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Impact of Terms of Trade Shocks on the South African Economy

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Abstract

This dissertation investigates the impact of terms of trade shocks on the South African economy using a Dynamic Stochastic General Equilibrium (DSGE) model estimated with Bayesian methods. South Africa's heavy dependence on commodity exports which account for approximately 60 percent of GDP—renders the economy highly vulnerable to fluctuations in global commodity prices, with significant implications for macroeconomic stability, growth, and policy. While existing studies have employed various methodologies including ARDL models and calibrated DSGE frameworks to examine external shocks, gaps remain in understanding the precise transmission channels, persistence, and sectoral propagation of terms of trade shocks within a structurally realistic, micro-founded model of the South African economy.

To address these gaps, this study adapts a small open economy DSGE model ((Gali and Monacelli, 2005)) and estimate it using Bayesian techniques with quarterly data spanning 1994Q1 to 2024Q3. Key variables include domestic output, inflation, the real exchange rate, terms of trade, and foreign output and inflation. The Bayesian approach allows for the integration of prior information with observed data, improving parameter identification and enabling a robust analysis of shock transmission.

Results indicate that terms of trade shocks are highly persistent ($\rho_q \approx 0.90$) and constitute a major driver of South Africa's business cycle fluctuations. Impulse response analysis reveals that a positive terms of trade shock boosts domestic output and appreciates the real exchange rate, with inflation responding gradually due to exchange rate pass-through effects. Variance decomposition shows that terms of trade shocks explain a substantial share of fluctuations in output, inflation, and the exchange rate, particularly over medium- to long-term horizons. Historical decomposition further confirms the dominant role of external commodity price shocks during key episodes such as the 2008–09 financial crisis and the post-2015 commodity downturn.

The study concludes that South Africa's commodity-dependent economic structure amplifies its exposure to global price volatility, with lasting effects on key macroeconomic variables. Policy recommendations include economic diversification, strengthened fiscal buffers, and enhanced monetary-fiscal coordination to mitigate external vulnerability. This research contributes to the academic literature by providing a structurally detailed, empirically grounded analysis of terms of trade shocks in South Africa and offers evidence-based insights for policymakers in small open commodity-exporting economies.

Keywords: Business Fluctuations; Cycles, Open Economy Macroeconomics (Terms of trade shocks), Bayesian DSGE model, South African economy, Commodity dependence, Macroeconomic transmission.

JEL Classification: E32, F41, C11, O55

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Thank you all.
Ms. TG Motsodisa

Declaration

Declaration

I, **Tiisetso Gladys Motsodisa**, hereby declare the following:

- The work presented in this dissertation is my original work. All material from other sources is identified, acknowledged and credited.
- I hereby confirm that this work has not been presented to confer credit for any other degree at any other institution.
- Where the work of others has been used, it has been properly attributed and referenced.

Signature: 

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Chapter 1

Introduction

1.1 Background

Terms of trade represent the relative price of a country's exports to its imports. This ratio represents the purchasing power derived from export revenues. The volatile nature of the terms of trade indicates the effects of global shocks on small, open economies. These fluctuations are unexpected, volatile, persistent, and mostly felt in commodity-dependent economies, Oviedo Gómez and Sierra (2019).

The South African economy is a definition of paradoxical contradiction. Though rich in agricultural and mineral resources, South Africa remains heavily dependent on commodity exports, amounting to 60 percent of the country's GDP (Leshoro, 2023). This dependence leaves the economy vulnerable to terms of trade shocks, which are defined as volatile fluctuations in the ratio of exports to imports Leshoro (2023). These events theoretically disrupt Small Open Economies (SOEs), through the Harberger-Laursen-Metzler (HLM) effect as an income consumption linkage Metzler (1949); Harberger (1957); Laursen (1978) and the Prebisch-Singer (PS) hypothesis (Prebisch, 1962; Singer, 1975), resulting in a long deterioration of commodity prices (Barattieri et al., 2021; Ejaz and Azam, 2024).

Hollander and van Lill (2018), established that South African business cycle dynamics are sensitive to model specification and confirmed that demand-side shocks dominate in the short run, while supply-side shocks drive the long run. However, this framework terms of trade was derived as a relative price rather than an identified structural shock, and their findings indicate that terms of trade play a limited role in the consultations of the South African economy. Furthermore, their single-sector setup cannot quantify how commodity price shocks transmit differentially across South Africa's economy. Hove et al. (2015), employed a New Keynesian DSGE model calibrated to the South African economy to evaluate optimal monetary policy responses to commodity terms of trade shocks, finding that CPI inflation targeting reduces macroeconomic volatility more effectively than exchange rate or non-traded inflation targeting regimes, though at the cost of increased exchange rate volatility. The study was calibrated its parameters was not estimated thus meaning that they are not statistically derived from South African data, which limits empirical precision and prevents the construction of confidence intervals around the impulse responses. Second, the study does not provide the variance or historical decomposition needed to quantify how much of South Africa's observed macroeconomic volatility is attributable to terms of trade shocks. This study, therefore extends Hove et al. (2015) by

introducing a Bayesian-estimated DSGE framework that produces statistically grounded parameter estimates and provides the structural decomposition needed to quantify both the magnitude of the shock and its sector-level transmission channels.

Leshoro (2023), employed Monte Carlo impulse response functions and variance decomposition to confirm that a negative term of trade shock significantly affects output, inflation, the exchange rate, and the trade balance in South Africa, with effects present in both the short and long run. However, three methodological limitations constrain the study's contribution. The reduced-form VAR framework cannot structurally identify the terms of trade shock; thus, the impulse responses reflect data correlations rather than causally identified transmission mechanisms. The simultaneous feedback among the terms of trade, monetary policy, and the exchange rate is not modelled separately. Furthermore, the aggregate framework cannot trace how the shock transmits differentially across South Africa's economy, it can not be used for counterfactual policy simulation. Therefore this study extends on the works of Leshoro (2023) by introducing a Bayesian DSGE model where terms of trade shocks is identified as a structural shock estimated on South African quarterly data, and traced through transmission channels.

The existing literature provides a foundation for this study but leaves a precise and addressable gap. Hollander and van Lill (2018), established that South African business cycle dynamics are sensitive to model specification and confirmed that demand-side shocks dominate in the short run while supply-side shocks drive the long run; however, their framework treats the terms of trade as a derived relative price rather than an identified structural shock, meaning their finding that terms of trade plays a limited role reflects a design choice rather than the true external exposure of the economy. Leshoro (2023), addresses the terms of trade question by employing Monte Carlo impulse response functions and variance decomposition to confirm that a negative terms of trade shock significantly affects output, inflation, the exchange rate, and the trade balance in South Africa in both the short and long run, the reduced-form VAR framework cannot structurally identify the shock, cannot model the simultaneous feedback between the terms of trade, monetary policy, and the exchange rate, and cannot be used for policy simulation. Hove et al. (2016), further the question by developing a New Keynesian DSGE model calibrated to South Africa and confirming across a panel of emerging market economies that CPI inflation targeting reduces the macroeconomic volatility generated by commodity terms of trade shocks more effectively than alternative regimes, yet their 2015 DSGE model relies on calibrated rather than statistically estimated parameters, limiting empirical precision, and neither study provides the variance decomposition or historical decomposition needed to quantify how much of South Africa's observed macroeconomic volatility is attributable to terms of trade shocks specifically.
A common limitation stands, the above-mentioned studies do not trace how a term of trade shock transmits differential across South Africa's economic landscape, thus leaving the sector-level transmission channels structurally quantified. This study therefore bridges these gaps by introducing a micro-founded small open economy Bayesian DSGE model in which the terms of trade shock is identified as a structural shock, its parameters are statistically estimated from South African quarterly data spanning 1994Q1 to 2024Q3, and its transmission is traced through impulse response functions, variance and historical decomposition providing the structural rigour, empirical precision. The study therefore contributes to existing research aimed at understanding the impact of terms of trade on

the South African economy. The study thus aims to bridge the gap by incorporating micro-founded SOE DSGE model of Gali and Monacelli (2005) with Bayesian estimation techniques to investigate the South African landscape and its responses to high commodity price volatility.

1.2 Problem Statement

South Africa's dependence on commodity exports, which account for approximately 60 percent of total export earnings Leshoro (2023), creates a persistent and theoretically grounded vulnerability to terms of trade shocks. The Harberger-Laursen-Metzler effect establishes that terms of trade movements transmit directly into real income and consumption through the income-consumption linkage, generating cyclical macroeconomic dynamics that are amplified in commodity-dependent economies Harberger (1957);Metzler (1949). The Prebisch-Singer hypothesis adds that this exposure is structural primary commodity prices deteriorate over time relative to manufactured goods, embedding South Africa's vulnerability into its long-run trading position Prebisch (1962); Singer (1975). Empirically, this theoretical prediction is well confirmed. Cashin et al. (2004), document that terms of trade shocks are primary determinants of output performance in commodity-exporting economies, generating fluctuations that are larger and more persistent than those in diversified economies. For South Africa specifically, the commodity price collapse of 2014 to 2016, the 2008 global financial crisis, and COVID-19-related price volatility each produced sharp contractions in output, rand depreciation, and fiscal instability that are directly traceable to terms of trade exposure. Yet despite this demonstrated importance, the dynamic transmission channels of these shocks remain imprecisely quantified. Leshoro (2023), identifies long-run relationships using ARDL methods but cannot capture simultaneous feedback mechanisms between terms of trade, exchange rates, and monetary policy. Hollander and van Lill (2018), provide the most rigorous Bayesian DSGE analysis of the South African business cycle but do not introduce the terms of trade as an independently identified structural shock, meaning their results cannot isolate the specific contribution of commodity price movements to macroeconomic fluctuations. The consequence is that policymakers cannot distinguish commodity-driven disturbances from domestically-generated ones a distinction that is critical for calibrating monetary policy responses and designing counter-cyclical fiscal interventions Hove et al. (2016).

Addressing this gap requires a framework that is simultaneously structural, dynamic, and empirically grounded in South African data conditions that jointly motivate the adoption of a Bayesian Dynamic Stochastic General Equilibrium (DSGE) approach. The DSGE framework, following the small open economy model of Gali and Monacelli (2005) provides the micro-founded structural backbone necessary for identifying individual shocks and tracing their transmission through explicitly modelled household, firm, and monetary policy behaviour. Unlike VAR or ARDL models, it generates structurally interpretable impulse response functions, variance and historical decomposition that can directly inform policy. Bayesian estimation addresses the limitations of classical methods by combining prior information from the existing South African and international DSGE literature with the model's likelihood function and observed data, producing posterior parameter distributions that are both empirically informed and theoretically constrained. An and

Schorfheide (2007), establish, Bayesian methods are particularly well suited to small open economy contexts where time series are short and parameter identification is challenging precisely the conditions of South African quarterly data from 1994Q1 to 2024Q3. This study therefore introduces the terms of trade as an explicitly identified AR(1) structural shock within a Bayesian-estimated SOE-DSGE model, rigorously quantifying the magnitude, persistence, and transmission channels of terms of trade shocks in South Africa and providing the structural empirical evidence that policymakers require to manage the economy's commodity price exposure.

1.3 Significance of the Study

Leshoro (2023),examines the importance of terms of trade for South Africa using ARDL methods, confirming that terms of trade fluctuations significantly affect key domestic macroeconomic variables. However, the ARDL framework cannot capture simultaneous feedback mechanisms between terms of trade movements, exchange rates, and monetary policy across multiple periods following the shock, and cannot be used for counterfactual policy simulation.Hollander and van Lill (2018), provide the most rigorous Bayesian DSGE analysis of the South African business cycle to date, offering validated parameter benchmarks that the present study draws upon directly. However, their framework treats the terms of trade as a derived relative price rather than an independently identified structural shock, meaning their results cannot isolate the specific contribution of commodity price movements to macroeconomic fluctuations. The present study addresses both limitations simultaneously thus embedding the terms of trade as an identified structural shock within a Bayesian-estimated SOE-DSGE framework, producing impulse response functions, variance and historical decompositions that are structurally interpretable and directly policy-relevant.

Assessing the impact of terms of trade shocks on South Africa's macroeconomic landscape is essential for understanding how these changes influence economic policy. The study's main value lies in supporting monetary policy formation: structures such as the South African Reserve Bank (SARB) can use the results to better estimate and analyse their responses to these shocks and to implement inflation and exchange rate management tools. Secondly, a clearer anticipation of the impact of terms of trade on variables such as Gross Domestic Product (GDP) enables policy-makers to implement proactive fiscal measures. Thirdly, an improved understanding of the dynamic relationship between terms of trade, exchange rates, and the trade balance supports more effective management of international economic relations. Fourth, by estimating how macroeconomic variables respond to terms-of-trade shocks, forecasting improves, leading to better economic planning.

Lastly, including foreign output and inflation enables the study to gives insight into external economic transmission channels affecting the South African economy. This is important for a Small Open Economy (SOE), as it helps policymakers, economic planners, and investors understand South Africa's global economic challenges and opportunities.

1.4 Research Objectives

1. Identify the transmission channels of terms of trade shocks within the South African economy.

2. Estimate the impact of terms of trade shocks on the South African economy.

3. Analyse and interpret the Impulse Response Functions.

1.5 Research Questions

1. How do terms of trade shocks transmit through South Africa's economic structure?

2. What are the macroeconomic effects of terms of trade shocks on key South African economic indicators?

3. How do the terms of trade shocks transmit thought the economy, based on the Impulse Response Functions?

1.6 Scope and Limitations

The study focuses on the South African economy due to its categorisation as an Emerging market and its status as a major Sub-Saharan powerhouse. The estimation, analysis, and interpretation of the impact of terms of trade shocks on the South African economy cover the period from 1994Q1 to 2024Q3, thus encompassing 30 years of data. The study focuses on seven macroeconomic variables, namely: GDP, Inflation, Real Board Exchange rate, Terms of trade, Foreign Output, and Foreign inflation. Specifically, the study analyses the impact of terms of trade on the South African economy and macroeconomic variables, with a focus on fluctuations in export and import prices relevant to South African trading sectors, including commodities, agriculture, and manufacturing. By employing the DSGE model and Bayesian inferences, it captures all structural shocks, characteristics, and economic dynamics.

Given the study's focus on the impact of terms of trade, other relevant external shocks, such as the global pandemic, financial crises, and monetary spillovers and supply shocks, may influence estimation results and may not be fully captured by the model. Furthermore, the model assumes a stable economy over the specified study period. Structural changes significant to the South African economy may affect the accuracy of the model results. Monetary and fiscal policy changes across regimes may create dynamics not captured by the model. Although the study offers valuable insights into macroeconomic responses, its results are tailored to South Africa's economy and may not be replicable in other countries. Further studies should take into account the characteristics of the specific country under study, as these are a consequence of the model parametrisation.

1.7 Methodology Overview

The methodology is based on the Small Open Economy model and employs the Dynamic Stochastic General Equilibrium (DSGE) framework with Bayesian inferences to analyse the impact of terms of trade on South Africa Gali and Monacelli (2005).The model specification, adopted from previous literature, is extended to better reflect structural characteristics specific to South Africa. To analyse small open economies effectively, the model incorporates nominal rigidities from staggered price setting, monopolistic competition,

complete exchange rate pass-through, and integrated international financial markets. It accounts for terms of trade shocks, thereby enabling a detailed analysis of their impact on South Africa. Key components include the Euler equation, the New Keynesian Phillips Curve (NKPC), the IS Curve, the Terms of Trade equation, and the Exchange Rate Dynamics equation.
Secondary quarterly data were collected for the key macroeconomic variables from the South African Reserve Bank (SARB), The St. Louis Federal Reserve (St. Louis Fed), and The Bank of International Settlements (BIS). The period of study covers 30 years, ranging from 1994Q1 to 2024Q3. The data processing includes seasonally adjusting the data (variables of interest). Thereafter, it was transformed into logarithmic form and then demeaned prior to estimation. Variables Foreign income and inflation are computed using the trade weights of South Africa's top three trading partners, namely, the Euro area (treated as a single entity), China, and the US. Trading weights are collected from the BIS for periods 1993 - 2019. GDP log differences are used to calculate output growth rates, which are then multiplied by 100 to provide quarter-to-quarter percentages. Consumer price index log differences are used to calculate inflation rates, which are then multiplied by 400 to get annualised percentage rates. Based on the weights of the top three trading partners of South Africa's GDP and CPI inflation, we compute international output and inflation. To calculate depreciation rates, we multiply the log differences (by 100) of the trade-weighted nominal effective exchange rate. While the real interest rate is expressed in levels, changes in the terms of trade are calculated as log differences and multiplied by 100. Every series is demeaned before estimation.

The DSGE model is solved with the use of perturbation methods and first-order approximation around the steady state. The estimation and solution provide policy functions that explain how the shocks impact the variables and thus the response of the variables terms of trade shocks. Stochastic simulations are therefore conducted to generate the artificial time series data. The model parameters are estimated utilising Bayesian estimation techniques. The prior distributions are based on the quantile distribution of the different parameters to be estimated. The likelihood function is estimated by utilising the Kalman Filter. Therefore, the posterior distribution is obtained. To analyse the estimation, the study uses impulse response functions (IRFs) which are computed to analyse how macroeconomic variables respond to the terms of trade shocks. The IRFs are thus investigated to identify the transmission channels of the shocks within the South African economic landscape (Chadha and Shibayama, 2018).

1.8 Structure of Dissertation

1.8.1 Chapter 1: Introduction.

The study is organised into six chapters, all addressing important concepts for understanding the impact of terms-of-trade shocks on the South African economy. The structure, therefore, investigates the topic from theoretical foundations to empirical reviews and policy implications. The following gives a brief content review of each chapter, thus serving as a road map to successfully navigate the contents of the study.

1.8.2 Chapter 2: Literature Review.

Present a review of the main foundations of terms of trade effects by examining theoretical frameworks and existing research on the study topic, SOE, DSGE models and Bayesian techniques of estimation. With a focus on South African and other similar economies.

1.8.3 Chapter 3: Methodology - Small Open Economy Model.

This chapter presents the theoretical framework for the SOE. Presenting an in-depth framework of the model adapted from Gali and Monacelli (2005),the develops a DSGE model for a Small Open Economy (SOE).

1.8.4 Chapter 4: Methodology.

This chapter outlines the methodological framework, centered on a Bayesian-estimated Small Open Economy DSGE model. It details the model specification, data construction, and estimation strategy designed to rigorously analyze the transmission of terms of trade shocks in South Africa.

1.8.5 Chapter 5: Estimation Results.

Provides a detailed description of the construction of the DSGE model, the Bayesian approach is explained and gives outlines of the collection, processing and transformation of data in the study. Presents a detailed interpretation of the estimation results from the DSGE model and Bayesian estimation of parameters. Analysing the impact of terms of trade on the South African economy through impulse response functions

1.8.6 Chapter 6: Conclusion and Recommendations.

This chapter summaries the key results and findings from the estimation and discusses the implications of understanding the impact of terms-of-trade shocks on the South African economy. It further suggests policy recommendations and areas for future research. The main objective of the study is to advance the understanding of terms-of-trade shocks in the South African economy by extending the methodology approach, Bayesian DSGE model. The research aims to provide an enhanced, quantitative analysis of the impact of terms-of-trade shocks, tracing their effects on macroeconomic variables through identified transmission channels to inform more effective stabilization policy.

