2 | 5896 | 5542 | 6120 | F(4,1 | 2.43 | 1. | 4. | 1. | 0. | 2. | 2. | 0. | 2.0 | |
| | | | .63 | .17 | .63 | 43) | | 50 | 39 | 12 | 95 | 06 | 15 | 97 | 3 | |
| TANZANIA | 1 | 1 | 6129 | 5939 | 6249 | F(4,1 | 2.43 | 7. | 1. | 0. | 3. | 7. | 2. | 0. | 0.3 | |
| | | | .79 | .56 | .79 | 57) | | 82 | 40 | 81 | 13 | 74 | 40 | 99 | 3 | |
| TANZANIA | 1 | 2 | 6102 | 5811 | 6286 | F(4,1 | 2.43 | 5. | 1. | 0. | 1. | 2. | 1. | 1. | 0.7 | |
| | | | .44 | .28 | .44 | 48) | | 63 | 96 | 44 | 13 | 09 | 94 | 39 | 8 | |
| TANZANIA | 2 | 1 | 6087 | 5834 | 6247 | F(4,1 | 2.43 | 5. | 1. | 1. | 3. | 7. | 3. | 1. | 0.2 | |
| | | | .47 | .28 | .47 | 51) | | 94 | 20 | 13 | 16 | 92 | 07 | 16 | 0 | |
| TANZANIA | 2 | 2 | 6083 | 5729 | 6307 | F(4,1 | 2.43 | 5. | 1. | 0. | 0. | 2. | 2. | 0. | 1.0 | |
| | | | .84 | .38 | .84 | 43) | | 02 | 28 | 54 | 92 | 47 | 18 | 36 | 4 | |

| | | | | | | | | | | | | | | | |
|-----|---|---|------|------|------|-------|------|----|----|----|----|----|----|-----|---|
| UAE | 1 | 1 | 5992 | 5789 | 6120 | F(4,1 | 8. | 1. | 1. | 3. | 4. | 2. | 1. | 0.0 | |
| | | | .32 | .41 | .32 | 56) | 2.43 | 80 | 21 | 48 | 36 | 21 | 53 | 36 | 5 |
| UAE | 1 | 2 | 5961 | 5657 | 6153 | F(4,1 | 2. | 1. | 1. | 1. | 1. | 2. | 0. | 1.4 | |
| | | | .32 | .50 | .32 | 47) | 2.43 | 36 | 08 | 06 | 00 | 91 | 78 | 71 | 8 |
| UAE | 2 | 1 | 5952 | 5686 | 6120 | F(4,1 | 7. | 1. | 2. | 2. | 4. | 3. | 1. | 0.3 | |
| | | | .09 | .25 | .09 | 50) | 2.43 | 11 | 09 | 60 | 43 | 20 | 27 | 68 | 1 |
| UAE | 2 | 2 | 5950 | 5583 | 6182 | F(4,1 | 2. | 0. | 1. | 0. | 2. | 2. | 0. | 0.2 | |
| | | | .91 | .79 | .91 | 42) | 2.44 | 44 | 36 | 19 | 82 | 24 | 47 | 56 | 3 |
| USA | 1 | 1 | 5770 | 5567 | 5898 | F(4,1 | 5. | 6. | 0. | 0. | 2. | 2. | 0. | 0.1 | |
| | | | .81 | .90 | .81 | 56) | 2.43 | 21 | 03 | 63 | 91 | 90 | 01 | 92 | 4 |
| USA | 1 | 2 | 5732 | 5428 | 5924 | F(4,1 | 1. | 4. | 0. | 0. | 4. | 1. | 0. | 0.8 | |
| | | | .09 | .27 | .09 | 47) | 2.43 | 26 | 51 | 80 | 37 | 22 | 87 | 61 | 6 |
| USA | 2 | 1 | 5738 | 5472 | 5906 | F(4,1 | 4. | 4. | 1. | 0. | 5. | 0. | 0. | 0.2 | |
| | | | .64 | .80 | .64 | 50) | 2.43 | 28 | 37 | 54 | 56 | 09 | 91 | 86 | 5 |
| USA | 2 | 2 | 5733 | 5366 | 5965 | F(4,1 | 0. | 2. | 1. | 0. | 3. | 1. | 0. | 0.5 | |
| | | | .19 | .08 | .19 | 42) | 2.44 | 80 | 12 | 13 | 74 | 58 | 15 | 83 | 3 |

