Public debt and inflation dynamics in South Africa: An estimated NK-DSGE model with a mixed monetary-fiscal regime

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Abstract

This paper studies how monetary and fiscal policy jointly shape inflation and public debt dynamics in South Africa. We develop and estimate a New Keynesian DSGE model that allows for a coexistence regime, in which both policies contribute to price stability, rather than operating under strict monetary or fiscal dominance. A key feature of the model is the distinction between backed and unbacked public debt, which determines whether debt is stabilized through future fiscal surpluses or inflation. The results show that South Africa is best characterized by a mixed policy regime with a moderate degree of fiscal backing. Compared to standard regimes, the coexistence framework delivers more balanced macroeconomic outcomes by moderating the responses of inflation, public debt, and output to shocks. These findings suggest that effective macroeconomic stabilization in emerging markets requires coordinated policy actions. More broadly, the results highlight that credible and well-aligned monetary-fiscal frameworks are essential for maintaining stability in the presence of rising public debt.

JEL Classification: E120, E31, E61, E63, H63

Keywords: Monetary and fiscal policy coordination; Fiscal inflation; Unbacked public debt; New-Keynesian DSGE; Bayesian.

1 Introduction

This paper examines the role of a coexistence regime in shaping the impact of monetary and fiscal policy shocks on the dynamics of public debt, inflation, and other key variables in South Africa, comparing it with two standard regimes: Regime M (monetary dominance or active monetary policy and passive fiscal policy) and Regime F (fiscal dominance or active fiscal policy and passive monetary policy). Under the coexistence regime, public debt is categorized into two components: backed and unbacked. The backed public debt is stabilized through future fiscal surpluses, while the unbacked public debt is stabilized through inflation,

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which is referred to as fiscal inflation (Bianchi et al., 2023). Thus, public debt is stabilized jointly through fiscal and monetary policy. This contrasts with the two standard regimes with distinct roles of monetary and fiscal policy. Under Regime M, monetary policy is responsible for price stability and fiscal policy is responsible for debt stabilization. Under Regime F, public debt is stabilized through inflation, as the fiscal authority does not adjust future taxes or surpluses (Leeper, 1991; Leeper and Leith, 2016). This latter regime aligns with the fiscal theory of price level (FTPL) (see, e.g., Cochrane, 2001; Leeper and Leith, 2016; Cochrane, 2023).

In South Africa, recent macroeconomic environments underscore the relevance of the coexistence regime. Since the global financial crisis (GFC), macroeconomic conditions have deteriorated, marked by unprecedented high public debt levels, high inflation, and sluggish economic growth (National Treasury, 2024). On the fiscal front, the public debt-to-GDP ratio increased rapidly from 27.0% in 2008 (pre-GFC) to 68.9% in 2020, and further to the peak of 77.3% in 2024. The latest surge in public debt was partly fueled by the 500 billion rand (approximately 10% of South Africa's GDP in 2020) Covid-19 stimulus package announced in April 2020, which was largely financed through medium- and long-term borrowing. The primary balance-to-GDP ratio has switched from surpluses to persistent deficits, as total government expenditure growth has consistently outpaced revenue growth.[1] The surge in government expenditure has been largely driven by increasing public sector wages, a rapid increase in household transfers aimed at cushioning households from the adverse effects of the GFC and the Covid-19 pandemic (see Figure 1), and liquidity injections into state-owned enterprises. Eskom, South African Airways, Transnet and Denel have received government bailouts amounting to approximately 300 billion rand since 2019, with Eskom being the largest beneficiary. At the same time, economic growth has slowed significantly, averaging just 1.1% since 2009 compared to 3.6% before the crisis, further constraining the fiscal authority's ability to stabilize debt through future surpluses despite ongoing consolidation efforts such as expenditure ceilings and tax increases.

On the monetary front, inflation has displayed a mixed pattern. Pre-GFC period, inflation was generally high and averaged 6.6% between 1994 and 2008, exceeding the upper bound of the 3-6% target range. It moderated after the GFC and averaged 5.2% between 2009 and 2020, aligning more closely with the target. However, inflation surged during the pandemic and remained elevated for an extended period. The recent surge in inflation coincided with a period of substantial increase in fiscal stimulus package. The SARB maintained a contractionary stance during the pre-GFC period, as the repo rate averaged 12.2% between 1994 and 2008. Monetary policy became more accommodative during the post-GFC period, with the repo rate declining to an average of 6.1% between 2009 and 2020. In response to the recent surge in inflation, the SARB shifted back to a contractionary stance in the first quarter of 2022. Thus, the repo rate was raised from 3.6% in the last quarter of 2021 to 8.25% in the second quarter of 2024 (see Figure 2).

Figures 1 and 2 reveal that the relationship between inflation and public debt has not been stable over time. While public debt has displayed a persistent increasing since the GFC, inflation declined after the GFC and increased following the COVID-19 pandemic. This changing co-movement suggests that the link between fiscal dynamics and inflation may be state-dependent, with periods of elevated fiscal stress associated

[1] Total government expenditure is defined as the sum of government consumption expenditure and transfers.

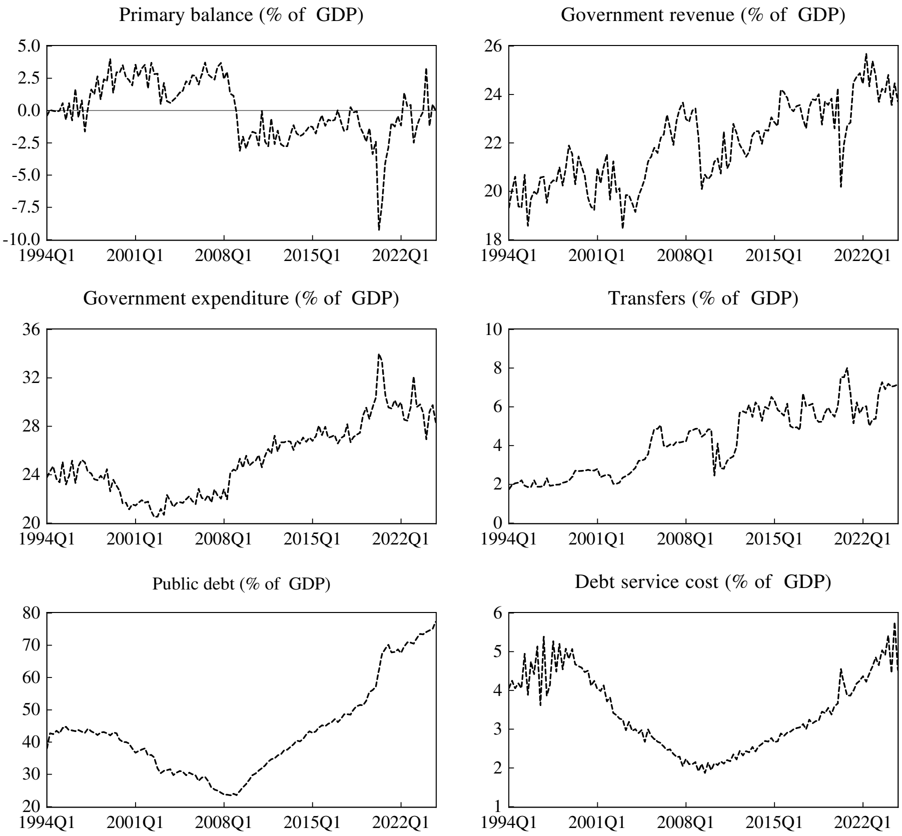


Figure 1: Evolution of selected fiscal variables. All variables are seasonally adjusted at an annual rate using the X-12 filter, except for government consumption expenditure, which is already seasonally adjusted at the source.

with stronger interactions between fiscal and monetary policy. This raises critical concerns regarding the fiscal authority's capacity to fully stabilize public debt through future fiscal adjustments and its broader implications for inflation dynamics, which also motivates our empirical investigation of a coexistence regime.

These developments suggest that partial fiscal backing provides a more realistic characterization of South Africa's policy environment, where public debt continues to rise despite fiscal consolidation efforts, potentially interfering with the price stability objective of the SARB. The FTPL asserts that monetary policy can only achieve price stability when complemented by a sustainable fiscal policy (see, e.g., Leeper, 1991; Sims, 1994; Cochrane, 2023). A large body of literature on the coordination of monetary and fiscal policy focuses on the two standard mixed policy regimes: Regime M and Regime F. These two extreme cases assume that the fiscal authority either fully stabilizes public debt through future fiscal surpluses (Regime M) or does not stabilize it at all (Regime F). However, the current macroeconomic challenges in South Africa make it difficult for the fiscal authority to stabilize all outstanding public debt through future primary surpluses. On the other hand, it is also unrealistic to inflate away all public debt. Thus, the relevance of a coexistence regime cannot be overemphasized, under which only part of public debt is backed by future fiscal adjustments, while the remaining component is stabilized through inflation dynamics (Bianchi et al., 2023). Understanding this interaction between fiscal and monetary policy is therefore critical for assessing the joint determination of inflation, public debt, and macroeconomic stability.