The research contributes to both academic and policy-making knowledge, the model thus offers a robust framework for understanding the transmission channels of the terms of trade shocks with the potential implications for the monetary policy, fiscal planning and trade relations. The focus of the study is on the Small Open Economy (SOE) such as South Africa, provides vital information on the dynamics and vulnerability of commodity exports dependent economies. By employing advanced econometrics and covering the comprehensive study period. The study thus provides critical insights into the dynamic relationship between terms of trade shocks and macroeconomic variable performances. The findings of the study therefor inform on policy-making and trade relations and provides an enhanced tool for anticipating expected shocks and mitigating the unexpected

shocks of international trading market fluctuations.

The following chapters of the study are as follows; Chapter 2 investigates the literature review including the theoretical frameworks and empirical works.

Chapter 2

Literature Review

The impact of terms of trade shocks on the South African economy has been the subject of extensive research, particularly given the country's significant dependence on the export of minerals and agricultural products. South Africa's commodity export structure makes it especially vulnerable to fluctuations in global commodity prices, with terms of trade shocks transmitting through trade balances, exchange rates, and inflation in ways that create sustained macroeconomic adjustment pressures. Cashin et al. (2004), establish that for commodity-dependent economies, movements in the net barter terms of trade are among the primary determinants of macroeconomic performance, generating output fluctuations that are both larger and more persistent than those experienced by diversified economies. For South Africa specifically, Leshoro (2023), finds that terms of trade fluctuations are significantly larger than those experienced by developed economies, reflecting the economy's deep exposure to global commodity price cycle.
This chapter reviews the theoretical frameworks and empirical literature that inform the study. Section 2.1 presents the theoretical foundations the Harberger-Laursen-Metzler effect and the Prebisch-Singer hypothesis that explain the mechanisms through which terms of trade shocks affect small open economies. Section 2.2 reviews the empirical evidence on terms of trade shocks across developing and emerging market economies, with particular focus on South Africa. Section 2.3 reviews how DSGE models have been applied to study terms of trade dynamics in small open economies, assessing what prior studies have found and where gaps remain. Section 2.4 reviews the application of Bayesian estimation techniques in this literature, summarising what these methods have revealed about terms of trade transmission. Section 2.5 situates South Africa within this broader literature through sectoral and comparative analysis.

2.1 Theoretical Foundations

2.1.1 Harberger-Laursen-Metzler (HLM)

Theoretical frameworks explaining the impact of terms of trade shocks on small open economies highlight several key mechanisms. The Harberger-Laursen-Metzler (HLM) effects posits that changes in terms of trade can significantly influence real income and consumption patterns, as higher export prices can lead to increased domestic consumption and investment (Barattieri et al., 2021). This effect is particularly relevant for South Africa, where commodity exports play a crucial role in the economy. The HLM hypothesis suggests that an improvement in the terms of trade can lead to higher real income, which

in turn can stimulate consumption and investment, thereby enhancing economic growth and performance Barattieri et al. (2021); Adler and Osorio Buitron (2020). Conversely, a deterioration in the terms of trade can have adverse effects on income and consumption, leading to economic contraction.

2.1.2 Prebisch-Singer Hypothesis

The Prebisch-Singer Hypothesis posits that the terms of trade for primary commodities tend to decline over time relative to manufactured goods. This hypothesis emerged in the mid-20th century when developing countries, heavily reliant on commodity exports, faced declining prices for their goods while the prices of manufactured imports rose. The Prebisch-Singer hypothesis suggests that developing countries face a long-term decline in their terms of trade due to the lower price elasticity of demand for primary commodities compared to manufactured goods. This theory emerged in the context of the post-war period, with Raúl Prebisch and Hans Singer highlighting the structural imbalances in the global economy. They argued that while developed countries benefit from industrialisation, developing nations are often left with deteriorating terms of trade.
The historical context of this theory is rooted in the economic realities of developing nations that emerged from colonial rule. Many of these countries found themselves in a position where their economies were structured around the export of raw materials, making them vulnerable to fluctuations in global commodity prices. The Prebish-Singer hypothesis highlights the structural inequalities in the global trading system, where developing countries are often at a disadvantage.

The Prebish-Singer hypothesis further posits that the terms of trade for developing countries tend to deteriorate over time, leading to a long-term decline in their economic welfare (Ejaz and Azam, 2024). This hypothesis underscores the vulnerability of South Africa's economy to external price shocks, as it relies heavily on commodity exports that may face declining prices in the global market. The Prebish-Singer hypothesis argues that the prices of primary commodities tend to decline relative to the prices of manufactured goods, which can lead to a persistent decline in the economic welfare of commodity-exporting countries (Prebisch, 1962; Singer, 1975). This theory is particularly pertinent for South Africa, where fluctuations in commodity prices can have significant implications for economic stability. Transmission mechanisms through which terms of trade shocks influence macroeconomic variables include changes in the trade balance, exchange rates, and inflation rates.
For instance, a positive terms of trade shock can improve the trade balance, leading to currency appreciation, which may subsequently affect inflation and output (Hassan and Zhang, 2021). Recent studies emphasize the role of monetary policy in mitigating the effects of terms of trade shocks in emerging market economies, highlighting the need for responsive policy frameworks (Malefane, 2020). DSGE models are instrumental in capturing these theoretical relationships, as they allow for the integration of various economic agents and their interactions over time, providing a comprehensive framework for analysing the effects of terms of trade shocks (Qiu et al., 2024).

2.2 Empirical Studies

Empirical studies on the effects of terms of trade shocks have shown varied results across different countries and contexts. For instance, Cashin et al. (2004) found that terms of trade shocks in Africa can be either short-lived or persistent, with significant implications for economic growth. Other studies have employed DSGE models to estimate the impact of terms of trade shocks, revealing that these shocks account for a substantial portion of output volatility in developing countries (Wolf, 2020). Tillmann (2020), utilising Bayesian estimation techniques has also been prominent in this field, applied Bayesian vector autoregression to analyse business cycles in low-income countries, including South Africa, highlighting the importance of terms of trade shocks in explaining economic fluctuations. These studies typically utilise macroeconomic data, including GDP, inflation rates, and trade balances, to assess the impact of terms of trade shocks on economic performance (Beirne and Renzhi, 2024).
Further empirical research has shown that the effects of terms of trade shocks can vary significantly based on the specific economic context of a country. Schmitt-Grohé and Uribe (2018) argue that while terms of trade shocks are often considered a major source of business cycles in emerging economies, their empirical significance may be overstated. Their analysis of structural vector autoregression (SVAR) models indicates that terms of trade shocks explain less than 10 percent of movements in aggregate activity in many countries . This finding suggests that while terms of trade shocks are important, they may not be the sole or even primary drivers of economic fluctuations, highlighting the need for a more nuanced understanding of the factors influencing economic performance in South Africa.

A growing body of empirical literature has examined the effects of terms of trade shocks on macroeconomic variables in South Africa and other emerging economies. Cashin et al. (2004), highlight that movements in the net barter terms of trade are key determinants of macroeconomic performance, particularly for commodity-exporting countries. Their findings indicate a strong correlation between terms of trade fluctuations and output variations, emphasizing the importance of these shocks in shaping economic trajectories. Moreover,Hollander and van Lill (2018) contribute a systematic evaluation of DSGE model specifications for the South African economy, finding that both parameter estimates and model dynamics are highly sensitive to model specification — particularly the inclusion or exclusion of financial frictions and open economy features. Their variance decomposition reveals that demand-side shocks dominate output fluctuations in the short run, while supply-side shocks become more important at medium to long horizons. Crucially, their open economy specification treats the terms of trade as a derived relative price rather than an independently identified structural shock, meaning their results cannot isolate the specific contribution of commodity price movements to South African business cycle dynamics.
According to Leshoro (2023), further investigates the significance of terms of trade shock in South Africa, employing impulse response functions to analyze the effects of export price volatility on domestic economic indicators. The study finds that South Africa's heavy reliance on commodity exports results in terms of trade fluctuations that are significantly larger than those experienced by developed economies, underscoring the vulnerability of the South African economy to external shocks.

2.3 DSGE Modeling of Small Open Economies

DSGE models have become the dominant framework for analysing terms of trade shocks in small open economies, and a substantial body of literature has applied these models to commodity-dependent emerging markets. The evidence from this literature establishes several consistent findings that provide the benchmark against which the results of the present study are evaluated.

Further, Gali and Monacelli (2005) develop the foundational small open economy New-Keynesian DSGE framework that underpins the present study. Their model demonstrates that in a small open economy, the degree of openness captured by the import share parameter α shapes both the slope of the New-Keynesian Phillips curve and the sensitivity of the output gap to external shocks. Their framework establishes that terms of trade movements affect domestic inflation through the consumption price index wedge, and that the exchange rate serves as a key adjustment mechanism absorbing external price disturbances. This framework has since been applied and extended extensively in the South African context.

For the South African economy, Steinbach et al. (2009) estimate an open economy New-Keynesian DSGE model using Bayesian techniques on quarterly data from 1990Q1 to 2007Q4, finding that external shocks including terms of trade movements play a secondary role in short-run output variance but become increasingly important at medium to long horizons. Their estimates of key structural parameters including price stickiness, monetary policy weights, and interest rate smoothing provide a direct benchmark for the parameter estimates reported in the present study. du Plessis et al. (2014), extend this work to a medium-sized open economy specification, confirming the SARB's strong anti-inflation bias and finding that the transmission of external shocks through the exchange rate channel is subject to significant persistence due to incomplete pass-through.

Kose (2002), applies a DSGE framework to a panel of small open economies and finds that world price shocks including terms of trade which accounts for 88 percent of the total output changes in emerging markets. Cashin et al. (2004), corroborate this finding for commodity-exporting economies specifically, documenting that terms of trade shocks generate output responses that are both large and persistent, lasting between four and eight quarters following the initial shock. Schmitt-Grohé and Uribe (2018), however, provide a more conservative estimate arguing that in many emerging market economies, terms of trade shocks explain less than 10 percent of aggregate output variance when identified through structural VAR methods rather than DSGE frameworks. This divergence between structural VAR and DSGE-based estimates of terms of trade importance motivates the Bayesian DSGE approach adopted in the present study, which allows for explicit identification of the terms of trade shock as a structural component with its own persistence and transmission channels.

The literature collectively establishes that the choice of model specification particularly whether terms of trade is modelled as an independently identified structural shock or as a derived relative price has a decisive effect on how much explanatory power is attributed to external commodity price movements. Hollander and van Lill (2018), make this point explicitly in the South African context, showing that the inclusion of alternative shock specifications substantially changes the variance decomposition results. The present study addresses this specification sensitivity directly by introducing the terms of trade as an explicitly identified AR(1) structural shock with Bayesian-estimated persistence and volatility parameters.

2.4 Bayesian Estimation of DSGE Models

Macroeconomists often favour Bayesian methods over classical ones when estimating dynamic stochastic general equilibrium (DSGE) models. This preference stems from the expanding toolkit of Bayesian techniques available for DSGE model estimation and evaluation, coupled with the growing computational power that makes Markov chain Monte Carlo (MCMC) simulation of these models feasible. Furthermore, Bayesian methods are better suited to handle the identification problems that frequently arise with these models, problems that traditional methods, regardless of data or computing power, struggle to resolve. The Bayesian framework is attractive because DSGE models are often considered simplifications of real-world economies. Bayesian estimation methods, such as the Metropolis-Hastings algorithm, provide a flexible framework for estimating DSGE models, particularly in the presence of parameter uncertainty (Georgiadis and Mösle, 2020). This approach contrasts with maximum likelihood estimation, which may not adequately capture the complexities of economic data in small open economies. Bayesian techniques allow for the incorporation of prior information, leading to more robust estimates of the model parameters. Previous applications of Bayesian DSGE estimation in studying terms of trade shocks have demonstrated their effectiveness in capturing the dynamic responses of macroeconomic variables to these shocks.

For instance, studies have shown that Bayesian methods can provide more accurate forecasts and insights into the transmission mechanisms of terms of trade shocks compared to traditional estimation techniques. This is particularly important for South Africa, where the high volatility of commodity prices necessitates a nuanced understanding of the potential impacts of terms of trade shocks on economic performance. Moreover, the application of Bayesian estimation techniques has facilitated the exploration of various policy responses to terms of trade shocks, allowing researchers to assess the effectiveness of different monetary and fiscal policies in mitigating the adverse effects of these shocks. This has important implications for policymakers, as it provides a framework for evaluating the potential trade-offs associated with different policy interventions in the context of terms of trade shocks. This study employs a Bayesian estimation approach for the DSGE model, which is distinguished by three principal features. First, unlike generalized method of moments (GMM) estimation, which relies on specific equilibrium conditions—such as the consumption Euler equation, the price-setting equation of intermediate goods producers, or the monetary policy rule. Bayesian estimation adopts a system-based approach. It fits the fully solved DSGE model directly to a vector of aggregate time series.

Second, estimation is grounded in the likelihood function generated by the DSGE model itself, rather than relying on external benchmarks such as the discrepancy between DSGE-model impulse responses and those from a vector autoregression (VAR).

Third, the Bayesian framework permits the formal incorporation of prior information through prior distributions, thereby enriching parameter estimation with insights not contained in the sample data. All estimation and evaluation methods face certain challenges, including potential model miss-specification and the possible under-identification of key parameters. These challenges are elaborated below, alongside a discussion of how the Bayesian approach helps address them.

Once it is acknowledged that a DSGE model is only an approximation of the true data-generating process, it becomes reasonable to accept that no single parameter vector can simultaneously recover the "true" structural parameters—such as the intertemporal elasticity of substitution or price-adjustment costs—and produce the most accurate impulse

responses to various shocks.
Different estimation methods are distinguished by how they measure the discrepancy between the true data-generating process and the approximating model. For example, likelihood-based estimators asymptotically minimise the Kullback–Leibler distance (see White, 1982). Maximum likelihood estimation (MLE) alone has not become the standard in DSGE analysis partly due to the "dilemma of absurd parameter estimates"—where estimates based solely on sample data often conflict with well-established empirical or theoretical knowledge.

In the Bayesian framework, this tension is resolved by reweighing the likelihood function using a prior density. The prior formally incorporates information external to the estimation sample, allowing the model to reconcile data-based evidence with pre-existing economic knowledge. If the likelihood function peaks at a value that is at odds with the information that has been used to construct the prior distribution, then the marginal data density of the DSGE model, defined as p(Y) = (— Y)p()d, (40) will be low compared to, say, a VAR, and in a posterior odds comparison the DSGE model will automatically be penalized for not being able to reconcile the two sources of information with a single set of parameters.
The methodologies employed in analyzing terms of trade shocks have evolved, with a notable shift towards the use of Dynamic Stochastic General Equilibrium (DSGE) models and Bayesian estimation techniques. Fernández-Villaverde and Guerrón-Quintana (2021); Oladunni (2020) provides a comprehensive overview of Bayesian methods for estimating DSGE models, which have become increasingly popular in macroeconomic research due to their ability to incorporate prior information and handle model uncertainty effectively. Kabundi and Loots (2010) have utilized structural vector autoregression (SVAR) models to assess the co-movement between South Africa and other economies, revealing important insights into the transmission of terms of trade shocks across borders. Additionally, the application of global VAR models, as demonstrated by Çakır and Kabundi (2013), allows for a nuanced understanding of South Africa's trade linkages with BRICS countries, further elucidating the impact of T terms of trade hocks on the domestic economy.

2.5 The South African Context

South Africa, as a small open economy, is significantly influenced by both external and internal factors that affect its terms of trade. The country's reliance on commodity exports makes it particularly vulnerable to fluctuations in global prices, which can lead to substantial changes in its trade balance and overall economic performance (Schmitt-Grohé and Uribe, 2018). The volatility of terms of trade is critical for South Africa, as it can impact inflation, investment, and consumption patterns, ultimately affecting economic growth.Prior research using DSGE models to study trade shocks in South Africa has highlighted the importance of capturing both external and internal effects on the terms of trade ratio (Schmitt-Grohé and Uribe, 2018).

For instance, studies have shown that terms of trade shocks can lead to significant adjustments in macroeconomic variables, emphasizing the need for comprehensive modeling approaches to understand these dynamics (Taiwo et al., 2023). Furthermore, the unique characteristics of the South African economy, including its structural challenges and socio-

economic disparities, necessitate a tailored approach to analysing the impacts of terms of trade shocks. In recent years, there has been a growing recognition of the need for South Africa to diversify its economy and reduce its dependence on commodity exports. This is particularly important in light of the potential long-term decline in the terms of trade for developing countries, as suggested by the Prebish-Singer hypothesis. By exploring alternative sectors such as technology and renewable energy, South Africa can enhance its economic resilience and reduce its vulnerability to external shocks.

2.5.1 Sectoral Impact Analysis

Mining Sector

The mining sector is particularly vulnerable to global commodity price fluctuations. For example, during the global commodity price boom from 2002 to 2008, South Africa's mining output increased dramatically, driven by high demand for gold and platinum. However, post-2008, declining prices led to significant job losses and decreased investment in mining operations. Moolman et al. (2023) indicated that regulatory challenges and global market conditions continue to threaten the sustainability of this critical sector. Furthermore, the decline in global commodity prices in 2015 led to significant job losses and mine closures, particularly in the platinum and gold sectors. Case studies, such as the impact of the Lonmin-mine, illustrate how price fluctuations can lead to economic instability in mining-dependent communities. The mining sector's reliance on global demand makes it particularly vulnerable to international market dynamics.

Agriculture

The agricultural sector's sensitivity to terms of trade shocks has been highlighted through various case studies. During the 2008 financial crisis, South African farmers faced reduced global demand for citrus and wine products, resulting in lower prices and profitability (Phetla, 2017). van Zyl et al. (2021) emphasised the importance of adaptive strategies, such as crop diversification and investment in technology, to enhance resilience against future shocks. Moreover, a case study of the Western Cape province showed that adverse terms of trade shocks led to reduced profitability for farmers, impacting employment and rural livelihoods. The agricultural sector's exposure to global price fluctuations can create instability for smallholder farmers who lack the resources to adapting to changing market conditions.

Manufacturing

The manufacturing sector faces challenges from terms of trade shocks, particularly when raw material prices rise. For example, the steel industry in South Africa has been affected by rising iron ore prices, leading to increased production costs and reduced competitiveness in global markets. The manufacturing sector's reliance on imported raw materials makes it susceptible to fluctuations in global commodity prices, which can impact overall economic growth (Fedderke and Naumann, 2011). Fedderke and Naumann (2011) showed that adverse terms of trade shocks could lead to decreased competitiveness for local manufacturers. Additionally, Khan et al. (2022) highlighted how increased energy costs exacerbated by terms of trade shocks have constrained production capabilities and growth within this sector.