Source: Author's own calculation from GVAR

Appendix 9: Average pairwise cross-section correlations: Variables and residuals

| | Country/region | Levels | First Differences | VECMX* Residuals |
|-----|----------------|---------|-------------------|------------------|
| y | CHINA | 0.7669 | 0.3874 | -0.1356 |
| y | EURO | 0.2372 | 0.3392 | -0.1267 |
| y | INDIA | 0.7601 | 0.2845 | 0.0180 |
| y | KENYA | 0.7483 | 0.1008 | 0.1253 |
| y | SOUTH AFRICA | 0.3596 | 0.3465 | 0.0013 |
| y | TANZANIA | 0.7623 | 0.3489 | 0.0415 |
| y | UAE | 0.7520 | 0.4672 | -0.0014 |
| y | USA | 0.6996 | 0.3771 | 0.1307 |
| Dp | CHINA | 0.9825 | 0.0626 | -0.0301 |
| Dp | EURO | 0.9830 | 0.0532 | -0.0288 |
| Dp | INDIA | 0.9811 | -0.0724 | -0.0398 |
| Dp | KENYA | 0.9866 | 0.1866 | 0.0632 |
| Dp | SOUTH AFRICA | 0.9855 | 0.1986 | 0.0601 |
| Dp | TANZANIA | 0.9814 | 0.1204 | 0.0134 |
| Dp | UAE | 0.9490 | 0.1377 | 0.0785 |
| Dp | USA | 0.9796 | 0.1609 | 0.0495 |
| ep | CHINA | -0.4000 | 0.2003 | 0.3263 |
| ep | EURO | 0.0257 | -0.4243 | 0.2763 |
| ep | INDIA | 0.1638 | 0.2087 | 0.2154 |
| ep | KENYA | 0.1804 | 0.1904 | 0.2519 |
| ep | SOUTH AFRICA | 0.1275 | 0.1081 | 0.1974 |
| ep | TANZANIA | 0.1672 | 0.2476 | 0.3183 |
| ep | UAE | -0.2882 | 0.2453 | 0.4751 |
| ep | USA | -0.2882 | 0.2453 | 0.4422 |
| r | CHINA | 0.2692 | 0.0783 | 0.0120 |
| r | EURO | 0.2727 | 0.0158 | -0.0336 |
| r | INDIA | 0.3449 | 0.0745 | -0.0240 |
| r | KENYA | -0.1153 | -0.0025 | 0.0003 |
| r | SOUTH AFRICA | 0.3125 | 0.0503 | -0.0172 |
| r | TANZANIA | -0.3022 | 0.0189 | -0.0063 |
| r | UAE | 0.0662 | 0.0249 | -0.0307 |
| r | USA | 0.1761 | 0.0808 | 0.0309 |
| npl | CHINA | 0.0818 | 0.3177 | 0.0106 |
| npl | EURO | 0.0747 | 0.2017 | -0.0454 |
| npl | INDIA | -0.0126 | 0.0416 | -0.0016 |
| npl | KENYA | -0.2524 | 0.2106 | -0.0162 |
| npl | SOUTH AFRICA | 0.2083 | 0.2775 | 0.0415 |
| npl | TANZANIA | 0.0765 | -0.0225 | -0.0625 |
| npl | UAE | 0.2028 | 0.2568 | -0.0374 |
| npl | USA | 0.0816 | 0.2464 | -0.0583 |

Source: Author's own calculation from GVAR

Appendix 10: Descriptive statistics for ln_GDP by sector

| Descriptive | GDP_AGR | GDP_MIN | GDP_MAN | GDP_CONS | GDP_TRADE | GDP_TRANS |
|--------------|----------|----------|-----------|----------|-----------|-----------|
| Mean | 26.86199 | 4.388305 | 8.651356 | 16.41441 | 10.73322 | 7.240678 |
| Median | 27.73675 | 4.040000 | 8.740000 | 16.55000 | 9.930000 | 7.290000 |
| Maximum | 31.62067 | 8.210000 | 10.57000 | 18.96000 | 13.34000 | 8.270000 |
| Minimum | 19.68279 | 3.180000 | 6.460000 | 12.39000 | 8.160000 | 5.200000 |
| Std. Dev. | 3.305132 | 1.019287 | 0.861859 | 2.114512 | 1.852515 | 0.674439 |
| Skewness | -1.09679 | 1.724801 | -0.108317 | -0.29355 | 0.264306 | -0.536874 |
| Kurtosis | 3.326707 | 5.821222 | 3.215546 | 1.586903 | 1.380950 | 2.937062 |
| Jarque-Bera | 12.09139 | 48.82016 | 0.229585 | 5.756260 | 7.131015 | 2.844032 |
| Probability | 0.002368 | 0.000000 | 0.891551 | 0.056240 | 0.028283 | 0.241227 |
| Sum | 1584.857 | 258.9100 | 510.4300 | 968.4500 | 633.2600 | 427.2000 |
| Sum Sq. Dev. | 633.5860 | 60.25883 | 43.08249 | 259.3273 | 199.0451 | 26.38237 |
| Observations | 59 | 59 | 59 | 59 | 59 | 59 |