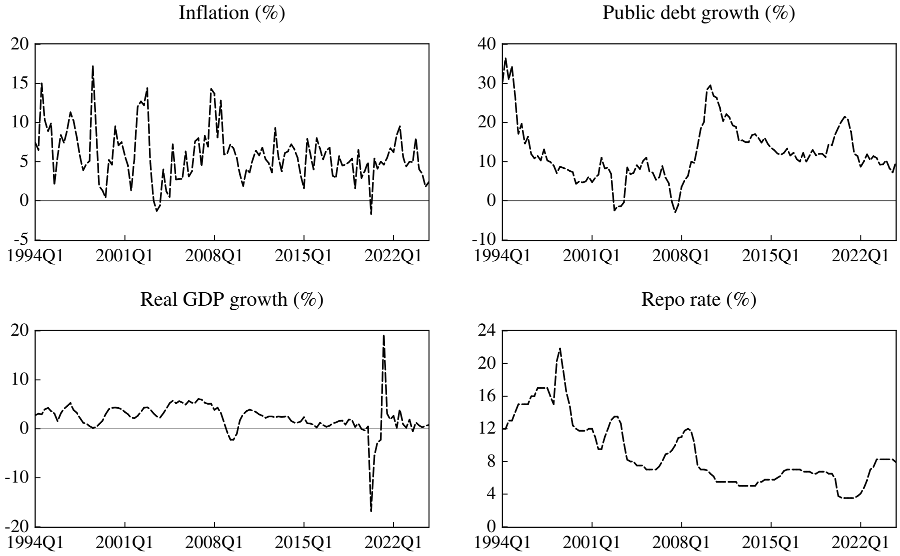


Figure 2: Evolution of real GDP, public debt, inflation and repo rate.

The present study contributes to the literature in several important ways. First, it builds on the recent framework of a coexistence regime - a setting that combines elements of both Regime M and Regime F, in which monetary and fiscal policy jointly contribute to price and debt stabilization, moving beyond the standard dichotomy of Regime M and Regime F. While this framework has been developed theoretically (see, Bianchi et al., 2023), empirical applications remain limited (see, Smets and Wouters, 2024), particularly for emerging market economies. Second, the present study introduces and estimates a key coexistence parameter, which governs the extent to which policy shocks influence unbacked public debt and corresponding fiscal inflation. This provides a tractable and empirically identifiable way to quantify how policy shocks are transmitted into the unbacked component of public debt and, in turn, into fiscal inflation. Third, the present study offers a structural estimation of the model using South African data, allowing us to quantify how fiscal conditions interact with inflation dynamics across different macroeconomic environments and the effectiveness of the coexistence regime in promoting the stability of both public debt and inflation. The present study is the first to develop a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) model for South Africa with a fiscal block, focusing on monetary and fiscal mixed policy regimes. The existing studies in the South African literature employ a standard NK-DSGE model with a fiscal block, but they focus solely on the standard Regime M (see, e.g., Jooste et al., 2013). Fourth, the present study conducts a subsample sensitivity analysis of the macroeconomic effects of policy shocks under the novel coexistence regime, comparing the pre-GFC and post-GFC periods. The subsample analysis is particularly relevant in the context of South Africa, as the 2007/08 GFC marked a significant shift in the macroeconomic environment from a period of favourable conditions (pre-GFC) to that of adverse conditions (post-GFC). This shift could have important implications for the propagation of policy shocks, warranting further exploration. Last, this analysis also explores the debt service cost channel, given the distinct interest rate environments between the two periods.

The present study develops a NK-DSGE model with a fiscal block and the role of monetary and fiscal policy coordination. The model introduces a novel fiscal rule that incorporates two components of public debt: backed and unbacked, as in Bianchi et al. (2023), which allows us to study the macroeconomic effects of fiscal and monetary policy shocks under the coexistence regime. We introduce a parameter governing the proportion of fiscal and monetary policy shocks influencing unbacked public debt. This contrasts with Bianchi et al. (2023), in which the authors categorize transfers from the US fiscal stimulus programs during crisis periods as those influencing unbacked public debt. Furthermore, we adapt the model to capture the salient characteristics of the South African economy. We estimate the model with Bayesian methods using South African data over the sample period 1994Q1-2024Q4. For the subsample sensitivity analysis, we estimate the model for two distinct periods: the pre-GFC period covering 1994Q1-2008Q4, and the post-GFC period covering 2009Q1-2024Q4.

The results show that under the coexistence regime, where the monetary and fiscal authorities coordinate to stabilize public debt, the economic effects of fiscal and monetary policy shocks are relatively balanced. Following the positive government consumption and transfer shocks, the coexistence regime delivers a balanced increase in inflation, while also achieving a relatively larger reduction public debt and higher output. In contrast, Regime M effectively controls inflation but at the cost of a relatively smaller reduction in public debt and a weaker output performance. Similarly, following a positive tax revenue shock, the coexistence regime leads to a moderate and more balanced response in public debt and inflation, with a relatively minimal reduction in output compared to Regime M and Regime F. In contrast, Regime M achieves a significant decline in public debt, but at the cost of higher inflation and a larger initial decline in output, as higher tax revenue reduces the need for government borrowing and household disposable income. When the economy experiences a contractionary monetary policy shock, both the coexistence regime and Regime F outperform Regime M by containing public debt without triggering inflation, while maintaining stable output. In contrast, while Regime M effectively achieves lower inflation, it does so at the cost of a higher public debt as well as a contraction in output, necessitating future fiscal adjustments to stabilize the debt. Such adjustments could be challenging in South Africa's current economic environment, considering the limited fiscal space and prolonged sluggish economic growth. Therefore, the coexistence regime emerges as a more desirable policy mix, effectively managing both public debt and inflation, while offering a solution to a relatively stable economic growth.

Historical shock decomposition supports the impulse response findings regarding the influence of monetary and fiscal policy shocks on the dynamics of public debt, inflation, and other key variables. The analysis reveals that while supply and demand shocks are the primary drivers of the dynamics of public debt and inflation, monetary and fiscal policy shocks also make a notable contribution. Subsample sensitivity analysis underscores the significant role of initial fiscal conditions and the debt service cost channel in influencing debt dynamics under the coexistence regime. During the pre-GFC period, favorable fiscal conditions contribute to a larger initial decline and a more moderate subsequent increase in public debt, while a stronger debt service cost channel amplifies the increase in public debt. Conversely, during the post-GFC period, adverse fiscal conditions dampen the initial decline but amplify the subsequent increase in public debt, while a weaker debt service cost channel helps to moderate the rise.

These findings highlight a key challenge for emerging market economies. When fiscal capacity is constrained, the burden of stabilizing public debt cannot be borne entirely by future fiscal surpluses, leading to a greater reliance on inflationary adjustment. As a result, price stability becomes more closely linked to fiscal conditions, complicating the conduct of monetary policy. The South African evidence provides a refinement of the conventional dichotomy between Regime M and fiscal Regime F. Rather than conforming to either regime, the results suggest that macroeconomic dynamics are better characterized by a coexistence regime, in which both fiscal and monetary forces jointly determine inflation. This indicates that the traditional binary classification may be too restrictive for economies facing persistent fiscal pressures.

The subsequent sections of the paper are organized as follows. Section 2 discusses the literature related to the present study. Section 3 outlines the model. Section 4 discusses the model estimation strategy and the estimation results; Section 5 discusses the impulse response analysis; Section 6 discuses historical shock decomposition of key variables; Section 7 discusses shock decomposition of components of inflation and public debt. Section 8 discusses the subsample sensitivity analysis; and Section 9 concludes.