2.5.2 Comparative Analysis

A comparative analysis reveals parallels between South Africa's experiences with terms of trade shocks and those of other emerging economies such as Brazil and Nigeria, reveals several insights:

Economic Structure: Like South Africa, both Brazil and Nigeria are heavily reliant on commodity exports, making them vulnerable to price fluctuations. However, Brazil's more diversified economy has allowed it to better absorb shocks. This highlights the importance of economic diversification for resilience.

Policy Responses: Brazil's proactive approach to diversifying its economy through investment in technology and infrastructure contrasts with South Africa's slower response. Lessons from Brazil's experience could inform South Africa's policy strategies, particularly in fostering innovation and supporting emerging industries.

Social Safety Nets: Nigeria's implementation of social safety nets during economic downturns provides a model for South Africa to enhance its support systems for vulnerable populations. Strengthening social safety nets can help mitigate the impacts of terms of trade shocks on low-income households.

Mexico: Mexico's vulnerability to oil price fluctuations mirrors South Africa's experience with commodity dependency. Studies indicate that both countries exhibit similar characteristics regarding reliance on specific commodities for export revenues Lessons learned from Mexico's diversification strategies could inform South Africa's approach to managing its economic vulnerabilities.

Argentina: Argentina's agricultural sector has faced significant challenges due to fluctuations in global food prices. Comparative studies reveal that Argentina's responses such as implementing export taxes on grains have aimed to stabilize domestic markets during periods of volatility South Africa might benefit from exploring similar policy frameworks tailored to its unique economic context.

Understanding the complexities of terms of trade shocks and their implications for South Africa requires a multifaceted approach that considers theoretical frameworks, empirical evidence, sectoral impacts, policy responses, and comparative analyses with other emerging economies. By leveraging insights from these areas, South Africa can develop more effective strategies to navigate the challenges posed by global economic fluctuations.

Chapter 3

Small Open Economic Model

The model follows the work of Gali and Monacelli (2005). In this section, the study will model the global economy as a continuity of small open economies (SOE) captured by a representative unit. The study is aware and recognizes that different economies are impacted by productivity shocks that are usually imperfectly correlated. The study then infers that the shock is identical to technological and market structure shocks.

The study furthers its investigation into the model by detailing the challenges occurring in these types of economies, focusing on households and firms. To simplify the model for the study, we make a note of the notion specified in the model. The study focuses on a single small economy and its relation to the global economy. The following notion will be used; variables ***without*** an i-index relate to the SOE modeled. Variables with an $i \epsilon$ [0,1] subscripts refers to the economy i, a single economy among the continuum of composed economies. In the concluding with the notation, variables with a *star superscript* (*) relate to the global economy, Gali and Monacelli (2005).

3.0.1 Households

A small open economy is comprised of a unit representative household seeking to maximize the following utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \, U(C_t, N_t) \tag{3.1}$$

Where N_t addresses the hours of labour, and C_t is an amalgamation of the consumption index as defined by;

$$C_t \equiv [(1-\alpha)^{\frac{1}{\eta}} (C_{H,t})^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} (C_{F,t})^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} \tag{3.2}$$

Where $C_{H,t}$ is the index of consumption of domestic goods and is hence determined by the CES function

$$C_{H,t} \equiv (\int_0^1 C_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj)^{\frac{\epsilon}{\epsilon-1}}$$

where $j \epsilon$ [0, 1] denotes the variety of goods. $C_{F,t}$ refers to the imported goods index

$$C_{F,t} \equiv (\int_0^1 (C_{i,t})^{\frac{\gamma-1}{\gamma}} di)^{\frac{\gamma}{\gamma-1}}$$

the index of quantity of good imported from the country i and consumed by the households in the domestic country is referenced by $c_{i,t}$ and thus given by an analogous CES functions:

$$C_{i,t} \equiv (\int_0^1 C_{i,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj)^{\frac{\epsilon}{\epsilon-1}}$$

As can be seen in the equations above ϵ is greater than 1 and thus shows the substitution between varieties (goods produced within any economy). Parameter $\alpha \in [0,1]$ is referred to as the degree of home preference bias, making it a an index for trade openness. η is greater than 0, measuring the domestic and foreign good sustainability from the perspective of the consumer in the domestic country. γ looks at the sustainability difference of foreign produced goods.

Equation (1) is subject to a budget constraint in the following form;

$$\int_0^1 P_{H,t}(j)C_{H,t}(j)dj + \int_0^1 \int_0^1 P_{i,t}(j)C_{i,t}(j)djdi + E_t\{Q_{t,t+1}D_{t+1}\} \leq D_t + W_tN_t + T_t \quad (3.3)$$

Where t=0, 1, 2,..., $P_{i,t}$ being the price of variety j, goods imported from country i ad expressed in the domestic currency (Rand), *i.e.* (using the currency of the South Africa economy being modeled). A portfolio held at the end of t period(including firm shares) receives a nominal payment in the t *+1* period denoted by D_{t+1}. W_t and T_t denote the nominal wage and lump-sum taxes. All the above stated variables are noted in the domestic currency. The stochastic discount factor is expressed $Q_{t,t+1}$, for a one-period preceding the nominal payments concerning the domestic household. The study assumes that the households of the domestic country have complete access to contingent claims, which are internationally traded. The model does not have money appearing in equations (1) and (2). Therefore, monetary policy will be specified and referred to an interest rate rule; thus the study does not explicitly inform to money in the model.

Arising from the efficient distribution of the any given expenditure ranging between different groups of goods, results in the following demand functions;

$$C_{H,t}(j) = (\frac{P_{H,t}(j)}{P_{H,t}})^{-\varepsilon} C_{H,t}; \quad C_{i,t}(j) = (\frac{P_{i,t}(j)}{P_{i,t}})^{-\varepsilon} C_{i,t} \quad (3.4)$$

The domestic price index(*i.e. domestically produced goods*) are represented by $P_{H,t} \equiv (\int_0^1 P_{H,t}(j)^{1-\varepsilon} dj)^{\frac{1}{1-\varepsilon}}$ for all $i,j \in [0,1]$, and $P_{i,t} \equiv (\int_0^1 P_{i,t}(j)^{1-\varepsilon} dj)^{\frac{1}{1-\varepsilon}}$ being the index price for imported goods from i country. Prices indexes are expressed in the currency of the domestic country. Following equation (4), thus $\int_0^1 P_{H,t}(j)\, C_{H,t}(j)dj = P_{H,t}C_{H,t} and \int_0^1 P_{i,t}(j)\, C_{i,t}(j)dj = P_{i,t}C_{i,t}$

Moreover, the model suggests the efficient allocation of expenditures on imported good are based in their country of origin

$$C_{i,t} = (\frac{P_{i,t}}{P_{F,t}})^{-\gamma} C_{F,t} \quad (3.5)$$

$P_{F,t} \equiv (\int_0^1 P_{i,t}(j)^{1-\gamma} di)^{\frac{1}{1-\gamma}}$ for all $i\epsilon$ [0,1] refers to the imported goods price index; expressed in the domestic currency. Further referencing to equation (5), it suggests that total expenditures can be written as $\int_0^1 P_{i,t}\, C_{i,t} di = P_{F,t}\, C_{F,t}$
Thus giving the optimal expenditure allocation between domestic and imported good;

$$C_{H,t} = (1-\alpha)(\frac{P_{H,t}}{P_t})^{-\eta} C_t; \quad C_{F,t} = \alpha(\frac{P_{F,t}}{P_t})^{-\eta} C_t \tag{3.6}$$

Where the consumer price index (CPI), is represented by $P_t \equiv [(1-\alpha)(P_{H,t})^{1-\eta} + \alpha(P_{F,t})^{1-\eta}]^{\frac{1}{1-\eta}}$ In this case the study takes notice that when the domestic and imported good price indexes are equal, it represents that the α parameter is corresponding to the share of imported good domestically consumed. It therefore also makes its worth mentioning that α represents the natural openness index.
The stud can therefore infer that total consumption expenditures are thus given by $P_{H,t}\, C_{H,t} + P_{F,t}\, C_{F,t} = P_t\, C_t$. Stating further the budget constraint that represented in the period.

$$P_t\, C_t = E_t\{Q_{t,t+1} D_{t+1}\} \leq D_t + W_t N_t + T_t \tag{3.7}$$

The period utility function takes the following form;

$$U(C,N) \equiv \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi}$$

The optimal household's problem conditions can be re-written as follows:

$$C_t^{\sigma}\, N_t^{\varphi} = \frac{W_t}{P_t} \tag{3.8}$$

Therefore resulting in the intra-temporal optimal condition;

$$\beta\, (\frac{C_{t+1}}{C_t})^{-\sigma} \frac{P_t}{P_{t+1}} = Q_{t,t+1} \tag{3.9}$$

To obtain the stochastic Euler equation, the study took into consideration the conditional expectations of both side of equation (9):

$$\beta\, R_t E_t \left\{ (\frac{C_{t+1}}{C_t})^{-\sigma} \frac{P_t}{P_{t+1}} \right\} = 1 \tag{3.10}$$

Going forth in the study, the study also takes note that equation (8) and (10) can be re-written into their log-linearised forms:

$$w_t - p_t = \sigma\, c_t + \varphi\, n_t$$

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1} - \rho) \tag{3.11}$$

The log of the respective variables is denoted by the lower case letters, where $\rho \equiv \beta^{-1} - 1$ represents the period discount rate and CPI inflation $\pi \equiv p_t - p_{t-1}, (with\, p_t \equiv\ log\, p_t)$

Domestic inflation, CPI inflation, the real broad exchange rate and the terms of trade: identities.

The study starts this section of the model by introducing assumptions, definitions and deriving identities that are used in the following equations, before continuing with analysis of the equilibrium.
Gali and Monacelli (2005), define *bilateral terms of trade* among domestic country and economy i as $S_{i,t} = \frac{P_i, t}{P_{H,t}}$, *i.e.* indicating the price of goods of country i in relation to domestic goods. Thus, the *effective terms of trade* can be expressed as follows;

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}} = (\int_0^1 S_{i,t}^{1-\gamma} di)^{\frac{1}{1-\gamma}}$$

The above equation can be approximated to the first order with the following lag-linear impression;

$$S_t \ = \ \int_0^1 s_{i,t} di \tag{3.12}$$

In order to satisfy the purchasing power parity (PPP) order $P_{H,t} = P_{F,t}$ the model log-linearised CPI formula around the symmetric steady state, therefore giving us the following expression;

$$P_t \equiv (1-\alpha) P_{H,t} + \alpha P_{F,t} = P_{H,t} + \alpha S_t \tag{3.13}$$

The *effective terms of trade,i.e the relative price of imported goods to the terms of goods produced domestically*, is denoted by $S_t \equiv P_{F,t} - P_{H,t}$. It is imperative to note that equations (12) and (13), are possible when the respectively the values of $\gamma = 1$ and $\eta = 1$ are held. Gali and Monacelli (2005) *define domestic inflation as the rate of change on the index of good prices produced domestically, i.e.* $\pi_{H,t} \equiv P_{H,t} - P_{H,t-1}$ and therefore the Consumer Price Index *(CPI inflation)* are linked to

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \tag{3.14}$$

Equation (14) thus expresses that the two measures of inflation mentioned above to the percentage change in terms of trade, are measured and indexed by αas trade openness. Therefore, the model assumes that the *law of one price* holds for all individual goods at all time periods (this is for all prices; imported and exported). Thus stating $P_{i,t}(j) = \varepsilon i, t \, P_{i,t}^i(j)$ for all $i.j \, \epsilon$ [0,1], where the bilateral nominal exchange rates $\varepsilon_{i,t}$ and the price of the country's i good and j expressed in the producer's currency. The model therefore plugs the above mentioned assumptions in to the $P_{i,t}$ and thus obtains that $P_{i,t} = \varepsilon_{i,t} P_{i,t}^i$ indicating that $P_{i,t}^i \equiv (\int_0^1 P_{i,t}^i(j)^{1-\varepsilon} dj)^{\frac{1}{1-\varepsilon}}$ Therefore the obtained definition for the terms of trade is given by the following equation;

$$S_t = e_t + P_t^\star - P_{H,t} \tag{3.15}$$

International risk sharing.

Assuming that there is a complete securities market, the first order condition is therefore related to equation (9) should hold in order for the representative household in no specific country, for instance we look at the representative household for country i;

$$\beta\,(\frac{C^i_{t+1}}{C^i_t})^{-\sigma}\,(\frac{P^i_t}{P^i_{t+1}})(\frac{\varepsilon^i_t}{\varepsilon^i_{t+1}})\;=Q_{t,t+1} \tag{3.16}$$

Therefore as we incorporate equations (9) and (16), together with the definition for the real exchange rate, it allows for the following expression;

$$C_t=\vartheta_t C^i_t Q^{\frac{1}{\sigma}}_{i,t} \tag{3.17}$$

In order to obtain the simplified relationship that links the domestics with world consumption and the terms of trade, we take the logs of both sides of equation (17) and integrate them over i and obtain;

$$\begin{aligned} c_t &= c^\star_t+\frac{1}{\sigma}q_t \\ &= c^\star_t+\frac{1-\alpha}{\sigma}s_t \end{aligned} \tag{3.18}$$

Where $c^\star_t\equiv\int^1_0 c^i_t di$ indicates the world consumption (in log) and the second equality only holds up to the first order approximation where η does not equal 1.

Uncovered interest parity and the terms of trade.

Taking into consideration the complete international financial markets assumptions, the price at equilibrium in domestic currency of a bond dominated by the foreign currency is given by $\varepsilon_{i,t}(R_{i,t})^{-1}=E_tQ_{t,t+1}\varepsilon_{i,t+1}$. In order to obtain the *uncovered interest parity* condition. The previous pricing equation can be incorporated with the domestic bond price equation, $(R_t)^{-1}=E_tQ_{t,t+1}$. Thus giving us the following condition

$$E_t\{Q_{t,t+1}[R_t-R^i_t(\varepsilon_{i,t+1}/\varepsilon_{i,t})]\}=0$$

Log-linearising around the steady state, and aggregating around i, gives us equation (19),

$$r_t-r^*_t=E_t\{\triangle e_{t+1}\} \tag{3.19}$$

Incorporating the log definition of terms of trade with the above equation gives us the following stochastic difference equation;

$$s_t=(r^*_t-E_t\{\pi^*_{t+1}\}-(r_t-E_t\{\pi_{H,t+1}\})+E_ts_{t+1} \tag{3.20}$$

In the model we hold a number of assumptions as true, first te assumption of stationarity as one of the models driving forces and the required assumption to have the PPP hold at the steady state, we can therefore solve equation (20) and thus obtain;

$$s_t=E_t\{\Sigma^\infty_{k=0}[(r^\star_{t+k}-\pi^\star_{t+k_1})-(r_{t+k}-\pi_{H,t+k+1})]\} \tag{3.21}$$

3.0.2 Firms

Technology.

Within the domestic economy, the average firm engages in the production of differentiated goods with linear technology and categorized by the production function:

$$Y_t(j) = A_t\, N_t(j)$$

The firm specific index is represented by $a_t = p_a\, a_{t-1} + \varepsilon_t$,which follows an AR(1) process where $a_t \equiv logA_t$. Therefore giving us a common marginal cost across all domestic firms as follows;

$$m_{ct} = -\nu + w_t - p_{H,t} - a_t$$

$\nu \equiv -\log(1-\tau)$, where τ is the subsidy for employment and its role will be discussed later in greater detail.

Let $Y_t \equiv [\int_0^1 Y_t(j)^{1-\frac{1}{\varepsilon}} dj]^{\frac{\varepsilon}{\varepsilon-1}}$ represents an aggregate domestic output index, comparable to earlier found index for consumption. This function will be utilized in the later sections as a reference, in order to derive the exact aggregate production function connected to the aggregate employment index. The study thus takes note of the following.

$$N_t \equiv \int_0^1 N_t(j)\, dj = \frac{Y_t\, Z_t}{A_t}$$

Equation (22) thus gives us an aggregate relationship, up to a first order approximation.

$$y_t = a_t + n_t \tag{3.22}$$

Price-setting

The model adopts the assumption from Calvo (1983) stating that firms adjust their prices in a staggered manner. As a result, every period, a fraction of firms expressed by $1-\theta$ are selected at random by themselves to set new prices. It is thus noteworthy to state that an individual firms likelihood to re-optimize their prices at a time period remains independent to the time elapsed since its last price reset. The detailed optimal price setting strategy for a typical firm resetting its price in time period t will be demonstrate that this strategy is effectively approximated by the log-linear rule.

$$\overline{p}_{H,t} = \mu + (1-\beta\theta)\, \Sigma_{k=0}^{\infty}\, (\beta\theta)^k E_t\, \{mc_{t+k} + P_{H,t}\} \tag{3.23}$$

Where, $\overline{p}_{H,t}$ is the log of the domestic prices that are newly set, and $\mu \equiv log(\frac{\varepsilon}{\varepsilon-1})$ providing the log of the gross mark-up in the steady state, this is also understood to be the optimal mark-up including flexible prices. The model is similar to a closed economy model, which has forward-looking price decisions. Understanding that firms adjust prices in a specific time period, aids to anticipate the effectiveness of price setting over a random number of future periods. Thus, rather than solely basing prices on current marginal costs, prices are determined as a mark-up over a weighted average of expected future marginal costs. Its also worth noting that the flexible price limit ($i.e$, $\theta \to 0$) and therefore we revert back to the familiar mark-up rule expressed as $\overline{p}_{H,t} = \mu + mc_t + P_{H,t}$

3.1 Equilibrium

3.1.1 Aggregate demand and output determination

Consumption and output in the small open economy

In order to have a good clearing market in the small open economy, the representative household necessitates the following;

$$\begin{aligned} Y_t(j) &= C_{H,t}(j) + \int_0^1 C^i_{H,t}(j)di \,\mathrm{d}i \\ &= [\left(\frac{P_{H,t}(j)}{P_{H,t}}^{-\varepsilon} [(1-\alpha)(\frac{P_{H,t}}{P_t})^{-\eta} C_t + \alpha \int_0^1 (\frac{P_{H,t}}{\varepsilon_{i,t} P^i_{F,t}})^{-\gamma} (\frac{P^i_{F,t}}{P^i_t})^{-\eta} C^i_t di \right] \end{aligned} \tag{3.24}$$

It is important to take note that the second equality has made use of the equations (5) and (6), alongside the assumption of symmetric preferences across countries, therefore implying that $C^i_{H,t}(j) = \alpha(\frac{P_{H,t}(j)}{P_{H,t}})^{-\varepsilon}(\frac{P_{H,t}}{\varepsilon_{i,t}P^i F,t})^{-\gamma}(\frac{P^i_{F,t}}{P^i_t})^{-\eta} C^i_t$
Therefore inserting equation (24) into the aggregate domestic output definition $Y_t = [\int_0^1 Y_t(j)^{1-\frac{1}{\varepsilon}} dj]^{\frac{\varepsilon}{\varepsilon-1}}$. We can therefore obtain the following equation;

$$Y_t = (1-\alpha)(\frac{P_{H,t}}{P_t})^{-\eta} C_t + \alpha \int_0^1 (\frac{P_{H,t}}{\varepsilon_{i,t} P^i_{F,t}})^{-\gamma} (\frac{P^i_{F,t}}{P^i_t})^{-\eta} C^i_t di \tag{3.25}$$

$$= (\frac{P_{H,t}}{P_t})^{-\eta} C_t [(1-\alpha) + \alpha \int_0^1 (S^i_t S_{i,t})^{\gamma-\eta} \varrho^{\eta-\frac{1}{\sigma}}_{i,t} di] \tag{3.26}$$