Source: Extract from estimation output E-views 12

Appendix 11: Descriptive statistics for NPLs by sector

| Descriptive | NPL_AGRI | NPL_CONSTR | NPL_MAN | NPL_MIN | NPL_TRADE | NPL_TRANS |
|--------------|----------|------------|----------|----------|-----------|-----------|
| Mean | 19.57997 | 6.883354 | 6.617627 | 16.65437 | 9.087196 | 8.305927 |
| Median | 18.29358 | 6.171376 | 6.520282 | 16.48664 | 6.749608 | 7.192913 |
| Maximum | 35.27922 | 17.89446 | 14.37469 | 40.72679 | 18.33109 | 21.31403 |
| Minimum | 12.42721 | 0.235408 | 1.877644 | 0.000000 | 4.454673 | 2.625593 |
| Std. Dev. | 5.051766 | 5.086332 | 2.540090 | 10.60919 | 4.217561 | 4.163016 |
| Skewness | 0.778498 | 0.422985 | 0.429225 | 0.180394 | 0.922833 | 1.212836 |
| Kurtosis | 3.282436 | 2.138886 | 3.497928 | 2.224233 | 2.429118 | 4.100959 |
| Jarque-Bera | 6.155686 | 3.582244 | 2.421138 | 1.799456 | 9.175457 | 17.44433 |
| Probability | 0.046059 | 0.166773 | 0.298028 | 0.406680 | 0.010176 | 0.000163 |
| Sum | 1155.218 | 406.1179 | 390.4400 | 982.6076 | 536.1446 | 490.0497 |
| Sum Sq. Dev. | 1480.180 | 1500.505 | 374.2194 | 6528.183 | 1031.694 | 1005.181 |
| Observations | 59 | 59 | 59 | 59 | 59 | 59 |

Source: Extract from estimation output E-views 12

Appendix 12: Descriptive statistics for control variables by sector

| Descriptive | EXCHANGE | INFLATION | INTEREST | OPENNESS |
|-----------------|----------|-----------|----------|-----------|
| Mean | 1.052670 | 7.521714 | 6.942691 | 42.61144 |
| Median | 1.020703 | 6.200000 | 6.214584 | 43.83656 |
| Maximum | 1.276775 | 19.80000 | 19.05572 | 57.10527 |
| Minimum | 0.836171 | 3.100000 | 0.795792 | 27.54306 |
| Std. Dev. | 0.116131 | 4.091724 | 4.425806 | 8.261807 |
| Skewness | 0.212796 | 1.268603 | 0.909656 | -0.075647 |
| Kurtosis | 2.113286 | 4.086686 | 3.259465 | 1.849160 |
| Jarque-Bera | 2.418473 | 19.04576 | 8.443045 | 3.368307 |
| Probability | 0.298425 | 0.000073 | 0.014676 | 0.185601 |
| Sum | 63.16022 | 451.3028 | 416.5615 | 2556.686 |
| Sum Sq. Dev. | 0.795694 | 987.7903 | 1155.678 | 4027.190 |
| Observations | 59 | 59 | 59 | 59 |