2 Related literature

The present section reviews the literature relevant to the present study. This study is related to two main streams of literature. The study closely relates to the emerging literature extending the (NK-DSGE) model with partially unbacked public debt to understand the influence of a mixed monetary-fiscal regime on the macroeconomic effects of policy shocks (see, e.g., Cochrane, 2022; Bianchi et al., 2023; Smets and Wouters, 2024).[2] Bianchi et al. (2023) estimate a two-agent NK-DSGE model with partially unbacked public debt to examine the effects of fiscal transfer shocks on the dynamics of inflation and economic growth in the US. The authors link the significant increase in transfers from the large fiscal stimulus programs during the crisis periods to unfunded transfers (i.e. transfers funded by unbacked public debt), while all other transfers correspond to funded transfers (i.e. transfers funded by backed public debt). They find that the high and persistent inflation in the mid-1960s to mid-1970s, and post-pandemic period was primarily driven by transfer shocks influencing unbacked public debt, while transfer shocks influencing backed public debt were not inflationary. The post-pandemic transfer shock led to a substantial increase in fiscal inflation amid economic recovery.

Similarly, Smets and Wouters (2024) extend the Smets and Wouters (2007) model with partially unbacked public debt to examine the effects of partial fiscal backing on the transmission of policy and non-policy shocks to inflation and economic activity in the US. The authors find that partial fiscal backing amplifies the inflationary effects of fiscal transfer and supply shocks. Furthermore, they establish that the high inflation in the 1970s and the post-pandemic period was fiscal in nature, aligning with the findings of Bianchi et al. (2023). While Bianchi et al. (2023) decompose fiscal transfer shocks into two components - influencing backed and unbacked public debt, and model all other shocks in a standard way influencing only backed

[2] Bianchi et al. (2023) refer to this mixed regime as a coexistence regime, while Smets and Wouters (2024) refer to it as an intermediate regime.

public debt, Smets and Wouters (2024) extend this approach by decomposing a broader range of both policy and non-policy shocks into these two components. Considering the existing literature, the novel coexistence regime has so far been studied within the context of an advanced economy, particularly the US economy.

The present study also relates to a growing body of literature examining the macroeconomic effects of policy shocks on the dynamics of public debt and inflation, under the two standard mixed policy regimes (see, e.g., Bhattarai et al., 2014; Bianchi, 2012; Bianchi and Ilut, 2017; Leeper and Leith, 2016; Leeper et al., 2017; Banerjee et al., 2022; Ascari et al., 2023; Mao et al., 2023). Regarding fiscal policy shocks, these studies show that a positive government spending shock either has a contractionary or a weaker expansionary effect on economic activity, consumption and inflation under Regime M, while it has a stronger expansionary effect under Regime F (Bianchi and Ilut, 2017; Ascari et al., 2023; Mao et al., 2023). This is due to the amplification of the positive wealth effect under Regime F, as private agents do not anticipate taxes to adjust in future in response to increase in the public debt. Similarly, a contractionary monetary policy shock that raises real interest rates is more inflationary under Regime F than under Regime M (see e.g., Bianchi, 2012; Bhattarai et al., 2014; Leeper and Leith, 2016). However, these studies also predominantly focus on advanced economies, while literature is limited in the context of South Africa.

Swanepoel (2004) assesses whether South Africa's monetary and fiscal policies were coordinated or uncoordinated between 1970 and 2003. The author shows that monetary and fiscal policy stance has alternated between periods of coordination and a lack thereof. Some studies in the context of South Africa examine the relationship between budget deficits and inflation using econometric models (see, e.g., Anoruo, 2003). Other related studies examine the effects of government spending shocks on South Africa's real business cycles, but discussions on public debt and inflation dynamics are limited (see, e.g., Jooste et al., 2013). Thus, while existing studies offer valuable insights into public debt and inflation dynamics, they leave a gap in understanding how coordinated policy actions influence the macroeconomic effects of policy shocks in South Africa. To our knowledge, no existing study has examined the effects of monetary and fiscal policy shocks on inflation and other key variables in South Africa, with a specific focus on the role of mixed policy regimes. The present study seeks to bridge this gap.

3 The model

While the model builds on a benchmark New Keynesian model, several features depart from the canonical framework and are central to our analysis. In particular, households invest in a portfolio of government bonds with different maturities and are subject to consumption and labor income taxes; public debt is decomposed into backed and unbacked components, and correspondingly the model features non-fiscal and fiscal inflation; a shadow economy is introduced to disentangle the dynamics of backed and unbacked public debt within a unified framework.

This model is also adapted to capture the salient characteristics of the South African economy, where a large proportion of the population is hand-to-mouth. The model is populated by two types of households (Ricardian and non-Ricardian) as in Galí et al. (2007). Both Ricardian (savers) and non-Ricardian (hand-to-mouth) households consume final goods and supply labor to the producing firms, but differ in their consumption pattern and financial behavior. Ricardian households smooth their consumption over time, invest in government bonds, own the producing firms, and receive dividends. In contrast, non-Ricardian households consume their entire disposable income from labor earnings and transfers from the government. Regarding taxation, both Ricardian and non-Ricardian households pay consumption and labor income taxes.

The producing firms comprise a continuum of intermediate-goods producing firms and a representative final-goods producing firm. The intermediate-goods firms use labor as the only input and face Rotemberg (1982) type price rigidity when setting the prices. The final-good firm aggregates intermediate goods to produce output.[3]

3.1 Households

There is a continuum of households indexed by $i \in [0, 1]$, which are divided into two groups, namely Ricardian households denoted by a superscript 'r' constituting a share of $1-\mu$, and non-Ricardian households denoted by a superscript 'nr' constituting a share μ.

3.1.1 Ricardian households

Ricardian households derive utility from real consumption (c_t^r) and disutility from the supply of labor hours (N_t^r) by maximizing the following expected lifetime utility function:[4]

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\xi_t^c \frac{\left(c_t^r - h c_{t-1}^r\right)^{1-\sigma}}{1-\sigma} - \chi \frac{(N_t^r)^{1+\eta}}{1+\eta} \right], \tag{1}$$

subject to the budget constraint:

$$(1+\tau_c)c_t^r + \frac{B_t}{R_t P_t} + \frac{(Q_t^m e^{\xi_t^{tp}})B_t^m}{P_t} = \frac{B_{t-1}}{P_t} + (1+\rho Q_t^m)\frac{B_{t-1}^m}{P_t} + (1-\tau_{n,t})\frac{W_t}{P_t}N_t^r + \frac{\Psi_t}{P_t}, \tag{2}$$

where the parameter $\beta \in (0, 1)$ denotes the households' discount factor, $h \in (0, 1)$ is the degree of internal habit formation in consumption, $\sigma > 0$ is the inverse of intertemporal elasticity of substitution, $\eta > 0$ is the inverse of Frisch elasticity of labor supply, and χ is the labor disutility parameter.

The term W_t denotes nominal wage, Ψ_t denotes nominal dividends from firms, and P_t is the price level. Consistent with the literature, this study assumes that only Ricardian households receive dividends, as they own the intermediate-goods producing firms (see, e.g., Galí et al., 2004; Galí et al., 2007; Bianchi et al., 2023). The terms τ_c and $\tau_{n,t}$ are tax rates on consumption and labor income, respectively.[5] This study assumes a time-varying labor income tax rate, while a constant consumption tax rate, reflecting the typical

[3] The production sector is a standard one in the NK-DSGE model and is presented in Appendix A.

[4] Aggregate variables in lowercase letters are expressed in real terms, while those in uppercase letters are in nominal terms, except for labor supply.

[5] In South Africa, personal income tax (a proxy for labor income tax) and value-added tax (a proxy for consumption tax) account for approximately 65% of total tax revenue, making them the largest contributors.

fiscal dynamics in most economies, including South Africa. Bianchi et al. (2023) also assume a constant consumption tax rate. Similarly, Leeper et al. (2010) model labor income tax as responsive to changes in public debt, while treating consumption tax as an exogenous process, reflecting the empirical observation that it rarely adjusts to changes in public debt in the US. Moreover, income tax rates are actively used as budget-balancing tools, whereas value added taxes (VAT) tend to remain stable due to political constraints. In South Africa, for example, VAT rate was increased only once from 14% to 15% during the sample period 1994-2024. Furthermore, a constant consumption tax rate allows us to precisely identify the effects of labor income tax on debt dynamics.

ξ_t^c denotes a consumption preference shock, which evolves according to the following AR(1) process:

$$\log(\xi_t^c) = \rho_c \log(\xi_{t-1}^c) + \epsilon_t^c, \tag{3}$$

where $\rho_c \in (0,1)$ is the persistence parameter of the preference shock. The innovation ϵ_t^c is an iid and normally distributed with zero-mean and constant variance (σ_c^2).