The above expressed equality is an observation from equation (17), where the effective terms of trade are denoted by S^i_t of the country$i$ and $S_{i,t}$ indicates the bilateral terms of trade between the domestic and foreign economy$i$. The models also considers the case of $\sigma = \eta = \gamma = 1$ therefore the above expressed equation (25), can be written as;

$$Y_t \ = C_t \, S^\alpha_t. \tag{3.27}$$

Deriving the first order approximation to equation (25) around the steady state, while taking note that $\int_0^1 S^i_t di = 0$. The model obtains the following;

$$y_t = c_t + \alpha\gamma s_t + \alpha(\eta - \frac{1}{\sigma} q_t) = c_t + \frac{\alpha\omega}{\sigma} s_t \tag{3.28}$$

therefore $\omega \equiv \sigma\gamma + (1-\alpha)(\sigma\eta - 1)$. Recalling that $\sigma = \eta = \gamma = 1$ also concludes that $\omega = 1$. The relating condition to the equation above, should hold for all countries. Therefore the *generic country i* expression can be written as,$y^i_t = c^i_t + \frac{\alpha\omega}{\sigma} s^i_t$. Thus the world market clearing can be derived by aggregating all the country and therefore arriving at the following condition

$$y^*_t \equiv \int_0^1 y^i_t di = \int_0^1 c^i_t di \equiv c^*_t \tag{3.29}$$

From the above equation we find that world output and consumption are indexed by $y^*_t and \ c^*_t$ in log. Thus with incorporating equation (27),(17) and (28); we find

$$y_t = y^*_t + \frac{1}{\sigma_\alpha} s_t \tag{3.30}$$

Where $\sigma_\alpha \equiv \frac{\sigma}{(1-\alpha)+\alpha\omega} > 0$ In conclusion, combining equations (11) the Euler equation and (27), the following can be found

$$y_t = E_t\{y_{t+1}\} - \frac{1}{\sigma}(r_t - E_t\{\pi_{t+1}\} - \rho) - \frac{\alpha\omega}{\sigma}E_t\{\triangle s_{t+1}\} \tag{3.31}$$

$$= E_t\{y_{t+1}\} - \frac{1}{\sigma_\alpha}(r_t - E_t\{\pi_{H,t+1}\} - \rho) + \alpha\Theta E_t\{\triangle y^*_{t+1}\} \tag{3.32}$$

Where $\Theta \equiv (\sigma\gamma - 1) + (1-\alpha)(\sigma\eta - 1) = \omega - 1$

Trade balance

The net exports in terms of the domestic output are denoted by the following expression, where $nx_t \equiv \frac{1}{Y}\left(Y_t - \frac{P_t}{C_t}P_{H,t}\right)$. Which is expressed as the output Y steady state. Recalling that $\sigma = \eta = \gamma = 1$ as it follows from equation (25) $P_{H,t}Y_t = P_tC_t$ for all t therefore it implies a balanced trade at all periods. With the first order approximation $nx_t = y_t - c_t - \alpha s_t$, when combining it with equation (27) it implies the following;

$$nx_t = \alpha(\frac{\omega}{\sigma} - 1)s_t \tag{3.33}$$

The sign relationship between the terms of trade and net exports is ambiguous, thus is it more generally dependent of the size relativity f $\sigma, \gamma and \eta$

3.1.2 The supply side: marginal cost and inflation dynamics

Marginal cost and inflation dynamics in the small open economy

The dynamics of domestic inflation in a small open economy in terms of the real marginal costs are represented by an equation that relates to one corresponding with a closed economy, therefore

$$\pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + \lambda\hat{mc}_t \tag{3.34}$$

$\lambda \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}$ Thus, marginal cost determination in la small open economy is different to that of a closed economy. Owing to the output and consumption wedge, and between the domestic and consumption prices wedge. Therefore in the model we have;

$$mc_t = -\nu + \sigma y^*_t + \varphi y_t + s_t - (1+\varphi)a_t \tag{3.35}$$

Equation (33), utilises equations (22) and (18). Therefore we see an increment in the marginal costs of terms of trade and world output. These variables influence real wage, with the wealth effect on labour supply and thus impacting domestic consumption. Terms of trade therefore has a direct effect on product wage at any given real wage. Technological influence (direct effect of labour productivity) and domestic output is related to what has been seen in the closed economy. Utilising equation (29), s_t can therefore be substituted and the expression can we re-written as the real marginal cost in terms of domestic output and productivity including world output:

$$mc_t = -\nu + (\sigma_\alpha + \varphi)y_t + (\sigma - \sigma_\alpha)y^*_t - (1+\varphi)a_t \tag{3.36}$$

Taking note of cases such as $\alpha = 0$ and $\sigma = \eta = \gamma = 1$ and thus implies that $\sigma = \sigma_\alpha$. Therefore concluding that the domestic real marginal cost is protected from foreign output fluctuations.

3.1.3 Equilibrium dynamics: a canonical representation

The section below demonstrates that small open economy log linearising equilibrium dynamics can be expressed in terms of output gap and domestic inflation therefore mirroring its counterpart representation the closed economy. This is referred to as the canonical, also provides the analysis basis and alternative policy rules evaluation in the much recent literature. The following main feature of a canonical; *(a)* the economy grows at a stochastic path, *(b)* wages and prices are assumed to be sticky, *(c)* consumption is displayed by the preferences that form habit, *(d)* investment into an economy is costly and lastly *(e)* within the model there are five exogenous shocks. Therefore these shocks are the firm's monopoly power, the work disutility, government expenditure and the Total factor productivity labour shock. All these shocks are stationary at AR(1), the final is a monetary policy shock included in a the Taylor rule.
We can therefore dine the output gap x_t as the log deviation of the domestic output y_t from its natural level $\bar{y}_t$, where it can be defined as the equilibrium level of output in the absence of normal rigidities (conditional on the world output y_t^*);

$$x_t \equiv y_t - \bar{y}_t.$$

The natural level of domestic output can be found after $mc_t = -\mu$ is imposed where for all t and thus solving the domestic output equation (34)

$$\bar{y}_t = \Omega + \Gamma a_t + \alpha \Psi y_t^* \tag{3.37}$$

For; $\Omega \equiv \frac{\nu-\mu}{\sigma_\alpha+\varphi}$, $\Gamma \equiv \frac{1+\varphi}{\sigma_\alpha+\varphi} > 0$, and $\Psi \equiv -\frac{\Theta\sigma_\alpha}{\sigma_\alpha+\varphi}$. Thus from equation (34) we can also ascertain that the real marginal cost of the domestic country and the output game are thus connected from the following expression;

$$\hat{mc}_t = (\sigma_\alpha + \varphi)x_t$$

In order to derive the New Keynesian Phillips curve (NKPC) for the small open economy in terms of the output gap, we combine the above shown expression with equation (32) and therefore obtain

$$\pi_{H,t} = \beta\, E_t\{\pi_{H,t+1}\} + \kappa_\alpha x_t \tag{3.38}$$

Where $\kappa_\alpha \equiv \lambda(\sigma_\alpha + \varphi)$. Importantly we can thus observe that the open economy Phillips curve therefore relates to that of the closed economy, with respects to the domestic inflation. The degree of openness α affects inflation dynamics only through its given size in the Phillips cure, which is indicated by; $\lambda(\sigma + \varphi)$. It can further be defined as the size response of inflation to any fluctuations in output gap.
A change in domestic output in the open economy, impacts the marginal costs on employment (indexed by φ) and σ_α captured the terms of trade (showing a degree of openness and domestic and foreign good sustainability). This under the assumption of $\sigma\eta > 1$ a increment in the openness decreases the adjustment size in the terms of trade in order to immerse change in domestic output that is relative to global output, therefore diminishing the adjustment impact on marginal cost and inflation.
With regard to equation (30), we can thus derive the dynamic IS-curve of the open economy in terms of the output gap;

$$x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma_\alpha}(r_t - E_t\{\pi_{H,t+1}\} - r\bar{r}_t) \tag{3.39}$$

Where,

$$\overline{rr_t} \equiv \rho - \sigma_\alpha \Gamma(1-\rho_\alpha)a_t + \alpha\sigma_\alpha(\Theta+\Psi)E_t\{\Delta y^*_{t+1}\}$$

is the natural interest rate in a small open economy. We can therefore conclude on the following factoids; The equilibrium of the small open economy has the same characterised forward looking IS curve as the closed economy. There are as to speak some difference *i.e.* the sensitivity of the output gap is influenced by the degree of openness and the other difference the model found, the natural interest rates depends on the expected global output growth resulting from the degree of openness and in so serving to an added domestic production.

Chapter 4

Methodology

4.1 Research Design

The methodology for investigating the impact of terms of trade shocks on the South African economy involves a multi-faceted approach that integrates theoretical modeling, empirical analysis, and econometric techniques. The research approach utilised to address the study's objectives is covered in this chapter. It provides a thorough explanation of the research strategy, data collection procedure, estimation techniques, and data used in the analysis. The chapter is divided into three subsets beginning with the model specification section 3.2, followed by the data section of the study found in section 3.3, estimation strategy in Section 3.4. indicates the small open economy model analysis framework.

4.2 Model Specification

The study begins with a robust theoretical framework that incorporates the New Keynesian DSGE (Dynamic Stochastic General Equilibrium) model, which is particularly suited for analysing small open economies like South Africa. This model allows for the examination of how terms of trade shocks propagate through the economy, affecting key macroeconomic variables such as output, inflation, and investment (Alpanda, 2013). The DSGE model is grounded in microeconomics foundations, capturing the behaviour of households and firms in response to external shocks. The study adapts the model of Gali (2025). The model consists of a forward-looking open economy IS-curve and a Phillips curve. An interest rate rule is used to explain monetary policy, while the CPI definition and Purchasing Power Parity assumption are used to introduce the exchange rate. The following equations direct how the small open economy (SOE) evolves.

4.2.1 The Model Equations

Consumption Euler equation

Where τ the inter temporal substitution elasticity, $0 < \alpha < 1$ is the import share (which gauges the degree of openness), and $\lambda = \alpha(2 - \alpha)(1 - \tau)$. Keep in mind that when $\alpha = 0$, the equation reduces to its closed economy version. Output yt, CPI inflation rate t, and nominal interest rate rt are the endogenous variables. The terms of trade are denoted by qt, the international output is denoted by yt, and the growth rate of an underlying non-stationary world technology process is denoted by zt. In order to

achieve stationarity in the model, both domestic and international output are expressed as percentage deviations from At. yt and zt are assumed to be exogenous variables that developing as AR processes. In respect to yt and zt's respective autoregressive coefficients Lubik and Schorfheide (2007).

Open Economy Phillips curve

Open economy Phillips curve, from the optimal price setting of domestic firms. The potential output in the absence of nominal rigidities is $yt = -\alpha(2-\alpha)(1-\tau)/\tau y * t + 1$. Again we remember that when $\alpha = 0$, the closed economy option is obtained. The slope coefficient or $k = 0$, depends on underlying structural factors including the elasticizes of labor supply and demand as well as variables that measure how sticky prices are. We treat k as structural because we do not use any additional data from the underlying model. To study exchange rate policies. The introduction of the real effective exchange rate is defined by the consumer price index (CPI). If relative PPP holds Exchange rate via the CPI if (Purchasing Power Parity holds, indicating the price of one): Thus, the world output is $\pi * t$ and is treated as unobservable. The study will treat $\pi * t$ as an observed variable.

Policy rule (Monetary policy rule described by an interest rate rule):

Because we assume the South African economy to be open, terms of trade has a great effect on the economy. Following Lubik and Schorfheide (2007), we do not solve for TOT endogenously rather we add the law of motion for terms of trade.

4.2.2 Measurement Equations

The following section of the study speaks to the measurement equation utilised in estimating the model. Measurement equations are utilised to relate unobservable variables with observed data. They specify how the variables in the model align to empirical measurements and equations. Second justification for the usage of measurement equation is for the account of errors and missing data, thus we incorporate error terms to capture differences between the variables in the model and the actual data utilised in the study. Thirdly, measurement equations allow for the control of variables included in the model cannot be observed, thus by explaining the relationship between observed and measure indicators we therefore capture the true value of the variable (Lubik and Schorfheide, 2007).

Growth rate of output

$$DY = 100 * (Y - Y_{-1} + Z) \tag{4.1}$$

DY represents the output put growth rate where, Y is the log of output, Y-1 is the lag log of output, Z represents the growth of technology and it is all multiplied by 100 to convert to percentage. The equation measure the quarter change percentage in output, given a technological process growth rate. The log (Y-Y-1) is the growth rate, and Z is the technological process accounted for in the model.

Inflation

$$INFL = 400 * \Pi \tag{4.2}$$

The above equation INFL explains the conversion of quarterly inflation rates to an annualised percentage rate. Thus, this equation relates the model's theoretical inflation variable to the observed CPI data. Where, PAI relates to quarterly inflation in the decimal form, 400* is the multiplier and thus performs two simultaneous functions. First, it converts the decimal form of the inflation rate into a percentage form which can be understood as PAI multiplied by 100. The second function therefore annualises the inflation quarterly rate, which can be considered PAI multiplied by 4.

Interest rate

$$INTRTE = 400 * R \tag{4.3}$$

Represents the conversion of nominal interest rate to annualised percentage rate. Where the T represents the quarterly decimal form of nominal interest rates. The multiplier 400* thus converts the decimal rate to percentage which is 100 multiply the R and after annualises the rate by multiplying it by 4. Thus, this can be seen as 4 multiplied the 100 multiply the R resulting in the observable model variable INTRTE.

Terms of trade

$$DTOT = 100 * (Q - Q{-}1 + Z) \tag{4.4}$$

The above referenced measurement equation (4.4) represents the percentage change in the terms of trade. It therefore measures the quarter-to-quarter percentage change of terms of trade while including and realising the technological process Z. The equation represents Q which is the log of terms of trade, Q-1 which represents the lag log of terms of trade, As mentioned Z represents the technological process and thereafter 100* is the multiplier that converts the variable percentage. This relates the model's theoretical terms of trade to the observed data. The following equation represents the foreign market of the model. Equations DY* and INFL* capture the foreign output and inflation, calculated using the weights of South Africa's largest trading partners. The calculation is explained in detail in the data section to follow.

Foreign output growth rate

$$DYstar = 100 * (Ystar - Ystar{-}1 + Z \tag{4.5}$$

Equation DY*, represents foreign output, where the equation converts the model's foreign output variable to an observable quarterly percentage growth rate taking into consideration the technological process Z. Where; Y* is the log of foreign output Y*-1 is the logged lag of foreign output, Z represents the technological growth rate and the multiplier 100 transforms the equation to percentage, thus resulting in the measurement for growth in foreign output. Foreign inflation

Foreign inflation

$$INFLstar = 400 * PAIstar \tag{4.6}$$

Represents the conversion of quarterly foreign inflation rates to an annualised percentage rate. Where the PAI* represents the quarterly decimal form of foreign inflation rates. The multiplier 400* thus converts the decimal rate to percentage which is 100 multiply the PAI* and after annualises the rate by multiplying it by 4. Thus, this can be seen as 4 multiplied the 100 multiply the R resulting in the observable model variable INFL*.

4.3 Data

South African quarterly data for the period of 1994Q1 - 2022Q3, were collected from the Bank of International Settlements (BIS), Federal Bank of St Louis (will be referred to as Fred) and the South African Reserve Bank (SARB). The study will not take into the structural break of 1994. The study's aim is not to compare but to analyse the impact of terms of trade shocks on the South African economy. The second reason for the data period is data availability. Using Fred for reasons of consistency in data collect, real GDP for South Africa is only available from 1994Q1.

All the data (variables of interest) is seasonally adjusted. Thereafter transformed into logarithmic form and then demeaned prior to estimation. Variables Foreign income and inflation are using the computed trade weights of the South Africa's top three trading partners namely, Euro area (treated as a single entity), China and the US. Trading weights are collected from the BIS for periods 1993 - 2019. GDP log differences are used to calculate output growth rates, which are then multiplied by 100 to provide quarter-to-quarter percentages. Consumer price index log differences are used to calculate inflation rates, which are then multiplied by 400 to get annualized percentage rates. Based on the weights of the top three trading partners of South African's GDP and CPI inflation, we compute international output and inflation. To calculate depreciation rates, we multiply the log differences (by 100) of the trade-weighted nominal effective exchange rate. While the real interest rate is expressed in levels, changes in the TOT are calculated as log differences and multiplied by 100. Every series is demeaned before estimation (Lubik and Schorfheide, 2007).

4.4 Estimation Strategy

This chapter presents and analyses the empirical results obtained from the estimated DSGE model for the South African economy, focusing on the impact of terms of trade shocks. The analysis employs Bayesian estimation techniques using quarterly data from 1994Q1 to 2024Q3, providing insights into the transmission mechanisms and macroeconomic responses to terms of trade fluctuations. The chapter is organised as follows. First, we present the parameter estimates, comparing prior and posterior distributions to assess the model's ability to capture key features of the South African economy. Second, we examine model diagnostics and convergence statistics to validate the estimation results. Third, we analyse impulse response functions to understand how terms of trade shocks propagate through different sectors of the economy. Fourth, we employ variance decomposition to quantify the relative importance of terms of trade shocks in explaining macroeconomic fluctuations. Finally, we present historical decomposition results to identify the contribution of terms of trade shocks to specific episodes in South Africa's economic history. Through this comprehensive analysis, we aim to address the research ob-

jectives outlined in Chapter 1, particularly focusing on identifying transmission channels of terms of trade shocks and estimating their impact on key South African macroeconomic variables. The results will provide valuable insights for policymakers and contribute to the existing literature on external shocks in small open economies.

The following provides the key components of the study and framework of the DSGE model estimated in this chapter. Endogenous Variables; Core macroeconomic variables: Output (Y), Inflation π, Interest Rate (R), External sector variables: Exchange Rate (Exch), Terms of Trade (Q),Foreign variables: World Output (Y*), World Inflation π^* and Potential Output (YPOT), Technology (Z). Exogenous Shocks; Domestic shocks: Demand (EY), Supply (EPAI), Exchange Rate (ER), External shocks: Terms of Trade (Eqq), Foreign Demand (EY*), Foreign Supply (EPAI*) and Technological shock (EZ). The following represents the key equation utilised in the study. Potential Output equation reflects external sector influence through Y* S Curve incorporates open economy elements including the terms of trade (Q), Open Economy New Keynesian Phillips Curve (NKPC) shows price dynamics and Exchange Rate equation links domestic and foreign prices furthermore, Taylor Rule includes exchange rate considerations (γex parameter).

It is therefore noticeable that the DSGE model, captures small open economy characteristics through alpha parameter, Incorporates both domestic and external shocks and Terms of trade follows an AR(1) process. Furthermore, the Technology shock affects multiple measurement equations and monetary policy responds to expected inflation, output, and exchange rate.