Source: Extract from estimation output E-views 12

Appendix 13: Unit root test for ln_GDP by sector

| Test | Variables | lnGDP_AG RIC | ln_GDP Min | ln_GDP Man | ln_GDP Con | ln_GDPtr ade | ln_GDPTr ans |
|--------------------------|---------------------|-----------------|---------------|---------------|---------------|-----------------|-----------------|
| ADF(intercept only) | Level | -2.12 | -3.47** | -1.64 | -2.67* | -1.03 | -4.14*** |
| | First Difference | -17.3*** | -7.43*** | -4.19*** | -8.06*** | 2.91* | -10.31*** |
| ADF(Trend& intercept) | Level | -2.08 | -5.37*** | -2.16 | -3.14 | -2.38 | -4.35*** |
| | First Difference | -17.15*** | -7.56*** | -4.18*** | -8.00*** | -2.86 | -10.21*** |
| PP(intercept only) | Level | -8.03*** | -3.47** | -4.43*** | -2.52 | -0.88 | -4.14*** |
| | First Difference | -24.77*** | 19.60*** | -13.46*** | -9.83*** | -9.55*** | -12.58*** |
| PP(Trend& intercept) | Level | -7.99*** | -5.37*** | -4.76*** | -3.05 | -2.6 | -4.35*** |
| | First Difference | -24.50*** | 23.75*** | -13.34*** | -9.91*** | 9.53*** | -12.42*** |

*, **, *** represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 14: Unit root test for NPLs by sector

| Test | Variables | Npl_Agr ic | Npl_Mi n | Npl_Ma n | Npl_Co ns | Npl_trad e | Npl_tran s |
|--------------------------|---------------------|---------------|-------------|-------------|--------------|---------------|---------------|
| ADF(intercept only) | Level | -3.41*** | -2.84* | -5.66*** | -1.71 | -1.7 | -2.80* |
| | First Difference | -7.67*** | - | 8.79*** | -7.13*** | -11.37*** | -12.45*** |
| ADF(Trend& intercept) | Level | 3.52*** | -2.98* | -5.80*** | -2.63 | -3.04 | -4.11*** |
| | First Difference | 7.61*** | - | 8.72*** | -7.09*** | -11.33*** | |
| PP(intercept only) | Level | -3.62*** | -2.78* | -5.81*** | -1.71 | -1.43 | -2.80* |
| | First Difference | -9.48*** | - | 9.61*** | -7.13*** | -11.51*** | -12.45*** |
| PP(Trend& intercept) | Level | -3.71** | -2.98 | -5.97*** | -2.63 | -2.93 | -4.11*** |
| | First Difference | -9.36*** | -9.53 | | -7.09*** | -12.14*** | |

*, **, *** represent the level of significance of 10percent, 5percent and 1percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 15: Unit root test for control variables by sector

| Test | Variables | InInf | InExch | InInt | Inopen |
|-----------------------|------------|----------|----------|-----------|----------|
| ADF(intercept only) | Level | -2.25 | -1.52 | -3.34 | -0.71 |
| | First | | | | |
| | Difference | -5.42*** | -6.42*** | -8.69*** | -3.04*** |
| ADF(Trend& intercept) | Level | -2.85 | -2.21 | -3.34 | -2.16 |
| | First | | | | |
| | Difference | -5.37*** | -6.38*** | -8.61*** | -3.18*** |
| PP(intercept only) | Level | -2.01 | -1.64 | -3.38*** | -0.42 |
| | First | | | | |
| | Difference | -5.42*** | -6.42*** | -12.24*** | -3.06*** |
| PP(Trend& intercept) | Level | -2.62 | -2.11 | -3.38** | -2.27 |
| | First | | | | |
| | Difference | -5.37*** | -6.38*** | -12.34*** | -3.26*** |

*, **, *** represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 16: Unit root test for NARDL for ln_GDP by sector

| Test | Variables | lnGDP_AG RIC | ln_GDP Min | ln_GDP Man | ln_GDP Con | ln_GDPtr ade | ln_GDPTr ans |
|---------------------------|---------------------|-----------------|---------------|---------------|---------------|-----------------|-----------------|
| ADF(intercept only) | Level | 0.2265 | -3.47** | -1.64 | 0.35* | -1.03 | -4.14*** |
| | First Difference | 0.26*** | -7.43*** | -4.19*** | 0.15** | 2.91* | -10.31*** |
| ADF(Trend& intercept) | Level | -2.08 | -5.37*** | -2.16 | -3.14 | -2.38 | -4.35*** |
| | First Difference | -17.15*** | -7.56*** | -4.18*** | -8.00*** | -2.86 | -10.21*** |
| PP(intercept only) | Level | -8.03*** | -3.47** | -4.43*** | -2.52 | -0.88 | -4.14*** |
| | First Difference | -24.77*** | 19.60*** | -13.46*** | -9.83*** | -9.55*** | -12.58*** |
| PP(Trend& intercept) | Level | -7.99*** | -5.37*** | -4.76*** | -3.05 | -2.6 | -4.35*** |
| | First Difference | -24.50*** | 23.75*** | -13.34*** | -9.91*** | 9.53*** | -12.42*** |
| KPSS(intercept only) | Level | 0.23 | 0.82*** | 0.35* | 0.47** | 0.82*** | 0.25 |
| | First Difference | 0.22 | 0.28 | 0.1 | 0.12 | 0.36** | 0.5** |
| KPSS(Trend& intercept) | Level | 0.26*** | 0.15** | 0.15** | 0.21** | 0.11 | 0.07 |
| | First Difference | 0.18** | 0.17** | 0.09 | 0.12* | 0.37*** | 0.5*** |