Ricardian households invest in a portfolio of one period government bonds (B_t) and long-term government bonds (B_t^m). It is essential to incorporate long-term bonds in the model, as the vast majority of domestic government debt is issued at medium- to long-term maturities (i.e., longer than one year), accounting for about 90 percent of total domestic government bonds.[6] As such, modelling long-term bonds is important for capturing the dynamics of the market value of public debt and the transmission of fiscal and financial shocks. The one period government bond earns a gross nominal return (R_t), which is the monetary policy rate. The long-term government bond is issued at a price (Q_t^m) in period t. This modelling choice is particularly relevant for South Africa, where about 90 percent of domestic government bonds have maturities longer than one year, making long-term bond pricing central to public debt dynamics. The parameter $0 < \rho < \beta^{-1}$ is a constant rate of decay of the maturity structure, which determines the average duration of the long-term bond portfolio, given as $(1 - \beta\rho)^{-1}$ (Woodford, 2001).

Solving Richardian households' optimization problem and combining the two Euler equations for short-term and long-term government bonds, we can derive a non-arbitrage condition that links the gross nominal return on the short-term bonds to the bond price as follows:

$$E_t \left(\frac{1 + \rho Q_{t+1}^m}{Q_t^m} \right) = R_t e^{\xi_t^{tp}}. \tag{4}$$

The term ξ_t^{tp} denotes a term premium shock, which acts as a compensation to the investors for holding long-term bonds amidst economic uncertainties, such as inflation risk (see, e.g., Bianchi et al., 2023). Thus, the term premium shock incentivizes Ricardian households to invest in long-term bonds. This shock is particularly relevant in the current environment, where the unprecedented high public debt level has increased term premia due to growing concerns over the sustainability of long-term debt. The shock evolves according

[6] Given that foreign public debt consists of only around 10% of South Africa's total public debt, we consider domestic public debt as a proxy for total public debt.

to the following AR(1) process:

$$\xi_t^{tp} = \rho_{tp}\xi_{t-1}^{tp} + \epsilon_t^{tp}, \tag{5}$$

where $\rho_{tp} \in (0,1)$ is the persistence parameter of the term premium shock and ϵ_t^{tp} is an iid innovation with zero-mean and constant variance (σ_{tp}^2).

3.1.2 Non-Ricardian households

Non-Ricardian households consume all their disposable income each period, without smoothing consumption in response to fluctuations in disposal income or intertemporally substituting based on changes in interest rates (Galí et al., 2007). Thus, the period-to-period utility function for non-Ricardian households is given as:

$$U_t(c_t^{nr}, N_t^{nr}) = \xi_t^c \frac{\left(c_t^{nr} - hc_{t-1}^{nr}\right)^{1-\sigma}}{1-\sigma} - \chi\frac{(N_t^{nr})^{1+\eta}}{1+\eta}, \tag{6}$$

subject to a budget constraint that equates their consumption to disposable income:

$$(1+\tau_c)c_t^{nr} = (1-\tau_{n,t})\frac{W_t}{P_t}N_t^{nr} + \frac{TR_t}{P_t}, \tag{7}$$

where N_t^{nr} denotes non-Ricardian households' labor supply and TR_t denotes lump-sum government transfers. This study assumes that only non-Ricardian households receive government transfers, as their earning capacity is limited, making them eligible for the program.

3.2 Government

The government's flow budget constraint is given as:

$$\frac{(Q_t^m e^{\xi_t^{tp}})B_t^m}{P_t} + \tau_t = (1+\rho Q_t^m)\frac{B_{t-1}^m}{P_t} + \frac{G_t^c}{P_t} + \frac{TR_t}{P_t}, \tag{8}$$

where the term $\tau_t = (\tau_c c_t + \tau_{n,t}w_t N_t)$ denotes total real tax revenue and G_t^c is the nominal government consumption expenditure. Following the literature, this study assumes one period bond is in zero net supply, implying $B_t = 0$ in equilibrium (see, e.g., Woodford, 2001).

We rewrite the government flow budget constraint in real terms as follows:

$$(Q_t^m e^{\xi_t^{tp}})b_t^m + \tau_t = (1+\rho Q_t^m)\frac{b_{t-1}^m}{\Pi_t} + g_t^c + tr_t, \tag{9}$$

where g_t^c is the real government consumption expenditure, and tr_t is the real government transfers. Thus, we define $g_t = g_t^c + tr_t$ as total government expenditure. This study assumes both g_t^c and tr_t evolve exogenously according to the following AR(1) processes:

$$\frac{g_t^c}{y_t} = (1-\rho_{gc})\frac{g^c}{y} + \rho_{gc}\frac{g_{t-1}^c}{y_{t-1}} + \epsilon_t^{gc}, \tag{10}$$

$$\frac{tr_t}{y_t} = (1-\rho_{tr})\frac{tr}{y} + \rho_{tr}\frac{tr_{t-1}}{y_{t-1}} + \epsilon_t^{tr}, \tag{11}$$

where y_t is the real GDP, $\frac{g_t^c}{y_t}$ denote real consumption government expenditure-to-GDP ratio and $\frac{tr_t}{y_t}$ denotes real transfers-to-GDP ratio.[7] The parameters $\rho_{gc} \in (0,1)$ and $\rho_{tr} \in (0,1)$ denote the persistence of government consumption expenditure and transfers, respectively. The innovations ϵ_t^{gc} and ϵ_t^{tr} denote iid government consumption and transfers shocks, respectively, with zero-means and constant variances (σ_{gc}^2 and σ_{tr}^2).

3.2.1 Coexistence regime

Following Bianchi et al. (2023), the fiscal rule under the coexistence regime consists of both backed and unbacked public debt. The fiscal rule is represented by a reaction function with future total tax revenue-to-GDP ratio ($\frac{\tau_t}{y_t}$) adjusting in response to changes in the market value of public debt-to-GDP:

$$\frac{\tau_t}{y_t} = \frac{\tau}{y}\left(\frac{d_{t-1}}{d_{t-1}^f}\right)^{\delta_\tau^{PF}}\left(\frac{d_{t-1}^f}{d}\right)^{\delta_\tau^{AF}} e^{\xi_t^\tau}, \tag{12}$$

where we define $d_t = \frac{Q_t^m b_t^m}{y_t}$ as the market value of the total outstanding real public debt-to-GDP ratio. The expression $d_t^f = \frac{(Q_t^m)^f (b_t^m)^f}{y_t^f}$ denotes the real market value of unbacked public debt-to-GDP ratio. Thus, the difference between d_t and d_t^f is the real market value of the backed public debt-to-GDP ratio, d_t^m. The relationship is more transparently expressed in log terms: $d_t^m = d_t - d_t^f$.

The parameter δ_τ^{PF} measures the responsiveness of future tax revenue to changes in backed public debt (the difference between total public debt and unbacked public debt). As such, backed debt is fully stabilized by an increase in future tax revenue, i.e. fiscal policy is passive. In contrast, the parameter δ_τ^{AF} measures the responsiveness of tax revenue to changes in unbacked public debt from its steady state.

The tax revenue shock ξ_τ evolves according to an AR(1) process as follows:

$$\xi_t^\tau = \rho_\tau \xi_{t-1}^\tau + \epsilon_t^\tau, \tag{13}$$

where the parameter $\rho_\tau \in (0,1)$ measures the persistence of tax revenue shock and ϵ_t^τ is an iid innovation

[7] A variable without a time subscript denotes its steady state value.

with zero-mean and constant variance (σ_{τ}^2).

The monetary authority follows a Taylor-type interest rate rule. As in Bianchi et al. (2023), the interest rate rule has two components of inflation - non-fiscal and fiscal:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\Pi_t}{\Pi_t^f}\right)^{\alpha_\pi^{AM}} \left(\frac{\Pi_t^f}{\Pi}\right)^{\alpha_\pi^{PM}}\right]^{1-\rho_R} e^{\epsilon_t^R}, \tag{14}$$

where Π_t^f denotes fiscal inflation, i.e. the level of inflation due to unbacked public debt, while Π_t denotes total inflation. Accordingly, non-fiscal inflation which corresponds to backed public debt is defined as $\Pi_t^m = \Pi_t - \Pi_t^f$, i.e. the difference between total inflation and fiscal inflation.

The parameter α_π^{AM} measures the response of monetary policy to changes in non-fiscal inflation, while the parameter α_π^{PM} measures the response of monetary policy to changes in fiscal inflation from steady state. The parameter $0 < \rho_R < 1$ represents the degree of interest rate smoothing. ϵ_t^R is an iid monetary policy shock with zero-mean and a constant variance i.e. $\sim (0, \sigma_R^2)$.