The use of Bayesian techniques limits the parameters identification problem (Lubik and Schorfheide, 2007). Bayesian methods take in consideration the data on hand of the specific country and assume the data to be fixed. Using the South African data on hand to the study, parameters will be solved, this we call our posterior density,as discussed above the study will follow Bayesian methods to estimate the parameters, therefore we will use the Bayesian theorem for parameter estimation. The prior density, the likelihood (taking data into consideration) and therefore obtaining our posterior density. Which will be considered to be constant.

4.4.1 Bayesian estimation

The study utilities Bayesian approach to estimate the parameters of the model. The Bayesian approach allows the use of market and empirical literature to estimate the parameters based on priors in the estimation. These priors are set to the beliefs of the research or study, based on the knowledge from other studies. Thereafter, the information on priors is updated by the Bayes law. Bayes Law is a powerful tool which improves the estimation of priors by updating the probability based on know data or the likelihood. It advocates for improved handling of unknown variables and the importance of precises estimation to avoid the occurrence of artificial economies. The usage of Bayesian estimation aids in the relevance of the study. Provided the vector of model parameters, and the prior beliefs $p\theta$ Bayesian estimation inferences determine updated belief of the parameter distribution given the observed data O.

$$p(\theta/O) = \frac{p(O/\theta)p(\theta)}{p(O)} \tag{4.7}$$

The LHS, represents the updated belief know as the posterior distribution on the vector of parameter θ. The RHS, indicates the computation of the posterior distribution. The prior belief of the model parameters is multiplied by the likelihood function $p(O/\theta)$ and thus divided by the marginal likelihood (understood as the observed data) p(O) of O. The below gives a closer interpretation at the equation above. and thus gives us the following on the interpretation. Likelihood function $p(O/\theta)$; This represents the observed data O, give then the prior distribution of the parameter θ DSGE estimation is formed directly from the model. Marginal Likelihood function p(O) $=f\ p(O/\theta)p(\theta)d(\theta$ which is interpreted as the likelihood of observing O. This thus helps the understand the posterior distribution (An and Schorfheide, 2007).

4.4.2 Priors

In Bayesian estimation, parameters are selected based on the research objective of the study and structure of the DSGE model. interest to be estimated. The number of parameters is unlimited, the research must identify the the most vital parameters to the study ensuring model identification and computational reliability. Priors are pivotal to Bayesian estimation, playing an important role in estimating DSGE models (An and Schorfheide, 2007). The benefits of having priors to the model is the handling the regions of the parameters space and weighing down the space where parameters are at odds with the observed data which are not included in the data. The second benefit of priors is the added curvature to the likelihood function. Therefore, priors influence the shape of the posterior distribution. Priors can be set up through the intuition of researcher based on previous literature, thus reflecting the researchers beliefs regarding the validity of economic theories and the characteristics of the country in question. Thus, priors have a direct affect and influence the shape of the posterior distribution (An and Schorfheide, 2007).

Prior's are informed by the researchers intuition, this is based on previous empirical literature selected to capture and reflect the economic theories, characteristics of the country under study. They may also be selected based on primary, observational data to align with stylised facts in the area of interest (An and Schorfheide, 2007). In order to estimate the DSGE model Hove et al. (2016) calibrated the parameters in their paper. Calibration though it has its benefits, has the disadvantage of estimating an artificial economy. A model where the parameters are manually set obtained from previous literature, steady state relationships and theoretical considerations, rather than being estimated statistically from actual data of the country under study.
The adopted Small Open Economy model from Gali and Monacelli (2005), provides a steady and valid foundation for analysing a Small Open Economy such as South Africa. The selection of study period and data treatment hence ensures the estimation of reliable model parameter. The advantages offered by Bayesian over the calibrated methods by including prior beliefs and previous literature provides the study with steady, reliable estimates more accurate the economy of South Africa. The measurement equation matches the data to the variable , historical decomposition thus enables detailed analysis of shock contributions to South African economic movements and volatility. These elements examine the channels through which terms of trade transmit. The estimations and results chapter that follows presents the estimation obtained from the foundations of the methodology and presents the posterior distribution and parameter estimations, variance

and historical decomposition to best answer the objectives and questions of the study. This chapter outlines the methodological framework utilised in the study to analyse the impact of terms of trade shocks on the South African economy. This approach therefore combines a theory- ground DSGE model with micro foundations with Bayesian estimation inferences to understand the dynamic relationship between key macroeconomic variables and terms of trade shock on the South African economy. The methodology thus addresses the objectives and questions of the study.

Chapter 5

Estimation and Results

This chapter presents and analyses the empirical results obtained from the estimated DSGE model for the South African economy, focusing on the impact of terms of trade shocks. The analysis employs Bayesian estimation techniques using quarterly data from 1994Q1 to 2024Q3, providing insights into the transmission mechanisms and macroeconomic responses to terms of trade fluctuations. First, we present the parameter estimates, comparing prior and posterior distributions to assess the model's ability to capture key features of the South African economy. Second, we examine model diagnostics and convergence statistics to validate the estimation results. Third, we analyse impulse response functions to understand how terms of trade shocks propagate through different sectors of the economy. Fourth, we employ variance decomposition to quantify the relative importance of terms of trade shocks in explaining macroeconomic fluctuations. Finally, we present historical decomposition results to identify the contribution of terms of trade shocks to specific episodes in South Africa's economic history. Through this comprehensive analysis, we aim to address the research objectives outlined in Chapter 1, particularly focusing on identifying transmission channels of terms of trade shocks and estimating their impact on key South African macroeconomic variables. The results will provide valuable insights for policymakers and contribute to the existing literature on external shocks in small open economies.

The following provides the key components of the study and framework of the DSGE model estimated in this chapter. Endogenous Variables; Core macroeconomic variables: Output (Y), Inflation π, Interest Rate (R), External sector variables: Exchange Rate (Exch), Terms of Trade (Q),Foreign variables: World Output (Y*), World Inflation π^* and Potential Output (YPOT), Technology (Z). Exogenous Shocks; Domestic shocks: Demand (EY), Supply (EPAI), Exchange Rate (ER), External shocks: Terms of Trade (Eqq), Foreign Demand (EY*), Foreign Supply (EPAI*) and Technological shock (EZ). The following represents the key equation utilised in the study. Potential Output equation reflects external sector influence through Y*, IS Curve incorporates open economy elements including the terms of trade (Q), Open Economy New Keynesian Phillips Curve (NKPC) shows price dynamics and Exchange Rate equation links domestic and foreign prices furthermore, Taylor Rule includes exchange rate considerations (γex parameter).

It is therefore noticeable that the DSGE model, captures small open economy characteristics through alpha parameter, Incorporates both domestic and external shocks and Terms of trade follows an AR(1) process. Furthermore, the Technology shock affects multiple

measurement equations and monetary policy responds to expected inflation, output, and exchange rate.

Table 5.1, depicts the Bayesian estimation results. The DSGE model estimation provides robust, data- informed parameter values characterising the South African economic structure. The results indicate an economy with specific behavioral and structural features, thus playing a vital role in understanding the transmission of terms of trade shocks.
The credibility of the model is based on the value of the log- MMD (1933.94). The model thus captures and generates data that mimics the South African data set. The log-MMD value obtained confirms that the model provides a reasonable statistical characterisation of the South African data. Furthermore, the study compares the value of the log-MMD and the log-prior (6.00), this comparison indicates that the data has updated our beliefs thus supporting the posterior estimations. The study further observes the estimation convergence of 111 observations from the study period (1995 -2022) ensures that the obtained results are set in the South Africa's economic history.

The Bayesian estimation provides a structurally sound and empirically valid model, replicating an authentic South African economic model. The results characterise the South Africa's small open economy with a predictable central bank, sticky prices and forward-looking consumers. τ =0.94 represents the country's intertemporal elasticity of substitution at this high posterior, suggests that the households of South Africa exhibit significant willingness to move their consumption over time in a response to interest rate changes. Thus implying a strong monetary policy transmission channel. The low slope Phillips curve $\kappa = 0.014$ indicates normal price rigidities. Thus, the inflation is slow to respond and adjust to changes in the marginal cost, hence providing the South African Reserve Bank (SARB), a window to align and influence economic growth. The openness of the economy represented by $\alpha = 0.0007$ is low compared to what we see of the economy, thus suggesting that the model captures a high degree of home production and consumption and that external shock are not fully captured by the import share parameter and the transmissions of these shocks. α is identified between the domestic and CPI inflation gap, through the consumption and output gap driven by terms of trade movements (Gali and Monacelli, 2005). When the terms of trade shock absorbs a large share of the external variation in the data as confirmed by the variance decomposition results in Section 5.4 the residual explanatory burden on the import share parameter is substantially reduced, which can produce a downward-biased posterior for α.
This sensitivity of open economy parameters to model specification and the selection of observable variables is documented in the South African DSGE literature, Paetz and Gupta (2016) with noting that the degree of openness is among the parameters for which prior specification has an influence on posterior estimates given limited identification from the data. The estimated monetary policy rule indicates that the SARB takes decisive actions, it strongly adheres to the Taylor rule principle with a posterior mode for inflation significantly above one $\gamma\pi$=1.28 showing the activeness to ensure macroeconomic stability. γy is estimated as the Taylor rule on output response, thus estimating the weight that the central bank places on stabilising output gap. The low estimated value thus indicates that the central bank reacts to changes moderately, suggesting that the primary focus of the bank is price stability. The central bank also shows a high degree of interest rate smoothing, estimated at ρr = 0.89, thus confirming the banks tendency to adjust rates slowly to avoid disrupting financial markets. A vital estimation for the study is the

persistence of terms of trade shocks ρq = 0.90. The high value estimated indicates that fluctuations in commodity prices have long terms lasting impacts on the South African economy, thus creating long periods of economic adjustments rather than short disruptions. Foreign output shock are highly persistent ρ^*= 0.95 , showing the long-lasting effect of the global economy.
In identifying the primary sources of economic fluctuations, the study estimated standard deviations of the structural shocks. σy= 0.071 indicating the high volatility of the domestic demand shock marking it as primary driver of the South African business cycle. Further the terms of trade shock σq= 0.030 and the technological shock σz=0.032 show considerable volatility, thus confirming a significant role in driving economic fluctuations on the economy. However, domestic inflation shocks σna = 0.011 and monetary policy shocks σr = 0.0025 are less volatile, suggesting that domestic supply side and unanticipated policy shock play a small role in fluctuations compared to demand and external factors.

The Bayesian estimation produces a structurally sound and valid model. The results thus characterise the South African economy. The high persistence and significant volatility if the terms of trade shocks estimated by ρq and σq give insight and provide quantitative evidence that external shocks have major and long lasting impact on the economy.
The following section discusses the impulse response functions, variance decomposition to trace and depict the dynamic impact of external shocks on the economy and macroeconomic variables.

Table 5.1: Bayesian Parameter Estimates: Priors and Posterior Modes

Parameter	**Description**	**Prior**	**Distribution**	**Mode**
Structural Parameters				
τ	Intertemporal Elasticity of Substitution	0.62	Beta	0.944
κ	Phillips Curve Slope	0.32	Gamma	0.014
α	Degree of Openness	0.20	Beta	0.007
Shock Persistence (AR1 coefficients)				
ρ_q	Terms of Trade Shock	0.36	Beta	0.901
ρ_{y^*}	Foreign Output Shock	0.95	Beta	0.953
ρ_{π^*}	Foreign Inflation Shock	0.41	Beta	0.348
ρ_z	Technology Shock	0.49	Beta	0.241
ρ_r	Interest Rate Smoothing	0.80	Beta	0.889
Taylor Rule Coefficients				
ψ_π	Inflation Response	1.20	Gamma	1.276
ψ_y	Output Gap Response	0.25	Gamma	0.177
ψ_e	Exchange Rate Response	0.12	Gamma	0.381
Shock Standard Deviations				
σ_y	Domestic Demand Shock	0.01	Inv-Gamma	0.071
σ_π	Domestic Inflation Shock	0.01	Inv-Gamma	0.011
σ_r	Monetary Policy Shock	0.01	Inv-Gamma	0.0025
σ_z	Technology Shock	0.01	Inv-Gamma	0.032
σ_q	Terms of Trade Shock	0.01	Inv-Gamma	0.030
σ_{y^*}	Foreign Output Shock	0.01	Inv-Gamma	0.032
σ_{π^*}	Foreign Inflation Shock	0.01	Inv-Gamma	0.0048

5.1 Priors

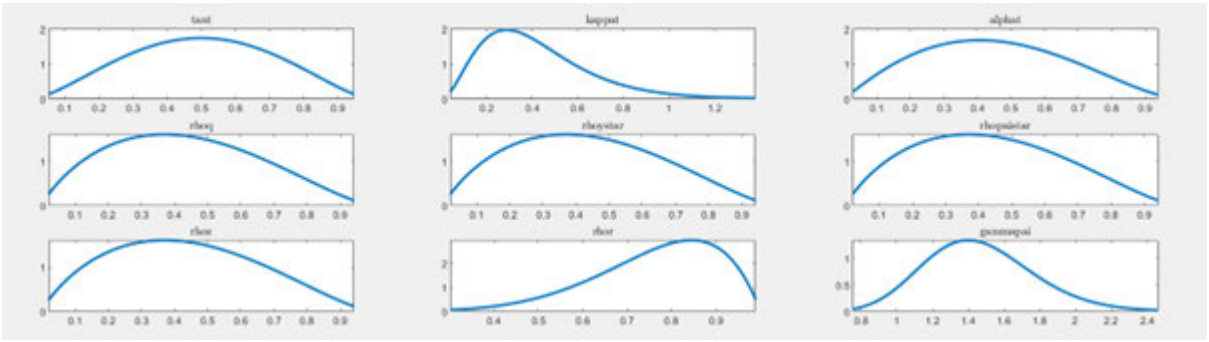

Figure 5.1: Prior distribution of structural parameters.

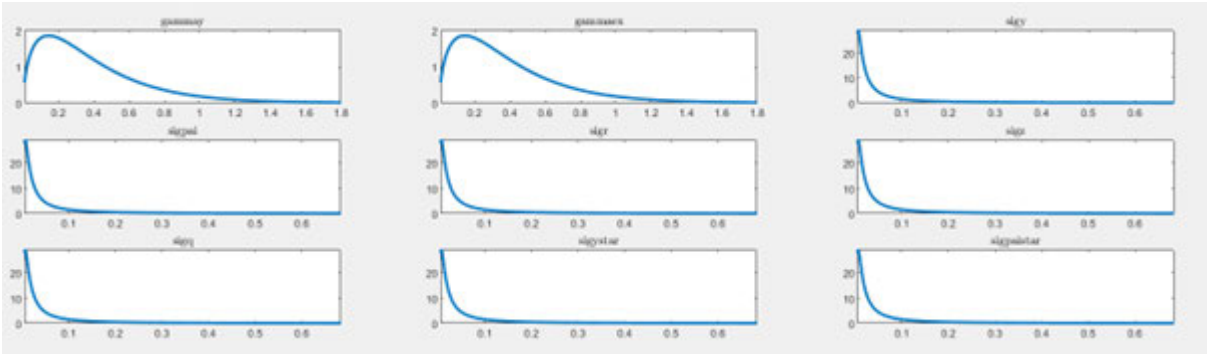

Figure 5.2: Prior estimation of structural parameters.

In figure 5.1 and figure 5.2 present the Bayesian parameter estimation, the prior distribution. Each plot depicts the distribution probability of the parameters. As discussed in the chapter 3, the Methodology parameter estimating using Bayesian inferences combines the prior belief of a researcher, the observed data to produce posterior distribution. τ follows the Beta distribution peaking around 0.5, representing the intertemporal elasticity of substitution. κ follows the Gamma distribution peaking around 0.3-0.4, representing the slope of the Phillips curve. α following the Beta distribution peaking around 0.5-0.6, representing the degree of openness. ρy* Shows persistence parameter for foreign output, bell-shaped with peak around 0.5. ρ* Persistence parameter for foreign inflation, bell-shaped distribution. ρq Persistence parameter for terms of trade shock. ρz Technology shock persistence parameter, ρr Interest rate smoothing parameter, showing high persistence (peaks towards 0.8-0.9) aligned with the estimated 0.849 of Hollander and van Lill (2018) for the benchmark SW-NK model with indicated a rage of 0.73 -0.89. Hence confirming the SARB's idealism towards gradual interest rate adjustment which is a robust feature. $\gamma\pi$ Taylor rule coefficient for inflation response, distribution starts around 1 and extends to 2.5.

In figure 5.2, the following parameters are estimated. γy Taylor rule coefficient for output response, γex Taylor rule coefficient for exchange rate response. σy Standard deviation of demand shock, showing an inverse gamma distribution. $\sigma\pi$ Standard deviation of inflation/supply shock. σr Standard deviation of interest rate/monetary policy shock. σq

Standard deviation of terms of trade shock. σz Standard deviation of technology shock. σy* Standard deviation of foreign output shock. $\sigma\pi$* Standard deviation of foreign inflation shock. The above estimated parameter estimations, follow Beta distributions for persistence parameters (bounded between 0 and 1) and the structural parameters follow normal/gamma distributions. The shapes and ranges of these priors seem consistent with standard assumptions in the literature for small open economy models. With regards to shock standard deviations (σ- parameters) have inverse γ distributions, which is standard in DSGE literature as these parameters should be positive and allow for fat tails. The distributions peak near zero and have long right tails, suggesting relatively tight priors on shock volatilities. Policy response parameters (γy and γex) have more diffuse distributions, allowing the data to have more influence on their posterior estimates. The intertemporal elasticity of substitution (taut) and openness parameter α have bell-shaped distributions centered around moderate values, reflecting reasonable assumptions about household behavior and trade openness. The Phillips curve slope κ prior suggests moderate price stickiness in the economy. The high persistence in the interest rate smoothing parameter ρr aligns with observed monetary policy behavior. The Taylor rule coefficient for inflation $\gamma\pi$ prior starts above 1, satisfying the Taylor principle for monetary policy effectiveness. Autoregressive coefficients (ρy*, $\rho\pi$*, ρq, ρz) show moderate to high persistence. These priors suggest shocks have lasting effects but eventually dissipate.

The terms of trade persistence (ρq) prior indicates expected prolonged effects of external shocks. The high persistence of the terms of trade shocks (ρq)=0.901 are consistent with findings from Mendoza (1995) and Kose (2002) document high persistence in commodity price shocks for emerging economics and hence supports the interpretation of terms of trade in South Africa which is created and sustained by the pressures of transitory adjustments. The inverse gamma shock parameters shapes show relatively tight priors on shock volatilities. These priors allow for occasional large shocks while maintaining stability. External shock volatilities (σq, σy*, $\sigma\pi$*) priors suggest meaningful influence of international factors. Monetary policy response coefficients (γy and γex)have more diffuse priors. This specification allows the data to strongly influence the posterior estimates of policy reactions. The exchange rate response prior (γex) reflects the open economy nature of the model.