*, **, *** represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 17: Unit root test for NARDL for ln_GDP by sector

| Test | Variables | Npl_Agri c | Npl_Mi n | Npl_Ma n | Npl_Con s | Npl_trad e | Npl_tran s |
|---------------------------|---------------------|---------------|-------------|-------------|--------------|---------------|---------------|
| ADF(intercept only) | Level | -3.41*** | -2.84* | -5.66*** | -1.71 | -1.7 | -2.80* |
| | First Difference | -7.67*** | - | 8.79*** | -7.13*** | - | - |
| ADF(Trend& intercept) | Level | 3.52*** | -2.98* | -5.80*** | -2.63 | -3.04 | -4.11*** |
| | First Difference | 7.61*** | - | 8.72*** | -7.09*** | - | - |
| PP(intercept only) | Level | -3.62*** | -2.78* | -5.81*** | -1.71 | -1.43 | -2.80* |
| | First Difference | -9.48*** | - | 9.61*** | -7.13*** | - | - |
| PP(Trend& intercept) | Level | -3.71** | -2.98 | -5.97*** | -2.63 | -2.93 | -4.11*** |
| | First Difference | -9.36*** | -9.53 | - | -7.09*** | - | - |
| KPSS(intercept only) | Level | 0.17 | 0.27 | 0.27 | 0.76*** | 0.60** | 0.68** |
| | First Difference | 0.13 | 0.10 | 0.5** | 0.12 | 0.23 | 0.09 |
| KPSS(Trend& intercept) | Level | 0.15 | 0.10 | 0.08 | 0.01 | 0.23** | 0.18** |
| | First Difference | 0.12 | 0.09 | 0.5*** | 0.1 | 0.16** | 0.44 |

*, **, *** represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 17: NARDL-Unit root test for control variables by sector

| Test | Variables | lnInf | lnExch | lnInt | lnopen |
|------------------------|------------------|----------|----------|-----------|----------|
| ADF(intercept only) | Level | -2.25 | -1.52 | -3.34 | -0.71 |
| | First Difference | -5.42*** | -6.42*** | -8.69*** | -3.04*** |
| ADF(Trend& intercept) | Level | -2.85 | -2.21 | -3.34 | -2.16 |
| | First Difference | -5.37*** | -6.38*** | -8.61*** | -3.18*** |
| PP(intercept only) | Level | -2.01 | -1.64 | -3.38*** | -0.42 |
| | First Difference | -5.42*** | -6.42*** | -12.24*** | -3.06*** |
| PP(Trend& intercept) | Level | -2.62 | -2.11 | -3.38** | -2.27 |
| | First Difference | -5.37*** | -6.38*** | -12.34*** | -3.26*** |
| KPSS(intercept only) | Level | 0.53** | 0.59** | 0.12 | 0.64** |
| | First Difference | 0.06 | 0.07 | 0.35 | 0.33 |
| KPSS(Trend& intercept) | Level | 0.13* | 0.12* | 0.12* | 0.19** |
| | First Difference | 0.04 | 0.06 | 0.38*** | 0.08 |

*, **, *** represent the level of significance of 10percent, 5percent and 1percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 189:Unit root test for banking sector variables