Following Leeper (1991), the present study assigns the values of the policy parameters to meet the conditions that guarantee the existence of a unique equilibrium solution with the coexistence of Regime M and Regime F. Fiscal policy is passive when $\beta^{-1} - \delta_\tau^{PF} < 1$, while monetary policy is active when $\alpha_\pi^{AM}\beta > 1$. Thus, the fiscal authority increases future tax revenue as needed to stabilize backed public debt and the monetary authority adjusts the nominal policy rate by more than one-to-one to control non-fiscal inflation. Fiscal policy is active when $\beta^{-1} - \delta_\tau^{AF} > 1$, while monetary policy is passive when $\alpha_\pi^{PM}\beta < 1$. Thus, the fiscal authority implements minimal or no fiscal adjustments to stabilize the debt, leading to fiscal-driven inflation, as the monetary authority inadequately or does not adjust interest rates in response to fiscal inflation.

3.2.2 The shadow economy

Following Bianchi et al. (2023), the present study augments the actual economy with a shadow economy. The shadow economy does not represent a separate economic sector. It is rather isomorphic to a fiscally led sub-economy and can be interpreted as an accounting device that tracks the unbacked public debt (d_t^f), which is expected to be stabilized through fiscal inflation (Π_t^f) within a unified framework. This framework provides a transparent framework to analyze the coexistence regime.

In Bianchi et al. (2023), the shadow economy tracks the unbacked component of public debt within an additive decomposition framework. In contrast, our approach introduces and estimates a coexistence parameter, ζ, that tracks the proportion of fiscal and monetary policy shocks influencing unbacked public debt and the corresponding fiscal inflation. A lower value of ζ implies that a smaller share of a given shock translates into movements in unbacked public debt and its associated fiscal inflation. It is worth noting that ζ does not split a policy shock across the actual and shadow economies, but rather governs how strongly a given shock feeds into the fiscal component of inflation within the overall equilibrium.

The shadow economy's fiscal and monetary rules are specified as:[8]

$$\frac{\tau_t}{y_t} = \frac{\tau}{y}\left(\frac{d^f_{t-1}}{d}\right)^{\delta_\tau^{AF}} e^{\zeta\xi_t^\tau}, \tag{15}$$

$$\frac{R_t^f}{R} = \left(\frac{R_{t-1}^f}{R}\right)^{\rho_R}\left[\left(\frac{\Pi_t^f}{\Pi}\right)^{\alpha_\pi^{PM}}\right]^{1-\rho_R} e^{\zeta\epsilon_t^R}, \tag{16}$$

Similarly, the shadow economy's government consumption expenditure and transfers equations are specified as:

$$\frac{g_t^f}{y_t^f} = (1-\rho_g)\frac{g}{y} + \rho_g\frac{g_{t-1}^f}{y_{t-1}^f} + \zeta\epsilon_t^g, \tag{17}$$

$$\frac{tr_t^f}{y_t^f} = (1-\rho_{tr})\frac{tr}{y} + \rho_{tr}\frac{tr_{t-1}^f}{y_{t-1}^f} + \zeta\epsilon_t^{tr}, \tag{18}$$

The remaining equations for the shadow economy are identical to that of the actual economy, distinguished by a superscript $'f'$.[9]

3.3 Standard regimes M and F

To compare the coexistence regime with the two standard regimes, the present study also considers the standard fiscal rule in the NK-DSGE literature, with public debt either fully backed (Regime M) or not backed at all (Regime F) (see, e.g., Leeper, 1991; Leeper and Leith, 2016). Under the two standard regimes, the fiscal authority adjusts future tax revenue in response to changes in the market value of total public debt from its steady state:

$$\frac{\tau_t}{y_t} = \frac{\tau}{y}\left(\frac{d_{t-1}}{d}\right)^{\delta_\tau} e^{\xi_t^\tau}, \tag{19}$$

where the parameter δ_τ measures the extent to which the fiscal authority adjusts future tax revenue-to-GDP ratio in response to changes in the market value of total public debt-to-GDP ratio from its steady state.

Similarly, the monetary policy rule follows the standard Taylor-type interest rate rule as follows:

[8] Smets and Wouters (2024) extend the concept of partial fiscal backing to all business cycle shocks. In contrast, Bianchi et al. (2023) focus solely on fiscal shocks in the context of partial fiscal backing, while assuming that all other business cycle shocks exclusively influence backed public debt.

[9] The complete set of equations for the actual and shadow economy are presented in appendix B.

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\alpha_\pi}\right]^{1-\rho_R} e^{\epsilon_t^R}, \tag{20}$$

where the parameter α_π measures the response of monetary policy to changes in total inflation from its steady state.

As shown in Leeper (1991), a unique equilibrium exists under Regime M when $\alpha_\pi\beta > 1$ and $\beta^{-1} - \delta_\tau < 1$, and under Regime F when $\alpha_\pi\beta < 1$ and $\beta^{-1} - \delta_\tau > 1$.

3.4 Market clearing and aggregation

In a symmetric equilibrium, $N_t(j) = N_t$, $Y_t(j) = Y_t$, and $P_t(j) = P_t$. The aggregation for labor hours is a weighted sum of Ricardian and non-Ricardian households labor hours as follows:

$$N_t = (1-\mu)N_t^r + \mu N_t^{nr}. \tag{21}$$

Similarly, the aggregation for consumption is a weighted sum of Ricardian consumption and non-Ricardian consumption as follows:

$$c_t = (1-\mu)c_t^r + \mu c_t^{nr}. \tag{22}$$

Aggregate equilibrium condition for labor supply is given as:

$$w_t = \frac{\chi(N_t)^\eta}{\lambda_t(1-\tau_{n,t})}. \tag{23}$$

3.5 Balanced growth path

The technology process (Z_t) grows at the rate $\lambda_{z,t} = Z_t/Z_{t-1}$, which aligns with the growth rate of the economy (see Appendix A.2). On a balanced growth path, the following aggregate variables are detrended with the technology process to obtain stationary variables expressed as: $\tilde{y}_t = \frac{y_t}{Z_t}$, $\tilde{c}_t = \frac{c_t}{Z_t}$, $\tilde{c}_t^r = \frac{c_t^r}{Z_t}$, $\tilde{c}_t^{nr} = \frac{c_t^{nr}}{Z_t}$, $\tilde{w}_t = \frac{w_t}{Z_t}$, $mc_t = \frac{mc_t}{Z_t}$, $\tilde{b}_t^m = \frac{b_t^m}{Z_t}$, $\tilde{d}_t = \frac{d_t}{Z_t}$, $\tilde{g}_t = \frac{g_t}{Z_t}$, $\tilde{g}_t^c = \frac{g_t^c}{Z_t}$, $\tilde{tr}_t = \frac{tr_t}{Z_t}$, $\tilde{\tau}_t = \frac{\tau_t}{Z_t}$. The Lagrangian multiplier is defined as $\tilde{\lambda}_t = \lambda_t Z_t$, and the stochastic discount factor as $\tilde{\Lambda}_t = \Lambda_t Z_t$. The model equations in the balanced growth path are listed in Appendix B.

4 Estimation

We estimate the NK-DSGE model for the South African economy using Bayesian methods.[10] Bayesian estimation allows researchers to include additional information about model parameters by specifying appropriate prior distributions for such parameters (An and Schorfheide, 2007). In this section, we discuss the prior and posterior distributions of the estimated parameters, prior which we discuss the observed variables and the calibrated parameters.

The shadow economy does not introduce additional independent shocks or parameters. Identification instead arises from cross-equation restrictions linking inflation dynamics, public debt accumulation, and bond pricing. The parameter ζ governs how shocks propagate through these relationships, thereby shaping the joint behavior of observed variables. As a result, the "shadow" variables are disciplined by the same set of observed variables and do not introduce additional degrees of freedom that would lead to over-parameterization.

4.1 Data

This study uses South African quarterly data over the sample period 1994Q1-2024Q4. The data set comprises a total of 8 observed variables, including real private consumption, real government consumption expenditure, real transfers, real tax revenue, real public debt, CPI inflation, short-term interest rate (repo rate), and long-term bond price (the inverse of 10-year bond yield).[11] The nominal fiscal variables are divided by the GDP deflator to obtain real values. All aggregate real variables are seasonally-adjusted and expressed in per capita terms by dividing each series by South Africa's working-age population (labor force). [12] The observed variables used in estimation are log-transformed and first-differenced, except for inflation which is stationary in levels. The data are largely sourced from the SARB database.[13]

4.2 Calibration

Following the standard approach in Bayesian estimation of DSGE models, we calibrate parameters that cannot be reliably identified from the observed variables being used in the estimation. Certain parameters are calibrated to ensure that the model's steady-state conditions match with the average values observed in the data, while others are adopted from existing literature.