5.2 Policy analyses: Impulse Response Functions

The main objective of the study is to analyse the terms of trade shock response of macroeconomic variables in South Africa. Impulse response functions of the seven endogenous variables and how they respond to economic structural shock such as terms of trade shocks, technological, productivity shock and supply shocks are analysed in order to explain the underlying transmission channels of the shocks and the impact on the variables. Figures 5.3, 5.4 and 5.5 present the impulse response functions for a supply shock, exchange rate shock, a demand shock and a terms of trade shock.

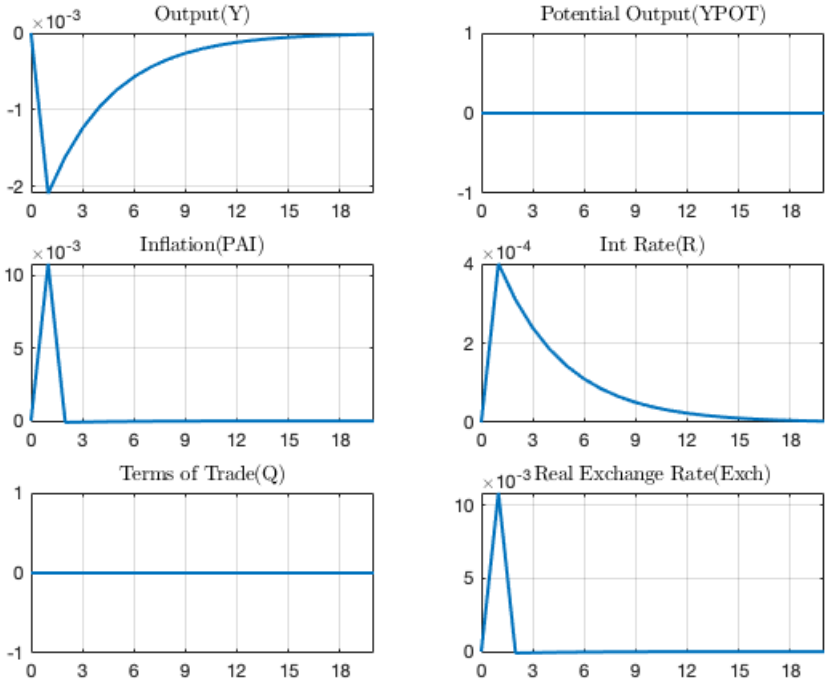

Figure 5.3: Impulse response function Supply shock

Figure 5.3, indicates the impulse response function for a supply shock. Where Output (Y) negatively responds to the shocks and gradually reverts to its steady state value. PAI, shows a positive response to a one standard deviation shock in supply and reverts to its steady state after 6-8 periods. Showing a that supply shocks has a larger impact on inflation. Q, terms of trade however does not responds to a supply shock. This would suggests a limited pass through of domestic supply shock to terms of trade. Potential Output, shows not response to a one standard deviation change supply shock. Therefore indicating that supply shocks do not affect potential output. These findings are consistent with the results of Hollander and van Lill (2018), who similarly found that cost push shocks ion South Africa do not affect potential output in their SW-NK model. Supply side shocks driving inflation variance rather than moving the productive curve. The study's findings are also consistent with the theoretical framework of Gali and Monacelli (2005) who indicate that in the New Keynesian models, nominal shocks include cost push shocks which thus affect the output gap without changing the natural rate of out and hence preserving the welfare separation between cyclical fluctuations and structural capacity that gives the DSGE framework its policy tractability. There is a delayed response to a one standard deviation with interest rates, thus indicating that interest rates react later to the shock.

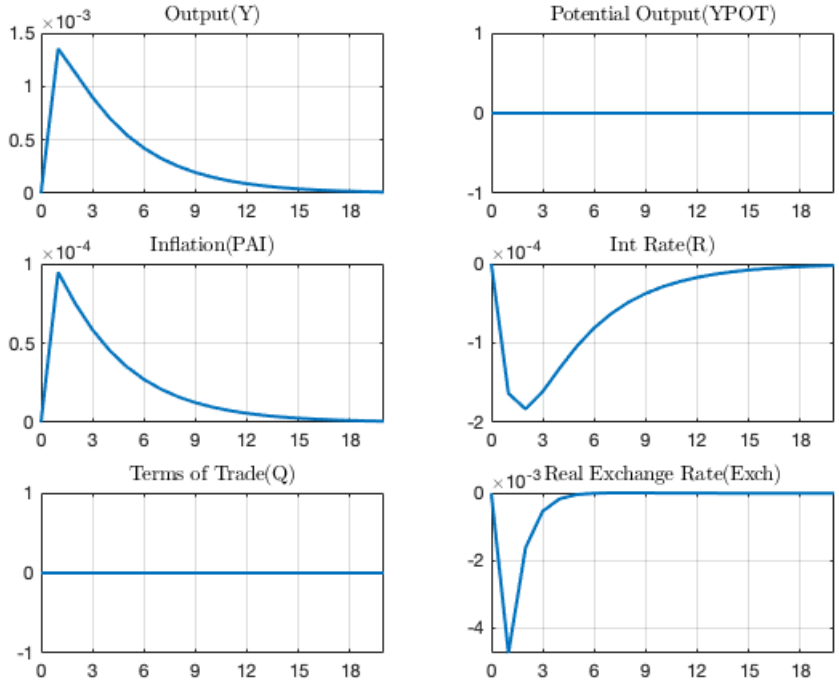

Figure 5.4: Impulse response function foreign supply shock

Figure 5.4 presents the macroeconomic responses to a foreign supply shock. Where Output shows a positive response to a foreign supply shock. Inflation has less responsive trend to that of Output, there is a small response to a one standard deviation change in foreign supply and inflation revers to its steady state in 10-12 periods. Terms of trade along with Potential output doe not respond to a foreign supply shock, indicating the limited impact of foreign supply shocks on terms of trade and potential output. Interest rates have negative response, which depicts a monetary allowance for to a foreign supply shock. The real exchange rate shows a quick depression to a foreign supply shock, which is then followed by a quick recovery.

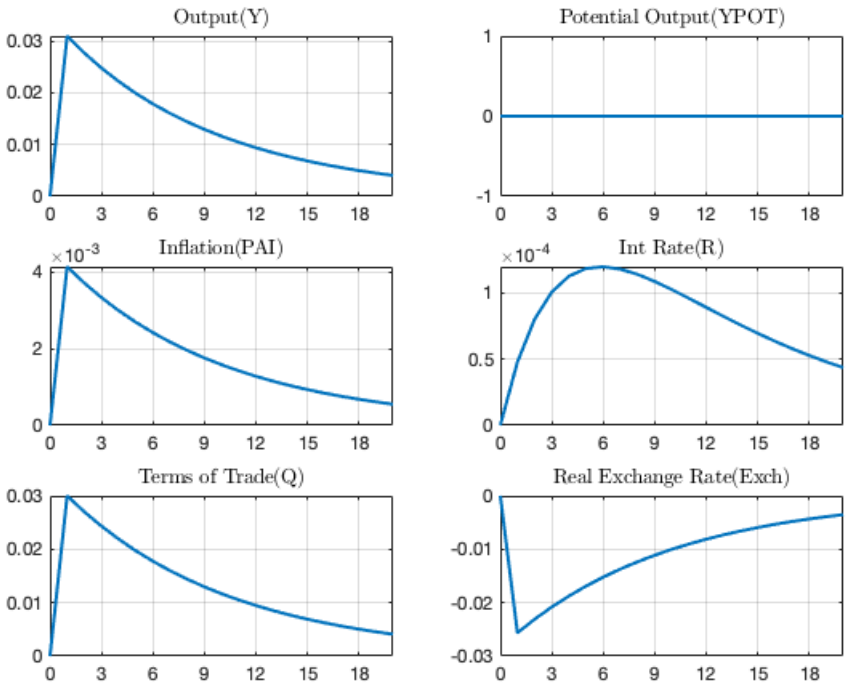

Figure 5.5: Impulse response function Terms of trade shock

Figure 5.5, Output (Y), Shows an immediate and substantial positive response, the positive response aligns with theoretical expectations for a commodity-exporting economy like South Africa, where improved terms of trade boost export revenues and domestic income. Inflation (PAI), Initial negative impact followed by a positive response. The inflation response suggests price adjustments in response to exchange rate movements and increased domestic demand. Terms of Trade (Q), Shows an immediate positive shock. The pattern reflects the autoregressive nature of terms of trade shocks. The persistence aligns with the commodity-price driven nature of South Africa's terms of trade. Potential Output (YPOT) shows minimal responses, the variables stay near steady state. Indicating that the terms of trade shocks primarily affect cyclical rather than potential output and the consistency with the model's theoretical structure where potential output is mainly driven by structural factors. Interest Rate (R), shows a gradual positive response, with a delayed reaction relative to other variables and the variables stays above the steady states. This provides insight of monetary policy tightening in response to increased economic activity and inflationary pressures. Real Exchange Rate (Exch), quick depreciation to a terms of trade shock reaching 2-3 quarters and showing a slow revert to the steady state. Thus, this response is a adjustment mechanism to terms of trade shock. In the standard small open economic framework, a positive terms of trade shock is expected to appreciate the exchange rate through stronger inflows from export revenues. The depreciation observed in the above figure, is thus consistent with the nominal interest rate simultaneous rise, indicating a monetary policy tightening which dampens domestic demand. This combination of higher domestic rates and rising inflation expectations creates a more complex exchange rate dynamic that the expected appreciation. Hollander and van Lill (2018), documented a similar response in the SOE-NK model, where the interaction between the risk premium shock and monetary policy response generates exchange rate response in

the opposite directions that the initial expectations. Transmission Mechanism, the terms of trade shocks primarily transmit through trade and exchange rate channels. Secondary effects operate through domestic demand and monetary policy responses. The adjustment process involves multiple quarters, suggesting significant persistence.
Economic Impact: Positive terms of trade shocks stimulate economic activity. Exchange rate adjustment helps facilitate external balance. Monetary policy responds to manage domestic implications. Policy Relevance, highlights the importance of managing terms of trade volatility. Suggests role for countercyclical policy. Indicates need for robust exchange rate management Responses reflect South Africa's nature as a commodity-exporting small open economy. Shows significant interconnections between external and domestic variables. Demonstrates the importance of terms of trade in driving business cycles. These results align with theoretical expectations and previous empirical findings for commodity-exporting economies, while providing specific quantification of the effects for South Africa Cashin et al. (2004). The substantial and persistent effects on output and exchange rates underscore the significance of terms of trade shocks for macroeconomic management in South Africa. Hove et al. (2016), calibrating a DSGE model for the South African economy found that a positive terms of trade shock raises output through the trade balance channel this being consistent with the observed response. Potential output not responding and staying around the steady state is consistent with Hollander and van Lill (2018), who indicates that supply side shocks do not permanently change potential output and that terms of trade shift impact output cyclically rather that the structural capacity in the economy.

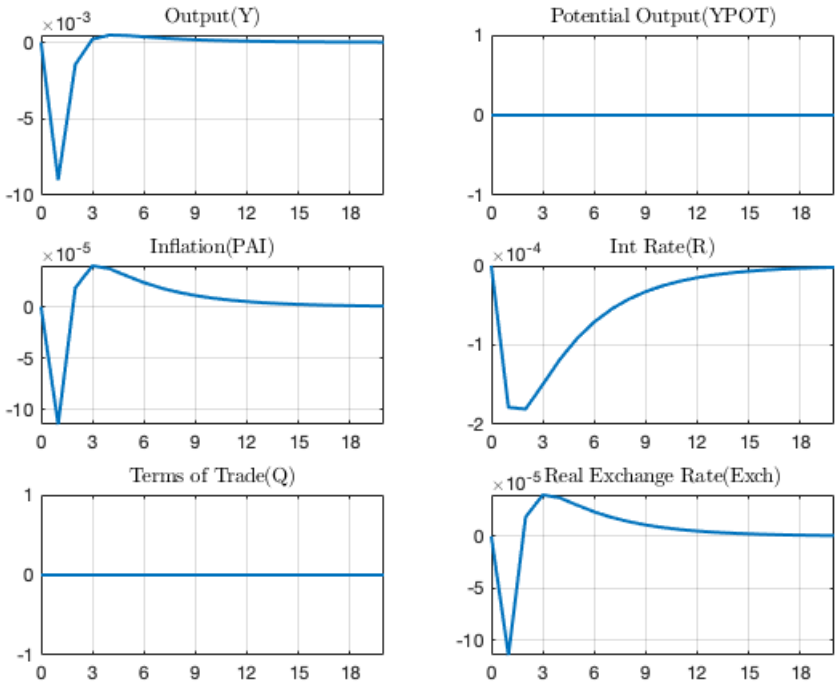

Figure 5.6: Impulse response function Technology shock

Figure 5.6, Output (Y), indicates a sharp negative response, and reverts back to its steady state recovering and stabilising to its steady state. This J-curve pattern shows an initial response and cost adjustment or disruption before the economy adjusts to the a tech-

nological change. Potential Output (YPOT), remains flat at zero, thus indicating that this technological shock does not alter the economy permanently. The other case might be that potential output responds the shock through different channels not captured in the short-term analysis. Inflation (PAI) shows the similar responses to Output (Y), a sharp negative response with a recovery to the steady state of the variable. This disinflationary response shows that technology shock may temporary increase production, reduce marginal costs and hence putting downward pressure of prices. Terms of Trade (Q) does not respond to a technological shock and remains flat and at zero. This does speak to the theory and economic relationship between technology and terms of trade. Domestic technology shocks should not affect South Africa's terms of trade, which are determined by international commodity prices This hence provides validation for the study's identification strategy, confirming that technology and terms of trade shocks operate through distinct, independent channels essential for isolating terms of trade effects in subsequent analysis. Interest Rate (R) indicates monetary accommodation, declining quickly and demonstrating a slow recovery until 18 periods. This counter cyclical response to dis inflationary pressures is broadly consistent with inflation-targeting frameworks. Real Exchange Rate (Exch) exhibits initial appreciation followed by persistent depreciation. The initial appreciation is interpretable through productivity gains and potential capital inflows. However, the subsequent prolonged depreciation is difficult to reconcile with beneficial technology improvements, particularly given unchanged terms of trade. This pattern likely reflects structural features of South Africa's volatile financial account and sensitivity to global capital flows rather than fundamental productivity-driven dynamics. Transmission Mechanism: Technology shocks transmit primarily through domestic supply-side channels affecting productivity and costs, with secondary effects through monetary policy and exchange rate adjustments. The rapid initial adjustment suggests quick price responses, though persistence in financial variables indicates gradual market adjustments. However, the disconnect between output movements and potential output, combined with the negative output impact, suggests the transmission mechanism may not be well-captured by current model specification Hollander and van Lill (2018).

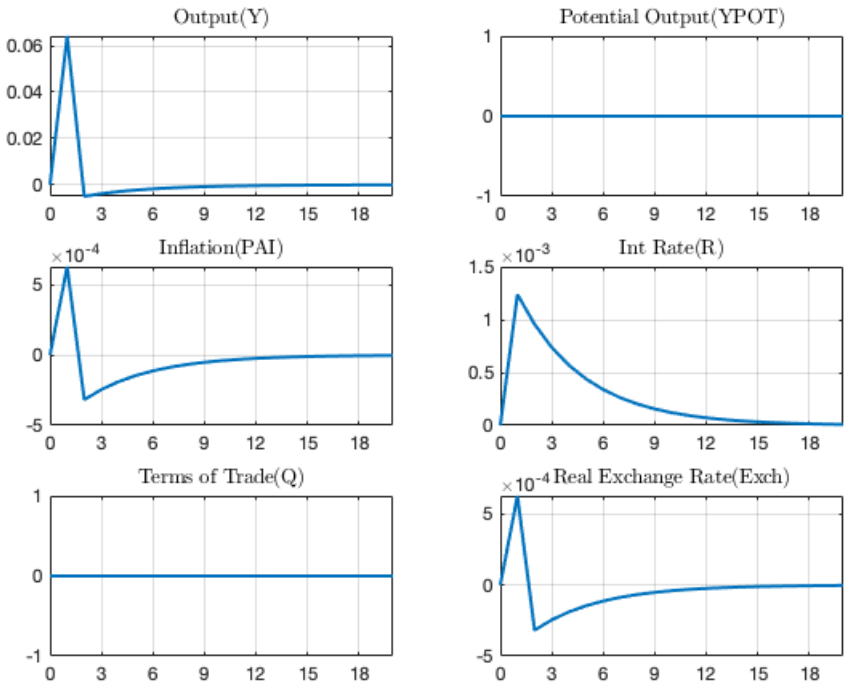

Figure 5.7: Impulse response function Demand Shock

Figure 5.7 A positive demand shock generates an immediate and temporary rise in output, peaking in the first period before returning to baseline by the third quarter. This response aligns with standard theory, where higher consumption, investment, or government spending boosts activity in the short run, but nominal rigidities fade and output reverts to trend. Inflation increases sharply on impact, reflecting demand-driven price pressures consistent with Phillips-curve dynamics, before briefly undershooting and stabilising as policy and price adjustments take effect.

The terms of trade show no meaningful response, confirming that domestic demand shocks do not influence globally-determined export and import prices in a small open economy. Potential output remains unaffected, reinforcing that demand disturbances only shift output around trend rather than altering long-run productive capacity.

Monetary policy reacts countercyclically: interest rates rise after the shock to contain inflation and only gradually return to steady state, consistent with credible inflation-targeting behaviour. The exchange rate initially appreciates as stronger domestic conditions and higher interest rates attract capital flows, before depreciating as external balance adjusts.

Overall, the effects of demand shocks are short-lived for output but longer-lasting for prices, interest rates, and the exchange rate, reflecting the interaction of goods-market dynamics, policy responses, and external adjustment mechanisms.

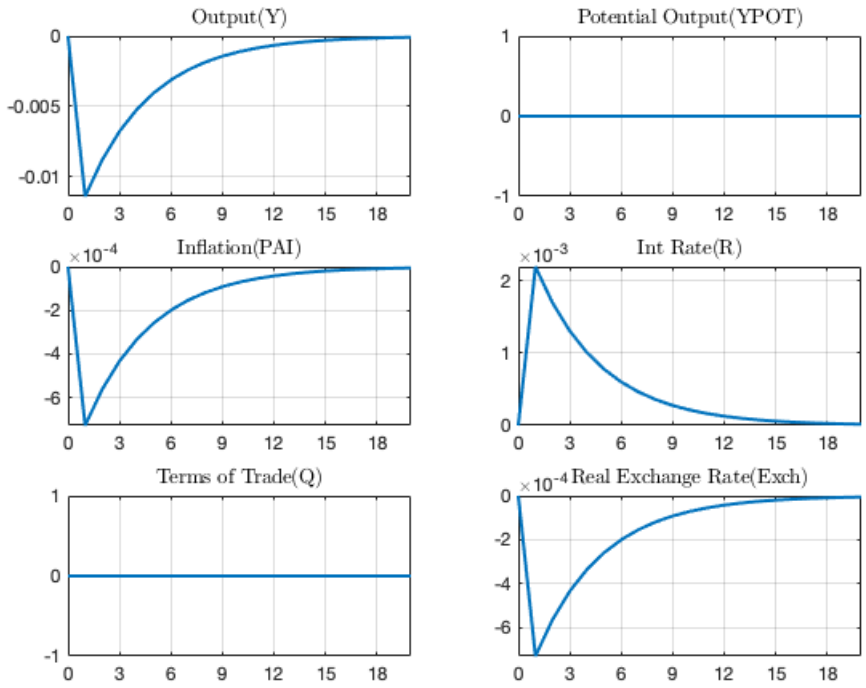

Figure 5.8: Impulse response function Exchange Rate shock

The above Figure 5.8 An exchange rate depreciation generates an immediate decline in output, which gradually returns to steady state after roughly twelve periods. Although depreciation should theoretically support export competitiveness, the contractionary effect suggests South Africa's heavy reliance on imported intermediate goods dominates, with higher input costs compressing margins and reducing domestic production capacity. The slow recovery highlights gradual price adjustment and sector reallocation.