| Variables | Test | Statistical Value | | P-value | |
|-----------|-------------------------|-------------------|------------|-----------|------------|
| | | level | First Diff | level | First Diff |
| NPLs | Levin, Lin & Chu t | -0.85 | -15.42 | 0.19 | 0.000*** |
| | Im, Pesaran and Shin | -3.34 | | 0.000*** | |
| | ADF - Fisher Chi-square | 67.01 | | 0.0023*** | |
| | PP - Fisher Chi-square | 74.88 | | 0.000*** | |
| ROA | Levin, Lin & Chu t | -2.52 | | 0.005*** | |
| | Im, Pesaran and Shin | -4.86 | | 0.000*** | |
| | ADF - Fisher Chi-square | 90.09 | | 0.000*** | |
| | PP - Fisher Chi-square | 117.11 | | 0.000*** | |
| LEV | Levin, Lin & Chu t | -1.43 | | 0.07* | |
| | Im, Pesaran and Shin | -2.82 | | 0.002*** | |
| | ADF - Fisher Chi-square | 64.41 | | 0.002*** | |
| | PP - Fisher Chi-square | 96.53 | | 0.000*** | |
| BAT | Levin, Lin & Chu t | 1.47 | -18.1 | 0.93 | 0.000*** |
| | Im, Pesaran and Shin | -0.4 | -18.69 | 0.34 | 0.000*** |
| | ADF - Fisher Chi-square | 39.2 | 377.66 | 0.32 | 0.000*** |
| | PP - Fisher Chi-square | 41.74 | 690.2 | 0.23 | 0.000*** |
| CAR | Levin, Lin & Chu t | -0.36 | -19.93 | 0.35 | 0.000**** |
| | Im, Pesaran and Shin | -2.33 | | 0.009*** | |
| | ADF - Fisher Chi-square | 61.99 | | 0.004*** | |
| | PP - Fisher Chi-square | 82.08 | | 0.000*** | |

*, **, *** represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Extract from estimation output E-views 12

Appendix 20: Unit root test for macroeconomic variables

| Variables | Test | Statistical Value | | P-value | |
|-----------|-------------------------|-------------------|------------|----------|------------|
| | | level | First Diff | level | First Diff |
| GDP | Levin, Lin & Chu t | -9.14 | | 0.000*** | |
| | Im, Pesaran and Shin | -13.09 | | 0.000*** | |
| | ADF - Fisher Chi-square | 238.62 | | 0.000*** | |
| | PP - Fisher Chi-square | 373.01 | | 0.000*** | |
| INF | Levin, Lin & Chu t | -0.46 | -1.46 | 0.32 | 0.07* |
| | Im, Pesaran and Shin | -3.65 | | 0.000*** | |
| | ADF - Fisher Chi-square | 61.49 | | 0.005*** | |
| | PP - Fisher Chi-square | 55.73 | | 0.019** | |
| REE | Levin, Lin & Chu t | -2.01 | | 0.027** | |
| | Im, Pesaran and Shin | -3.62 | | 0.000*** | |
| | ADF - Fisher Chi-square | 61.22 | | 0.005*** | |
| | PP - Fisher Chi-square | 43.75 | 425.45 | 0.175 | 0.000*** |
| OIL | Levin, Lin & Chu t | -2.44 | | 0.007*** | |
| | Im, Pesaran and Shin | -4.74 | | 0.000*** | |
| | ADF - Fisher Chi-square | 78.83 | | 0.000*** | |
| | PP - Fisher Chi-square | 78.83 | | 0.000*** | |
| INT | Levin, Lin & Chu t | -9.38 | | 0.000*** | |
| | Im, Pesaran and Shin | -7.82 | | 0.000*** | |
| | ADF - Fisher Chi-square | 128.02 | | 0.000*** | |
| | PP - Fisher Chi-square | 146.97 | | 0.000*** | |

*, **, *** represent the level of significance of 1percent, 5percent and 10percent, respectively.

Source: Extract from estimation output E-views 12

Ethical Clearance Letter



14 Sept 2022

Ms Khadijah Kishimba (221030517)
School Of Acc Economics&Fin
Westville

Dear Ms Khadijah Kishimba,

Original application number: 00016084

Project title: Macro-prudential tools, banking sector resilience and economic growth in Tanzania

Exemption from Ethics Review

In response to your application received on 12 Sept 2022, your school has indicated that the protocol has been granted **EXEMPTION FROM ETHICS REVIEW**.

Any alteration/s to the exempted research protocol, e.g., Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through an amendment/modification prior to its implementation. The original exemption number must be cited.

For any changes that could result in potential risk, an ethics application including the proposed amendments must be submitted to the relevant UKZN Research Ethics Committee. The original exemption number must be cited.

In case you have further queries, please quote the above reference number.

PLEASE NOTE:

Research data should be securely stored in the discipline/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours sincerely,

Prof Josue Mbonigaba
Academic Leader Research
School Of Acc Economics&Fin

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