Table 1 reports the calibrated parameters. The steady state technology growth rate (λ_z) is calibrated at 1.005 to match South Africa's average annual growth rate of 2.0% over the sample period. The steady-state gross inflation rate is set to 1.0145, corresponding to the sample mean of an annual inflation rate of 5.8%.

[10] We solve and estimate the model using Dynare version 6.2 (Adjemian et al., 2024). The model is solved under rational expectations, and equilibrium determinacy is ensured by imposing the Blanchard-Kahn conditions at each parameter draw. Only determinate solutions are retained, and all reported posterior estimates satisfy these conditions.

[11] This study uses the 10-year bond yield as a proxy for generating the bond price given that over 90% of South Africa's total outstanding public debt is long-term.

[12] Real private consumption and real government consumption expenditure are obtained directly from the source as seasonally adjusted series. In contrast, transfers, tax revenue, public debt are seasonally adjusted using X-12 filter at annualized rate. To ensure robustness, JDemetra+ is also employed as an alternative seasonal adjustment method. The series generated by X-12 and JDemetra+ are nearly identical, so are the estimation results, indicating that the results are robust to the choice of seasonal adjustment method.

[13] Except for labor force data which is obtained from Statistics South Africa (Stats SA) and the GDP deflator obtained from the FRED database.

The household discount factor is calibrated at 0.994 to match the average annualized nominal short-term interest rate of 9.1% observed over the sample period. Accordingly, the parameter governing the decay rate of the bond maturity structure (ρ) is calibrated at 0.981. This value ensures an average duration of the long-term bond portfolio of 40 quarters (or 10 years).

Table 1: Calibrated parameters and steady state key ratios.

Calibrated parameters			Steady state ratios of main variables		
Parameter	Notation	Value	Variable	Notation	SS value
Household discount factor	β	0.994	Public debt-to-GDP	b^m/y	0.430
Steady state gross inflation	Π	1.0112	Private consumption-to-GDP	c/y	0.661
Steady state technology growth rate	λ_z	1.005	Govt. expenditure-to-GDP	g/y	0.253
Bond maturity decay parameter	ρ	0.981	Transfers-to-GDP	tr/y	0.043
Inverse Subst. elasticity: consumption	σ	1	Total tax revenue-to-GDP	τ/y	0.318
Inverse Frisch elasticity: labor	η	5	Labor income tax rate	τ_n	0.252
Labor disutility parameter	χ	2.592	Consumption tax rate	τ_c	0.145
Share of non-Ricardian households	μ	0.7			

The inverse of the intertemporal elasticity of substitution of consumption (σ) is set to 1, consistent with standard value commonly used in the literature (see, e.g., Gali and Monacelli, 2005). The inverse of Frisch elasticity of labor supply (η) is set to 5, as in Steinbach et al. (2009). The labor disutility parameter is derived at 2.592. The proportion of non-Ricardian households (μ) is calibrated at 0.7, fairly consistent with Jooste et al. (2013). This large share of non-Ricardian households reflects South Africa's severe income inequality with a significant segment of the population lacking sufficient resources for savings or investment.

Regarding fiscal parameters, the labor income tax rate (τ_n) is calibrated at 0.252 to ensure that the steady state total tax revenue-to-GDP ratio guarantees a balanced government budget constraint. This value is slightly higher than the average personal income tax (PIT) rate of 0.213 from the data. The consumption tax rate (τ_c) is set to 0.145, matching the sample mean derived from the data.

The steady-state ratios of main variables are calibrated to match their sample means in the data. Precisely, the public debt-to-GDP ratio (b^m/y) is set to 0.43. It is worth noting that this average mean value from the data is lower than the current elevated public debt levels. Given the calibrated consumption and labor income tax rates, the steady state total tax revenue-to-GDP ratio is derived at 0.318. Total government expenditure-to-GDP ratio (g/y) is calibrated at 0.253, while government transfers-to-GDP ratio (tr/y) is calibrated at 0.043, matching their respective sample averages. The private consumption-to-GDP ratio (c/y) is derived at 0.661, which is slightly above the observed average mean of 0.617.

4.3 Prior distributions

Tables 2 and 3 present the prior distributions, means, and standard deviations of the estimated model parameters. The choice of prior means and standard deviations is informed by the existing DSGE literature. The consumption habit formation parameter (h) is assigned a beta distribution with a mean of 0.7 and a standard deviation of 0.05, as in Gupta and Steinbach (2013). The Rotemberg price adjustment cost parameter (Ω_p) follows a gamma distribution with a mean of 118 and a standard deviation of 10.0 (Balcilar et al., 2017). The interest rate smoothing parameter in the monetary policy rule is assigned a beta distribution with a mean of 0.73 and a standard deviation of 0.05 (Ortiz and Sturzenegger, 2007).

The priors for fiscal and monetary policy response parameters are set to guarantee a unique stationary equilibrium under alternative mixed policy regimes, as discussed in Section 3.2.1. Under Regime M, the monetary policy response to inflation (α_π) and the tax revenue response to public debt (δ_τ) follow gamma distributions with means of 1.5 and 1.2, respectively, and standard deviations of 0.05 (see, e.g., Leeper et al., 2017). Under Regime F, α_π and δ_τ follow beta distributions with means of 0.005 and 0.001, respectively, and standard deviations of 0.0005. Under the coexistence regime, the monetary policy response to non-fiscal inflation (α_π^{AM}) and the tax revenue response to backed public debt (δ_τ^{PF}) are assigned gamma distributions with means of 1.5 and 1.2, respectively, and standard deviations of 0.05. In contrast, the monetary response to fiscal inflation (α_π^{PM}) and the tax revenue response to unbacked public debt (δ_τ^{AF}) are both assigned beta distributions with means of 0.005 and 0.001, respectively, and standard deviations of 0.0005 (Leeper et al., 2017).

The parameter governing the proportion of fiscal and monetary policy shocks influencing unbacked public debt (ζ) is assumed to follow a beta distribution with a mean of 0.25 and a standard deviation of 0.05. This prior suggests that a large portion of the shock (75%) influences the backed component of public debt, reflecting a relatively high degree of fiscal backing under South Africa's fiscal framework. This aligns closely with the estimated degree of fiscal backing of 83% in Smets and Wouters (2024) for the US economy. Ideally, the fiscal authority is expected to maintain credibility in stabilizing public debt. At the same time, the prior also allows for the possibility that a non-negligible portion of public debt arising from policy shocks remains unbacked, recognizing the country's limited fiscal space amid elevated public debt levels.

For the shock processes, we assume that the persistence parameter of all shocks follows a beta distribution with means ranging from 0.5 to 0.9 and a standard deviation of 0.1, in line with the literature (see, e.g., Steinbach et al., 2009; Gupta and Steinbach, 2013; Leeper et al., 2017). The standard deviation of all structural shocks follow an inverse gamma distribution with a prior mean of 0.01 and a standard deviation of 0.1 (Liu and Molise, 2020).

Table 2: Prior and posterior distributions of estimated parameters.

		Coexistence regime		Regime M		Regime F	
		Marg.lik.=-1556.16		**Marg.lik.=-1292.41**		**Marg.lik.=-1582.64**	
	Prior distribution	Posterior distribution		Posterior distribution		Posterior distribution	
Parameters	Mean, s.d.	Mean	95% interval	Mean	95% interval	Mean	95% interval
Habit formation (h)	B (0.7, 0.05)	0.927	[0.916, 0.933]	0.694	[0.643, 0.745]	0.923	[0.904, 0.933]
Rotemberg price adjustment (Ω_p)	G (118, 10.0)	137.7	[117.2, 157.6]	88.28	[73.01, 104.2]	123.5	[104.4, 143.2]
Interest rate smoothing (ρ_R)	B (0.73, 0.05)	0.847	[0.813, 0.879]	0.820	[0.791, 0.848]	0.820	[0.785, 0.852]
Monetary and fiscal policy parameters							
Regime M							
Monetary response to inflation (α_π)	G (1.5, 0.05)			1.514	[1.475, 1.552]		
Fiscal response to public debt (δ_τ)	G (1.2, 0.005)			1.197	[1.188, 1.207]		
Regime F							
Monetary response to inflation (α_π)	B (0.005, 0.0005)					0.005	[0.004, 0.006]
Fiscal response to public debt (δ_τ)	B (0.001, 0.0005)					0.001	[0.000, 0.002]
Coexistence regime							
Monetary response to non-fiscal inflation (α_π^{AM})	G (1.5, 0.05)	1.501	[1.403, 1.599]				
Monetary response to fiscal inflation (α_π^{PM})	B (0.005, 0.0005)	0.005	[0.004, 0.006]				
Fiscal response to backed public debt (δ_τ^{PF})	G (1.2, 0.005)	1.200	[1.190, 1.210]				
Fiscal response to unbacked public debt δ_τ^{AF}	B (0.001, 0.0005)	0.001	[0.000, 0.002]				
Unbacked portion of shock parameter (ζ)	B (0.25, 0.05)	0.442	[0.345, 0.539]				

Note: B denotes beta, G denotes gamma, s.d. denotes standard deviation, and Marg.lik. denotes log marginal likelihood. The posterior densities are obtained using the Random-Walk Metropolis algorithm. For each regime, two parallel MCMC (Markov Chain Monte Carlo) chains are generated, each consisting of 100,000 draws.