Inflation initially falls before slowly reverting to equilibrium, which is counterintuitive for a depreciation shock. This likely reflects demand-compression effects outweighing imported-inflation pressures, or model-driven dynamics where weak activity suppresses price growth more than exchange-rate pass-through raises it.

The terms of trade remain unaffected, consistent with theory, confirming that nominal exchange-rate movements and global commodity-driven price ratios adjust through separate channels. Potential output shows no meaningful reaction, reinforcing that exchange-rate shocks influence cyclical activity rather than long-run productive capacity.

Interest rates rise sharply and remain elevated for a sustained period, signaling a contractionary monetary policy stance aimed at managing exchange-rate volatility and inflation expectations. The real exchange rate depreciates immediately and mean-reverts only gradually, illustrating persistent price rigidities and slow external adjustment.

Overall, the exchange-rate shock transmits primarily through imported-input costs and monetary policy tightening, leading to short-run contractionary effects and gradual macroeconomic adjustment.

5.3 Variance decomposition

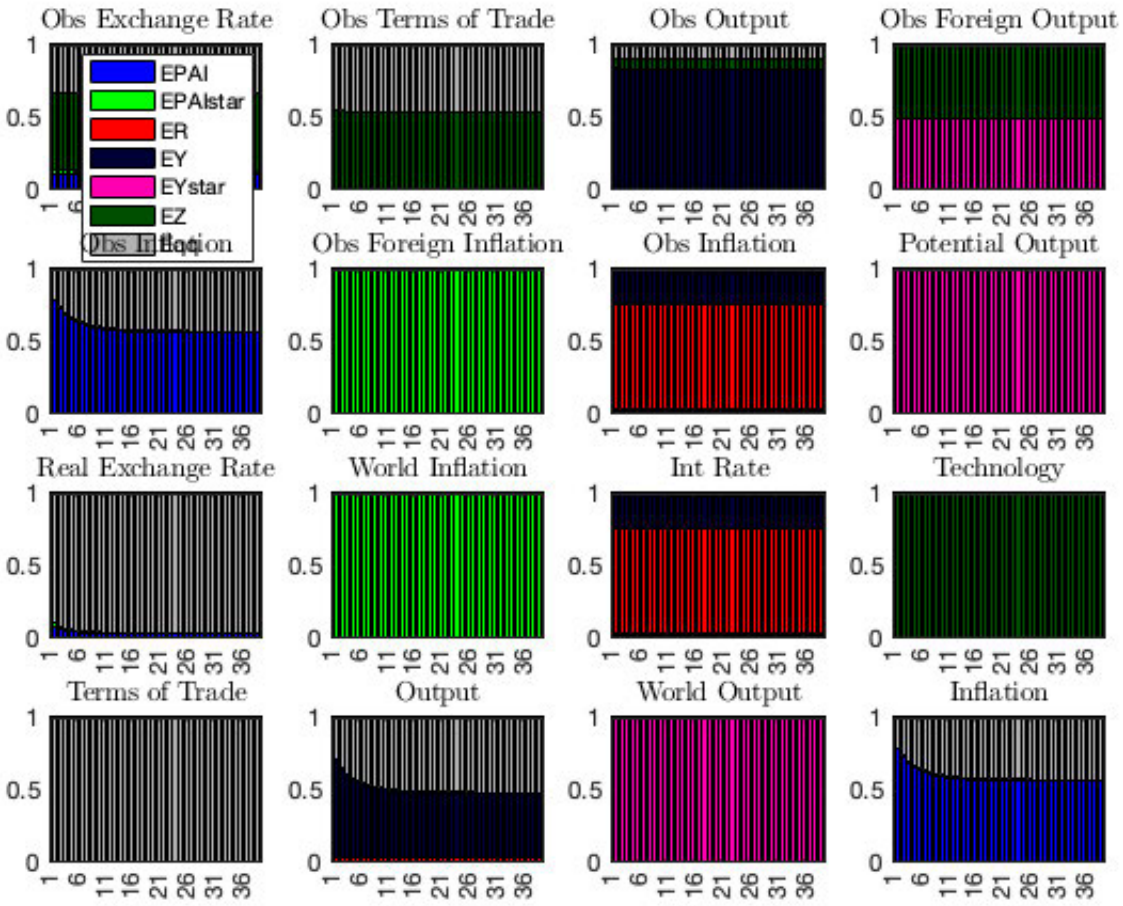

Figure 5.9: Variance Decomposition

Figure 5.9 The variance decomposition results highlight the relative importance of structural shocks in explaining fluctuations in key South African macroeconomic variables and reinforce the small open–economy nature of South Africa. Exchange-rate variation is driven by a broad mix of shocks with no single dominant source, reflecting exposure to multiple global channels. Terms-of-trade movements are primarily driven by external commodity-price shocks, confirming that South Africa is a price-taker in world markets. Output fluctuations are largely explained by domestic output shocks, underscoring the importance of internal structural constraints—such as energy supply, infrastructure, and policy uncertainty—while terms-of-trade shocks play a secondary role. Foreign output, world output, and world inflation are almost entirely driven by their own shocks, validating the exogeneity of global variables. Inflation shows domestic price shocks dominating in the short run, but external terms-of-trade shocks becoming more influential at longer horizons, highlighting challenges for monetary policy in the presence of externally-driven inflation pressures. Potential output and technology are overwhelmingly explained by their respective structural shocks, consistent with long-run supply-side fundamentals.
Overall, the analysis reveals a clear separation between external variables (driven by

global conditions) and domestic macroeconomic dynamics (driven mainly by internal shocks). While short-run stabilization should focus on domestic demand and monetary policy, medium-term policies must address terms-of-trade and exchange-rate volatility. Long-term growth depends on structural reforms targeting productivity, infrastructure reliability, institutional quality, and policy certainty. These results, alongside the impulse response analysis, provide comprehensive insight into how shocks propagate through the South African economy and where policy can most effectively support stability and growth.

The findings indicate that domestic demand shocks dominate output flows in the short run while the global terms of trade shocks become influential at the longer runs this being in line with the works of (Hollander and van Lill, 2018), who find that risk premium and exogenous shocks to dominate the output variance in the short run while supply shocks appear in the middle to long run. The present identification of the terms of trade shock as a structural shock provides the study a more precise quantification of the external channel, where this is absorbed into the more general exogenous spending and risk premium components Hollander and van Lill (2018).

5.4 Historical decomposition

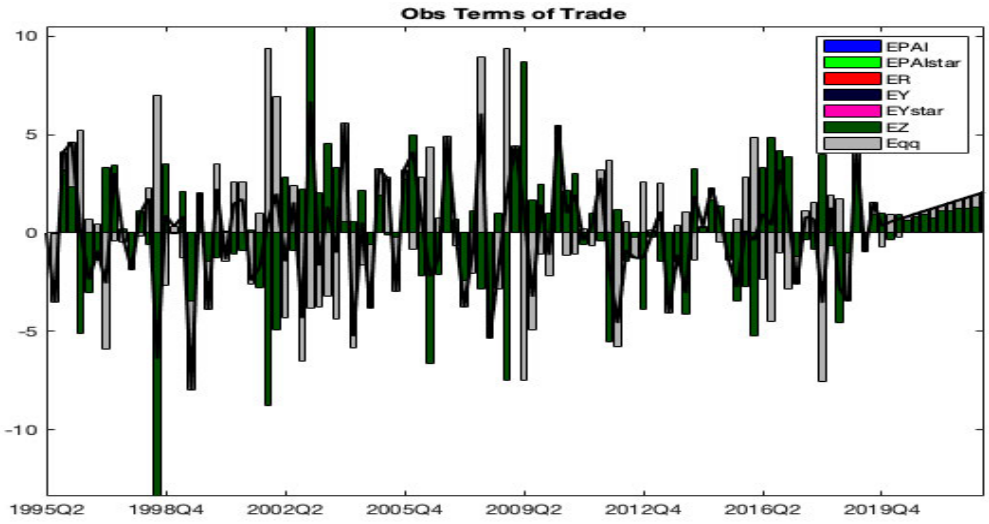

Figure 5.10: Historical decomposition of terms of trade

Figure 5.10 indicates that fluctuations in the South African economy's terms of trade are primarily driven by EZ shock between 1995 and 2019. This shock captures the global volatility associated with EZ. The study observes a significant negative EZ driven by multiple global events in 1998Q4 which was the market crisis. Depicted also in the figure, the study observes a large negative contribution during the 2008/2009 financial crisis thus reflecting the volatility of the global commodity and trade market. Positive period of EZ contributes to the 2002 commodity boom, thus corresponding with te global demand for raw material and resource exports. The Eqq component contributes meaningfully to the historical composition of terms of trade, observed at a smaller magnitude compared to EZ. The two shocks often contribute to terms of trade but in opposite directions thus

suggesting of structural volatility. Thus indicating that while external shock dominate terms of trade patterns, and domestic responses helping to moderate the impact on the South African economy.
Overall the decomposition indicates that the South African economy's terms of trade are most influenced by the external shock most particularly commodity-fluctuations with domestic channels in the position of stabilising the impacts. These finding further reinforces the perspective that the South African economy is most dependent on the to global and external demand conditions as a price taker.

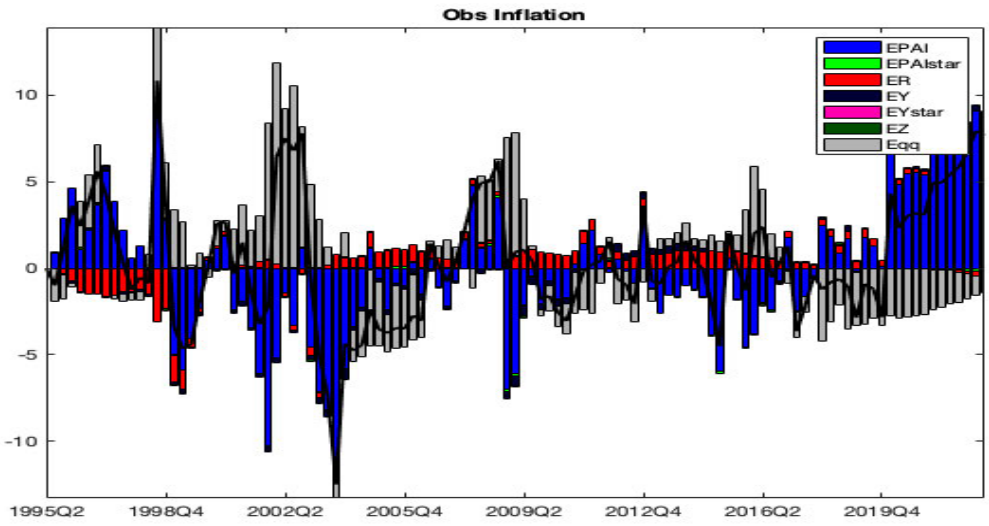

Figure 5.11: Historical decomposition Inflation

Figure 5.11 shows that inflation dynamics in South Africa during 1995–2019 were primarily driven by EPAI (supply-side/cost-push) shocks, which consistently explain most of the observed fluctuations. These shocks are particularly dominant in the late 1990s and early 2000s, reflecting periods of exchange-rate volatility, energy price pressures, and structural transition. Negative contributions around the early 2000s and the 2008–2009 financial crisis highlight the role of global disinflationary forces during downturns.
Additional influences arise from external price and persistence shocks (EPIstar/EPI), especially in earlier years, while contributions from ER and EZ shocks are comparatively smaller and more stabilising. Following the adoption of inflation targeting in the 2000s, the magnitude of shocks declines, indicating improved policy credibility and better anchoring of inflation expectations.
Overall, the results suggest that South African inflation has historically been driven predominantly by cost-push and external price shocks, with a noticeable reduction in volatility over time as monetary policy strengthened.

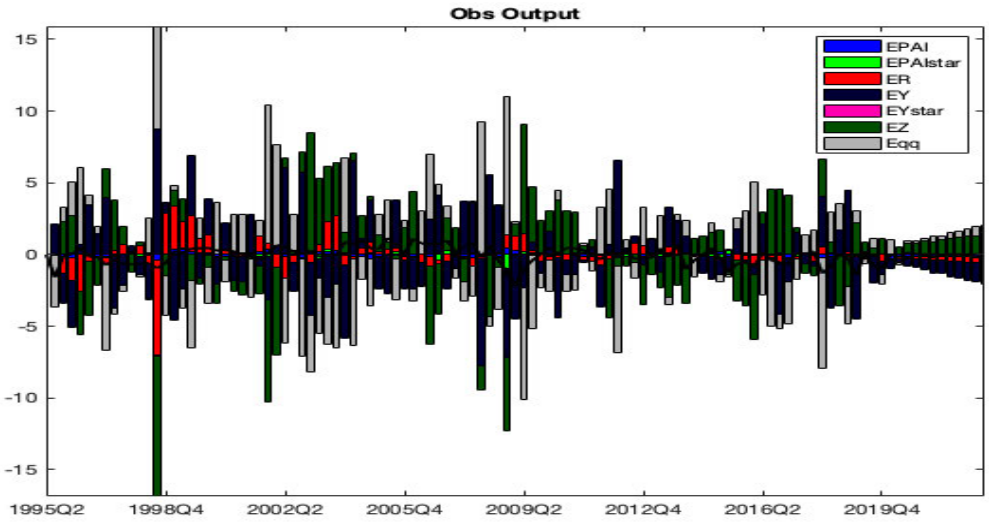

Figure 5.12: Historical decomposition Output

Figure 5.12 indicates that fluctuations in South African output over 1995–2019 were mainly driven by EZ shocks, reflecting the strong influence of external and commodity-related factors on domestic economic activity. Large negative contributions during the late-1990s emerging-market turmoil and again during the 2008–2009 global financial crisis highlight the economy's sensitivity to global demand and commodity price cycles. Positive EZ contributions during the early- to mid-2000s are consistent with the commodity boom period.

Other shocks, including EPAI and domestic demand-related disturbances, play supporting roles but generally with smaller magnitudes relative to EZ. Eeq occasionally offsets EZ shocks, suggesting some internal adjustment mechanisms, though these are weaker compared to external forces. The reduced volatility in later years reflects a gradual stabilisation in macroeconomic conditions prior to 2019.

Overall, the results suggest that South Africa's output dynamics are highly influenced by external shocks, particularly commodity-market movements, reaffirming the economy's vulnerability to global conditions and export-driven cycles.

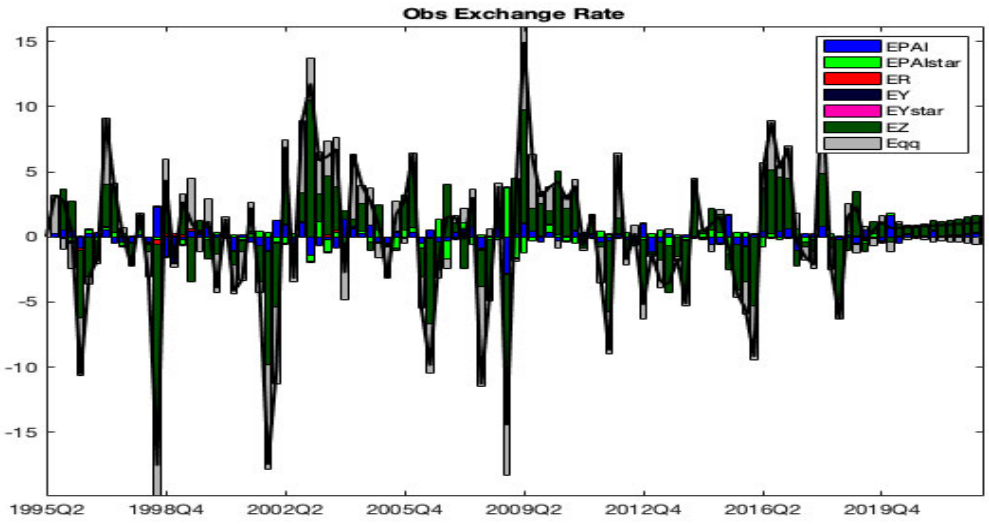

Figure 5.13: Historical decomposition Exchange Rate

Figure 5.13 indicates that fluctuations in the South African exchange rate over the period 1995–2019 were predominantly driven by Eeq shocks (the terms of trade shock), reflecting the profound influence of global commodity prices and external trade conditions on the currency's value. Large negative Eeq contributions, indicating a depreciating pressure on the Rand, are evident during the 2008–2009 global financial crisis and the 2015–2016 period marked by the "taper tantrum" and a sharp decline in commodity prices. These episodes highlight the currency's acute sensitivity to collapses in global demand and investor sentiment towards emerging markets. Conversely, the sustained positive contributions from Eeq during the early- to mid-2000s commodity super-cycle and the post-2010 recovery phase are consistent with periods of strong export revenues, which bolstered the currency.

The EZ shock (technology shock) acts as a secondary but important driver, with its positive contributions (suggesting appreciation pressures from improved productivity) notably tempering the exchange rate's depreciation during the 2008-09 crisis. Other domestic shocks, including EPAI (inflation/supply shock) and ER (monetary/exchange rate shock), play more volatile but generally supporting roles. The ER shock, in particular, shows instances of active offsetting movements, for example around 2001 and 2015, suggesting periods of policy intervention or shifts in capital flows aimed at managing currency volatility.

The reduced amplitude of all shocks in the years immediately prior to 2019 suggests a period of relative stabilization in the external drivers of the exchange rate, before the new volatilities of the 2020s.

Overall, the historical decomposition clearly demonstrates that the South African Rand is a classic commodity currency, whose dynamics are overwhelmingly determined by external terms of trade shocks. This reaffirms the economy's structural vulnerability to global commodity cycles and the critical challenge this poses for monetary policy and economic planning.