Table 3: Prior and posterior distributions of structural shocks.

		Coexistence regime		Regime M		Regime F	
	Prior distribution	Posterior distribution		Posterior distribution		Posterior distribution	
Parameters	Mean, s.d.	Mean	95% interval	Mean	95% interval	Mean	95% interval
AR(1) persistence parameters							
Gov. consumption exp. shock (ρ_{gc})	B (0.5, 0.1)	0.689	[0.603, 0.771]	0.655	[0.551, 0.761]	0.712	[0.627, 0.799]
Transfers shock (ρ_{tr})	B (0.5, 0.1)	0.930	[0.888, 0.953]	0.924	[0.894, 0.953]	0.873	[0.827, 0.917]
Tax revenue shock (ρ_τ)	B (0.5, 0.1)	0.865	[0.784, 0.951]	0.474	[0.376, 0.572]	0.918	[0.857, 0.953]
Preference shock (ρ_c)	B (0.5, 0.1)	0.501	[0.365, 0.622]	0.374	[0.266, 0.479]	0.469	[0.315, 0.605]
Term premium shock (ρ_{tp})	B (0.5, 0.1)	0.057	[0.047, 0.072]	0.055	[0.047, 0.069]	0.056	[0.047, 0.072]
Technology shock (ρ_{λ_z})	B (0.9, 0.1)	0.947	[0.940, 0.952]	0.951	[0.949, 0.952]	0.949	[0.945, 0.952]
Price mark-up shock (ρ_θ)	B (0.5, 0.1)	0.479	[0.337, 0.617]	0.472	[0.379, 0.568]	0.549	[0.414, 0.681]
S.d. of shocks							
Gov. consumption exp. shock (σ_{gc})	IG (0.01, 0.1)	0.013	[0.011, 0.015]	0.010	[0.009, 0.011]	0.012	[0.011, 0.014]
Transfers shock (σ_{tr})	IG (0.01, 0.1)	0.006	[0.005, 0.007]	0.006	[0.005, 0.007]	0.006	[0.005, 0.007]
Tax revenue shock (σ_τ)	IG (0.01, 0.1)	0.049	[0.042, 0.056]	0.311	[0.269, 0.354]	0.046	[0.040, 0.052]
Monetary policy shock (σ_R)	IG (0.01, 0.1)	0.005	[0.004, 0.005]	0.018	[0.014, 0.022]	0.004	[0.003, 0.004]
Preference shock (σ_c)	IG (0.01, 0.1)	0.515	[0.428, 0.597]	0.072	[0.058, 0.088]	0.469	[0.376, 0.558]
Term premium shock (σ_{tp})	IG (0.01, 0.1)	0.064	[0.056, 0.072]	0.050	[0.044, 0.057]	0.065	[0.057, 0.073]
Technology shock (σ_{λ_z})	IG (0.01, 0.1)	0.009	[0.007, 0.010]	0.011	[0.009, 0.012]	0.008	[0.007, 0.009]
Price mark-up shock (σ_θ)	IG (0.01, 0.1)	2.896	[2.148, 3.683]	2.309	[1.789, 2.845]	2.537	[1.862, 3.243]

Note: B denotes beta, IG denotes inverse gamma, and s.d. denotes standard deviation. The posterior densities are obtained using the Random-Walk Metropolis algorithm. For each regime, two parallel MCMC (Markov Chain Monte Carlo) chains are generated, each consisting of 100,000 draws.

4.4 Posterior estimates

The last six columns of Tables 2 and 3 present the estimated parameter posterior means along with their 5% and 95% density intervals under the three mixed policy regimes. The estimation results show that the data are reasonably informative on the estimated parameters and stochastic processes. This is reflected in the posterior estimates for most parameters and standard deviations that are more sharply peaked than their priors.[14]

The habit persistence parameter (h) is estimated at 0.93 under the coexistence regime, compared to 0.69 under Regime M and 0.92 under Regime F. These estimates suggest a high degree of habit formation in consumption under the coexistence regime and Regime F, in line with the estimated value in Bianchi et al. (2023). The estimated habit persistence under Regime M aligns with the standard NK-DSGE literature, where h is typically set to 0.7 (see, e.g., Smets and Wouters, 2007; Steinbach et al., 2009). The Rotemberg price adjustment parameter (Ω_p) is estimated at 137.7 under the coexistence regime, compared to 88.3 under Regime M, and 123.5 under Regime F.[15] These results suggest that price stickiness is relatively higher under the coexistence regime and Regime F compared to Regime M. These findings are consistent with the findings in Smets and Wouters (2024), where both the coexistence regime and Regime F have greater price rigidity than Regime M.[16]

Turning to the estimated parameters governing the monetary and fiscal rules, the interest rate smoothing parameter (ρ_R) is estimated at 0.85 under the coexistence regime, consistent with the estimates under Regime M (0.82) and Regime F (0.82). This value is also closely in line with the estimated value in Ortiz and Sturzenegger (2007) and Bianchi et al. (2023). The monetary policy responses to non-fiscal and fiscal inflation (α_π^{AM} and α_π^{PM}) are estimated at 1.501 and 0.005 under the coexistence regime, similar to those under Regime M (1.51) and Regime F (0.005), respectively. These estimates are in line with those in the literature (see, e.g., Smets and Wouters, 2024). For the fiscal rule, the responsiveness of tax revenue to backed and unbacked public debt (δ_τ^{PF} and δ_τ^{AF}) is estimated at 1.20 and 0.001 under the coexistence regime, similar to estimates obtained under Regime M (1.197) and Regime F (0.001), respectively.

Regarding the persistent parameters for the exogenous shock processes, the estimated posterior means for most shocks are broadly consistent across all three regimes, except for tax revenue and preference shocks. Notably, the technology shock is the most persistent across all three regimes. This result is broadly in line with the findings in the South African literature (see, e.g., Gupta and Steinbach, 2013). The high persistence suggests that the shocks will account for a significant portion of the forecast error variance of the model's variables at long horizons. For the standard deviations of the shock processes, the estimated posterior means for most shocks broadly align with prior expectations under all three regimes, except for price mark-up and preference shocks.

The log marginal likelihood for the coexistence regime is −1556.16 compared with −1292.41 under Regime

[14] The results of the prior and posterior marginal densities and multivariate convergence diagnostics plots are presented in Appendix E.

[15] These estimates of the Rotemberg price adjustment parameter correspond to Calvo price parameter values of 0.78, 0.73, and 0.77, respectively (see, e.g., Leith and Liu, 2016).

[16] In Smets and Wouters (2024), the coexistence regime is an intermediate regime, Regime F is fiscal-led regime, and Regime M is monetary-led regime.

M and −1582.64 under Regime F. These results suggest that Regime M provides a better fit to the data, followed by the coexistence regime, and lastly Regime F.

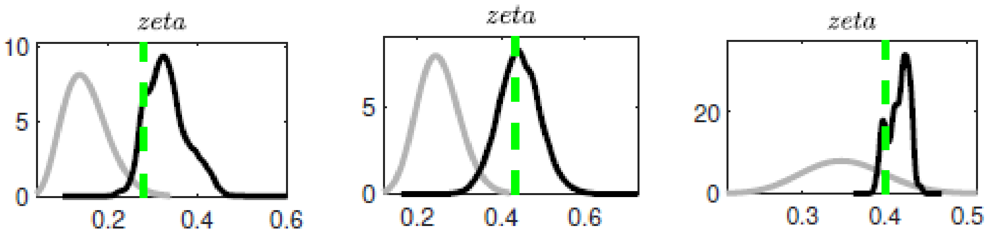
4.5 ζ: Prior-sensitivity and Posterior robustness

The parameter governing the fraction of monetary and fiscal policy shocks that affect the unbacked component of public debt, ζ, is estimated at 0.44. This implies that approximately 56% of policy shocks are absorbed by the backed component of public debt. While this suggests a non-negligible degree of fiscal backing in South Africa, it remains lower than the estimated 83% for the United States reported in Smets and Wouters (2024). This difference reflects structural constraints typical of emerging market economies, including a relatively narrow tax base, a sizeable informal sector, and weaker tax compliance. These factors limit the fiscal authority's capacity to generate sufficient revenue, thereby constraining the extent to which public debt can be stabilized through future fiscal surpluses. In contrast, advanced economies benefit from broader and more diversified tax systems, supported by stronger institutional capacity, which enhances their ability to sustain higher levels of fiscal backing.