Chapter 6

Conclusions and Recommendations

The main objective of the study is to quantify the transmission channels of the terms of trade shocks through the South African economy using the Bayesian - estimated small open economy DSGE model. The set is set up around three objectives that guided the research namely; to identify the channels through which terms of trade shock propagate, to estimate the impact and persistence of the shocks in key macroeconomic variables and to interpret the impulse response functions in terms of their implications for policy.
The impulse response functions indicate that a positive terms of trade shock generate responses that are both theoretically consistent and empirically sound for the South African economic landscape. The effect of the shock is felt strongly in the first quarter and dissipates over the next four quarters, thus confirming that terms of trade shocks are temporarily felt in the South African economy rather than permanent and persistent. This finding directly correlates with the following implications; policy responses to commodity price fluctuations need not be permanent structural parameters, rather they should be calibrated to the shocks horizon.
Output responds positively and immediately to a positive terms of trade shock, this is driven through the trade balance channel. Rising commodity prices increasing export revenues which feeds into income and stimulates domestic investment thus raising production in the trade-able goods sector. Thus this transmission is consistent with HLM theory described in the theoretical literature review confirming that South Africa's commodity exports dependence directly creates a direct and quantifiable link between the global commodity prices and the domestic economic activity.
The real exchange rate inversely responds to a positive terms of trade shocks thus producing a currency appreciation for the South African rand. This reflects stronger foreign exchange inflows from the increased revenues generated by exports. This thus benefits the manufacturing sector in the short run through cheaper imports and simultaneously reduces the international competitiveness of non-commodity exports. The variance decomposition hence confirms that the terms of trade shocks contribute to the exchange rate changes, which prior studies using aggregate frameworks Hollander and van Lill (2018) were unable to identify because the terms of trade shocks were not modeled as an independent structural shock.
Supply shocks are not affected by a terms of trade shock contrasting the above result. Thus confirming a separation between productivity and external price driven dynamics in the South African economy. This is important as it indicates that the South African Reserve Bank can use the model and framework to differentiate between inflation that shows up domestically requiring tightening response and inflation that originates from

commodity fluctuations which would require a more strong and accommodative stand given the temporary nature of the shock.

6.1 Limitations and Challenges

The specification does not fully account for the exogenous shocks, the Kalman filter may produce biased estimations. Thus, the study proposes the addition of structural breaks and time-varying parameters to enhance estimations. For instance, the 2007/2008 financial crisis which is indicated on the historical composition. Further research of this topic should incorporate time varying parameters and structural breaks to improve estimation around global shocks.
The single sector treatment of the South African economy as single productive sector, while it falls in with Gali and Monacelli (2005). This thus limits the impact of the sectoral transmission channels and analysis. The mining, agricultural and manufacturing sector respond differently to terms or trade shocks. The model is limited to capturing the aggregate responses but does not decompose the sectoral contributions and responses. The next natural step should be expanding the work to a multi-sectoral model.

6.2 Research Gaps and Motivations

Despite the existing literature, there are notable gaps in understanding the specific impacts of terms of trade shocks on the South African economy. Many studies focus on broader regional trends or do not adequately incorporate the unique characteristics of the South African economy in their models. This research aims to address these limitations by employing a Bayesian DSGE framework tailored to South Africa, enhancing the understanding of how terms of trade shocks influence economic performance Leshoro (2023). The motivation for this study lies in its potential contributions to academic literature and policy formulation. By providing a detailed analysis of terms of trade shocks in the South African context, the research can inform policymakers about the economic implications of these shocks and guide strategies to mitigate their adverse effects Leshoro (2023);Hove et al. (2016).
Understanding the transmission mechanisms of terms of trade shocks can help policymakers design more effective monetary and fiscal policies to stabilise the economy and promote sustainable growth. Moreover, the study aims to contribute to the growing body of literature on the role of Bayesian estimation techniques in economic modeling. By demonstrating the effectiveness of these techniques in capturing the dynamics of terms of trade shocks, the research can provide valuable insights for future studies in this area. The findings of this research may also have implications for other small open economies facing similar challenges, thereby contributing to the broader understanding of the impact of terms of trade shocks on economic performance.
Bayesian estimation is the advanced tool of estimating DSGE macroeconomic model, as it provides with advanced handling of diverse models and precise estimates. The main contribution of this study is to provide a methodology extension on the question of interest. The impact of terms of trade on the South African economy with the inferences of Bayesian estimation. The model is small open economy and has micro foundations thus capturing fluctuations and shocks of the economy in question. With a high degree of export dependence of the economy is taken into account by including export volume

and export income shocks. The Kalman filter performs well in estimating and analysing macroeconomic patterns and performances in key variables such as output, inflation and terms of trade. The model does indicate that there are deviations to interest rates and exchange rates. The prior distributions provide a reasonable starting point for Bayesian estimation while allowing sufficient flexibility for the data to inform the final parameter estimates. The choices align with both theoretical considerations and empirical evidence from similar small open economies.

The state space form of rational expectations solution of the model is used to determine unobservable state variables of the model and assess the contribution of structural shocks. The impulse response functions show the following with regards to the main objective of the study, the impact of terms of trade on the South African economy. The variables responses are compatible with economic theory, the results obtained in the study of terms of trade enhanced the impact of shocks and thus gave precise analysis on the impact of shocks and therefore give policy-making bodies the insight to handling anticipated shocks. A positive terms of trade shock affects the macro variables in the first quarter and lasts for almost four quarters. Therefore, with a positive terms of trade shock, stronger export prices have been derived, thus increasing economic activity and the shock is hence a temporary shock. Permanent shocks, would thus indicate a positive technological shock, increasing output and thus increase exports and therefore increasing terms of trade. As we saw in the impulse response functions, supply shocks do not affect terms of trade and potential output.

With regards to investments, a positive terms of trade shocks affects output in a favourably through the trade balance, thus increasing income and investments. This is thus the impact of a positive terms of trade, which thus increases production domestic export goods. The real exchange rate has an inverse repose. Which indicates an appreciation of the South African Rand, which results in strong foreign exchange inflows into the country. In the short term, the appreciation benefits the manufacturing sector, as they are dependent on the external markets for the stability of the imported and domestic good. The commodity market benefits from the positive terms of trade shock, the stronger the currency to the dollar, the high the export prices of commodity will be. Thus, the country benefits from a terms of trade positive shock. Hence, the model precisely predicts the direction of responses of endogenous variables during the speculative attack on the domestic currency in 2015. Overall, the model gives sound results on the fundamental sources of fluctuations in the economy and the transmission mechanisms of structural shocks.

6.3 Policy Implications

The findings of this study carry three concrete implications for monetary and fiscal policy in South Africa. First, inflation targeting requires a commodity shock filter. The results show that a positive terms of trade shock raises output and appreciates the exchange rate while generating only moderate inflationary pressure through import price dynamics. This means that CPI inflation following a commodity price surge does not straightforwardly signal domestic overheating. If the SARB responds to commodity-driven CPI increases with aggressive tightening, it risks suppressing output in a context where the shock is temporary and self-correcting. The model's impulse response functions suggest that the appropriate policy window is approximately four quarters the duration over which the shock's effects dissipate and that monetary policy should be calibrated to this horizon rather than reacting to the peak-quarter CPI reading in isolation. Second, exchange rate

management must account for the Rand's commodity currency dynamics. The confirmed appreciation of the Rand following a positive terms of trade shock reinforces the characterisation of the Rand as a commodity currency. This appreciation, while beneficial for import-dependent manufacturers in the short run, compresses the competitiveness of non-commodity exports and may crowd out manufacturing investment over the medium term a Dutch disease dynamic that the variance decomposition results implicitly support. Policymakers should consider building countercyclical foreign exchange reserve buffers during commodity boom periods, partially sterilising the appreciation to protect the competitiveness of the non-commodity export sector. Third, fiscal policy should be anchored to the shock's persistence, not its magnitude. Because the terms of trade shock is temporary dissipating within four quarters fiscal expansions financed on the assumption of sustained commodity revenue are structurally dangerous. The historical decomposition shows that South Africa's periods of weak growth from 2014 on wards coincided with demand-side contractions that followed the withdrawal of the commodity boom. A commodity revenue stabilisation fund, accumulating reserves during positive terms of trade periods and deploying them counter-cyclically during downturns, would mechanically embed the model's finding about shock persistence into fiscal planning. This is a more empirically grounded version of the diversification strategies historically pursued under the Industrial Policy Action Plan — grounded not in general economic reasoning but in the specific dynamics identified by this model.

6.4 Future Research Directions

Identifying areas for future research can offer insights into strengthening resilience to terms-of-trade shocks. Several areas merit further exploration.
Firstly, future studies should incorporate the financial sector and frictions which would follow along with the works of Hollander and van Lill (2018). Expanding on the New Keynesian DSGE model by integrating the financial frictions treating the financial market as perfect and complete, meaning credit flows, interest rate pass through and financial shocks have independent effect on the real economy. This would allow the model to capture the cycles of how commodity prices interact with credit condition and bank dynamics which is unmodelled in the current model. Secondly, estimating the model is two sub samples, pre and pot the 2007/2008 financial sector, this would test whether the transmission channels of the terms of trade shocks have changed as South Africa's trade integration has increased and deepened in previous years. Thirdly, the current model treats South Africa as a singular productive sector which is standard of the Gali and Monacelli (2005) study and model. Expanding the framework to include multi-sector components in the model, would allow the differential responses of mining, agriculture and manufacturing providing the sector level policy evidence that aggregate models do not supply.

Furthermore, beyond the structural model extensions two broader directions become apparent. The first is building on the technological advancements. Research into the role of technology in diversifying the economy and enhancing productivity in sectors such as agriculture and manufacturing could inform policy development. Identifying emerging technologies that can drive growth in South Africa is essential for future competitiveness. Studies exploring digital transformation within manufacturing sectors could reveal pathways for growth and competitiveness.

The second broader addition in the direction of South Africa's informal-sector. Understanding the informal-economy dynamics is vital. Studying how the informal economy responds to terms-of-trade shocks and its role in economic resilience could lead to more inclusive policy frameworks. Researching the informal sector's adaptability during economic downturns can provide valuable insights for policymakers.

Bibliography

Adler, G. and Osorio Buitron, C. (2020). Tipping the scale? the workings of monetary policy through trade. *Review of International Economics*, 28(3):744–759.

Alpanda, S. (2013). Identifying the role of risk shocks in the business cycle using stock price data. *Economic Inquiry*, 51(1):304–335.

An, S. and Schorfheide, F. (2007). Bayesian analysis of dsge models. *Econometric reviews*, 26(2-4):113–172.

Barattieri, A., Cacciatore, M., and Ghironi, F. (2021). Protectionism and the business cycle. *Journal of International Economics*, 129:103417.

Beirne, J. and Renzhi, N. (2024). Debt shocks and the dynamics of output and inflation in emerging economies. *Journal of International Money and Finance*, 148:103167.

Çakır, M. Y. and Kabundi, A. (2013). Trade shocks from bric to south africa: A global var analysis. *Economic modelling*, 32:190–202.

Cashin, P., Céspedes, L. F., and Sahay, R. (2004). Commodity currencies and the real exchange rate. *Journal of Development Economics*, 75(1):239–268.

Chadha, J. S. and Shibayama, K. (2018). Bayesian estimation of dsge models: Identification using a diagnostic indicator. *Journal of Economic Dynamics and Control*, 95:172–186.

du Plessis, S., Smit, B., and Steinbach, R. (2014). Monetary policy and financial shocks in an empirical small open-economy dsge model. Technical report, Mimeo.

Ejaz, M. and Azam, A. (2024). Impact of capital inflows on exchange rate in developing economies: A panel data analysis. *Pakistan Journal of Social Sciences (PJSS)*, 44(1).

Fedderke, J. and Naumann, D. (2011). An analysis of industry concentration in south african manufacturing, 1972–2001. *Applied Economics*, 43(22):2919–2939.

Fernández-Villaverde, J. and Guerrón-Quintana, P. A. (2021). Estimating dsge models: Recent advances and future challenges. *Annual Review of Economics*, 13(1):229–252.

Gali, J. and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, 72(3):707–734.

Gali, M. (2025). Monetary policy. *Economics*.

Georgiadis, G. and Mösle, S. (2020). Introducing dominant-currency pricing in the ecb's global macroeconomic model. *International Finance*, 23(2):234–256.

Harberger, A. C. (1957). Some evidence on the international price mechanism. *Journal of Political economy*, 65(6):506–521.

Hassan, T. A. and Zhang, T. (2021). The economics of currency risk. *Annual Review of Economics*, 13:281–307.

Hollander, H. and van Lill, D. (2018). A structural decomposition of the south african business cycle. *W. Boshoff, Business cycles and structural change in South Africa: an integrated view*.

Hove, S., Mama, A. T., and Tchana, F. T. (2015). Monetary policy and commodity terms of trade shocks in emerging market economies. *Economic Modelling*, 49:53–71.

Hove, S., Touna Mama, A., and Tchana Tchana, F. (2016). Terms of trade shocks and inflation targeting in emerging market economies. *South African Journal of Economics*, 84(1):81–108.

Kabundi, A. and Loots, E. (2010). Patterns of co-movement between south africa and germany: Evidence from the period 1985 to 2006. *South African Journal of Economics*, 78(4):383–399.

Khan, I., Zakari, A., Ahmad, M., Irfan, M., and Hou, F. (2022). Linking energy transitions, energy consumption, and environmental sustainability in oecd countries. *Gondwana Research*, 103:445–457.

Kose, M. A. (2002). Explaining business cycles in small open economies:'how much do world prices matter?'. *Journal of International Economics*, 56(2):299–327.

Laursen, K. (1978). The integrated programme for commodities. *World Development*, 6(4):423–435.

Leshoro, T. L. (2023). An analysis of the importance of terms of trade in south africa using impulse response function. *Global Business Review*, 24(2):243–257.

Lubik, T. A. and Schorfheide, F. (2007). Do central banks respond to exchange rate movements? a structural investigation. *Journal of Monetary Economics*, 54(4):1069–1087.

Malefane, M. R. (2020). Trade openness and economic growth in botswana: Evidence from cointegration and error-correction modelling. *Cogent Economics & Finance*, 8(1):1783878.

Mendoza, E. G. (1995). The terms of trade, the real exchange rate, and economic fluctuations. *International Economic Review*, pages 101–137.

Metzler, L. A. (1949). Tariffs, the terms of trade, and the distribution of national income. *Journal of Political Economy*, 57(1):1–29.

Moolman, A. M., Fouché, J. P., and Leendertz, V. (2023). Sustainability reporting in pandemics: Theoretical development of guidelines for improved reporting. *Cogent Economics & Finance*, 11(2):2246321.

Oladunni, S. (2020). Oil price shocks and macroeconomic dynamics in an oil-exporting emerging economy: A new keynesian dsge approach. *CBN Journal of Applied Statistics*, 11(1):1–34.

Oviedo Gómez, A. F. and Sierra, L. P. (2019). The importance of terms of trade in the colombian economy. *Revista CEPAL*.

Paetz, M. and Gupta, R. (2016). Stock price dynamics and the business cycle in an estimated dsge model for south africa. *Journal of International Financial Markets, Institutions and Money*, 44:166–182.

Phetla, K. (2017). *Monitoring and evaluation in the National Department of Agriculture, Forestry and Fisheries*. University of South Africa (South Africa).

Prebisch, R. (1962). Economic bulletin for latin america. *Santiago*, 7(1).

Qiu, D., Lan, Y., Cao, A., and Tan, L. (2024). Research on the impact of china's free trade zone policies on urban economic development. *China Economic Journal*, 17(3):481–498.

Schmitt-Grohé, S. and Uribe, M. (2018). How important are terms-of-trade shocks? *International Economic Review*, 59(1):85–111.

Singer, H. W. (1975). The distribution of gains between investing and borrowing countries. In *The strategy of international development: Essays in the economics of backwardness*, pages 43–57. Springer.

Steinbach, M., Mathuloe, P., and Smit, B. (2009). An open economy new keynesian dsge model of the south african economy. *South African Journal of Economics*, 77(2):207–227.

Taiwo, S., Uwilingiye, J., and Osei-Assibey, K. (2023). Macroeconomic fluctuations in sub-saharan africa: Role of external shocks. *Available at SSRN 4675714*.

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van Zyl, J., Meyer, A. J., de Waele, D., and Malan, A. P. (2021). Host plant penetration, development and life cycle of a heterodera schachtii population from the western cape province, south africa. *Journal of Plant Diseases and Protection*, 128(2):517–525.

Wolf, M. (2020). A partial and defective us-china trade truce. *Financial Times*, 21.

Appendix A

Corrections report

This appendix contains the corrections report of the thesis.

Student report to confirm error corrections

Student name: Tiisetso Motsodisa
Student No: 223139984
Dissertation title: The Impact of Terms of Trade on the South African Economy.
Supervisor/s: Dr. CK Tipoy
Qualification: MCOM – Economics (Coursework)
School: School of Accounting, Economics and Finance

Date: 30.03.2026

Student Signature:

Page	Error	Corrections
	INTERNAL EXAMINER	
7	Elaborate on the works of Hollander and van Lill's (2018)	- Expanded the work, explained the objective of the study, what the findings were and what we failed to learn from Hollander and van Lill's (2018). - Snythesising paragraph describes how the study aims to expand on Hollander and van Lill's (2018).
7-8	Describe the methodology in detail.	- Expanded on the benefits of using the Bayesian DSGE - Deepened and broadened the study's description of the relationship and methodology.
	Focus on the relationship of the study	- Addressed
8-9	Problem Statement: What is the main problem? What question is the study asking	- The study identifies the theoretical issue with terms of trade, commodity dependence, and explains it through the HLM and the Prebish-Singer frameworks. - Expands on empirical studies to motivate the importance of the study. - Introduction of terms of trade as a structural parameter.
8-9	Methodology explanation – why the limitation, and how we solve and address.	- Introduction of Bayesian estimation. generates structurally interpretable impulse response functions, variance and historical decomposition that can directly inform policy. Bayesian estimation addresses the limitations of classical methods by combining prior information from the existing South African and international DSGE literature with the model's likelihood function and observed

		data, producing posterior parameter distributions that are both empirically informed and theoretically constrained.
9	Secondary problem	- States limitations of the previous models - Introduces Bayesian estimation, which addresses the limitations of classical methods.
9	Significance of the Study – Cite two studies (Indicates how they are different by distinguishing the focus of this study)	- Addressed.
13	Literature review (The first page and 17 under the literature review section are not a literature review. This is just a discussion about DSGE).	- Introduces the chapter, provides a brief overview of the topic, and provides the structure of the chapter.
16 -17	Literature review (The first page and 17 under the literature review section are not a literature review. This is just a discussion about DSGE).	- Introduces the DSGE model and provides empirical literature on the model.
	Literature review – Citations	- Added more empirical works (More citations)
	Chapter 3 - Small Open Economic Model: Fix the equation typos	- Corrected all typos in the equations. Equations have been aligned to the text and edited.
36-37	4.4.2 – Priors – specify the method of parameter collection	- The study informs on the parameter estimation using the Bayesian method.
43	Estimation – Compare findings to previous studies. Pg 42 Potential output does not respond to the shock. Have other studies found similar results?	- Addressed. The study compares our findings to those of Hollander and van Lill (2018),
45	Theoretical contradiction: Interest rate appreciation and exchange rate depreciation	- Addressed, Hollander and van Lill (2018), documented similar results
57 - 58	Conclusion: Discuss the implications of your findings. Repetition of details in previous chapters	- Addressed. - Discussed the policy implications thoroughly. - Removed repeated details and expanded more on discussing the findings.
	Grammar	- Addressed.
	EXTERNAL EXAMINER	
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Appendix B

Turnitin Originality Report

This appendix contains the Turnitin originality report for this thesis.

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