While ζ is not directly observable, it does not represent a mechanical share of fiscally backed debt. Rather, it governs the fraction of policy shocks that are absorbed by the unbacked component of public debt and stabilized through inflation. The posterior estimate (0.44) departs substantially from the prior mean (0.25), indicating that the data - via the joint dynamics of inflation, public debt, and long-term bond prices - are informative about this parameter. This estimate suggests that a non-trivial share of policy shocks in South Africa is resolved through inflationary adjustment, consistent with limited fiscal space and elevated debt service costs in the post-GFC period, rather than implying a precise measure of fiscal credibility. Although fiscal backing is relatively lower than in advanced economies such as the United States, our findings suggest that South Africa is best characterised by a mixed monetary-fiscal regime rather than outright Regime F.

Given the central role of ζ in the model, we conduct a dedicated prior sensitivity and posterior robustness analysis for this parameter. We consider three alternative prior means for ζ (0.15, 0.25, and 0.35). The choice of these prior means is guided by the degree of fiscal backing implied by a realistic policy framework. In principle, fiscal authority is expected to credibly stabilize public debt through future fiscal surpluses. A lower prior mean of $\zeta = 0.15$, therefore, corresponds to a high degree of fiscal backing, whereby a larger portion of the policy shock (approximately 85%) influences the backed component of public debt, consistent with estimates reported for the US economy (see, Smets and Wouters, 2024). In contrast, a relatively higher prior mean of $\zeta = 0.35$ allows for a weaker degree of fiscal backing, with only about 65% of shocks affecting the backed component of public debt.

Figure 3 reports the sensitivity analysis results, showing that the posterior estimate of ζ is 0.33 when the prior mean is set to 0.15, increases to 0.44 when the prior mean is 0.25 (baseline), and slightly declines from 0.44 to 0.41 when the prior mean is set to 0.35. These results suggest that, despite variation in prior assumptions, the posterior estimates converge to a relatively narrow range of approximately 0.4 - 0.45. Moreover, the posterior distribution under the baseline prior (0.25) is relatively concentrated and well-behaved, suggesting that the likelihood is informative in this region. While some degree of prior sensitivity remains - as is common in estimated DSGE models - the results do not appear to be driven by the prior alone. The findings imply that extreme values associated with very high fiscal backing are not strongly supported by the data, whereas a regime with more moderate fiscal backing appears to be more consistent with observed recent macroeconomic conditions in South Africa.



(a) Prior mean = 0.15 (b) Prior mean = 0.25 (c) Prior mean = 0.35

Figure 3: Prior mean vs posterior estimates of the parameter ζ under the coexistence regime.

5 Impulse response analysis

This section presents the estimated impulse responses of the main variables to government consumption, tax revenue, and monetary policy shocks. We evaluate the dynamics under the coexistence regime, in comparison with the two standard regimes: Regime M and Regime F, complemented by the variance ratios of inflation-to-output and public debt-to-output.

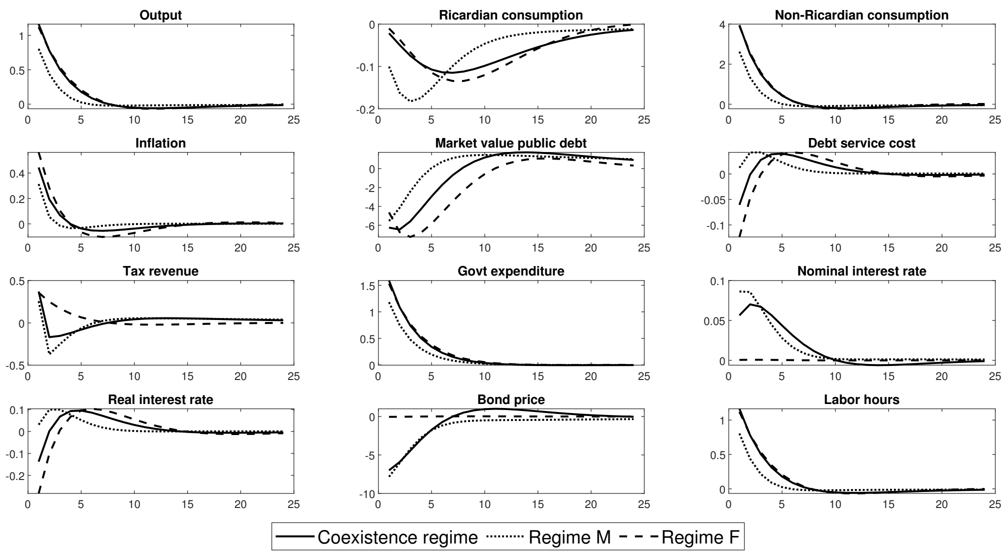


Figure 4: Responses of the main variables to a positive government consumption expenditure shock under three policy regimes: coexistence regime (solid line); Regime M (dotted line); and Regime F (dashed line). Responses are in percentage deviations from steady state.

Figure 4 presents the impulse responses of the main variables to an expansionary government consumption expenditure shock. Under Regime M, the shock generates a relatively smaller increase in non-Ricardian consumption and a more pronounced decrease in Ricardian consumption. Under Regime M, fiscal policy is passive and fully backs public debt through future taxes. As a result, Ricardian households anticipate higher future tax liabilities, which dampens their consumption response and weakens the positive wealth effect of government spending. Non-Ricardian households, on the other hand, directly benefit from the shock. Although non-Ricardian consumption increases, the aggregate demand response remains modest, leading to a relatively small increase in output and inflation. Additionally, moderate nominal and real rigidities, evidenced by the relative low degrees of price stickiness and habit formation, dampen the impact of government spending on private consumption, hence the moderate increase in inflation in response to moderate increase in aggregate demand. Nominal and real interest rates increase, as the monetary authority commits to price stability. The market value of public debt initially declines but subsequently recovers more quickly, due to the combined effect of falling bond prices, a temporary increase in tax revenue, and higher debt service costs. Tax revenue initially increases in response to higher government expenditure, but subsequently declines, reflecting the fiscal authority's proactive response to debt dynamics. Labor hours also increase moderately in line with the dynamics in output. The transmission mechanism for government consumption expenditure shock observed under Regime M is broadly in line with the standard NK-DSGE in the literature (see, e.g., Jooste et al., 2013; Leeper et al., 2017).

Under Regime F, the increase in non-Ricardian consumption is more pronounced than under Regime M, as the positive wealth effect is enhanced following transfers to non-Ricardian households, and the decline in Ricardian consumption is moderate but relatively more persistent. This results in a stronger increase in output. As such, inflation increases more strongly under Regime F than under Regime M, due to increased aggregate demand. Due to the monetary authority's passive stance, nominal interest rates and bond prices remain unchanged. As a result, real interest rates and debt service costs decline significantly. The market value of public debt declines more strongly than observed under Regime M, due to the combined effects of higher tax revenue, lower debt service costs, and a stronger increase in inflation. Tax revenue converges back to its steady state much more slowly than under Regime M, given the stronger decline in public debt. Labor hours also increase more strongly, consistent with the increase in output. Similarly, the dynamics under Regime F are broadly in line with the FTPL literature (see, e.g. Bianchi and Ilut, 2017; Ascari et al., 2023).

Under the coexistence regime, the increases in non-Ricardian consumption, output, and labor hours closely mirror those observed under Regime F, both in terms of direction and magnitude. The estimated strong rigidities (habit formation) under the coexistence regime and Regime F complement the positive effect of government spending on private consumption. In contrast, the decline in Ricardian consumption is smaller than that observed under Regime F. However, the initial increase in inflation is relatively smaller than that observed under Regime F due to moderate aggregate demand, as the partial backing of public debt moderates the positive wealth effect. Consequently, nominal interest rates increase less strongly than under Regime M, as the monetary authority only partially controls inflation. Thus, the declines in real interest rates, debt service costs, public debt, and tax revenue are balanced between the magnitudes observed under the two standard regimes. These findings are similar to the dynamics of the estimated intermediate regime in Smets and Wouters (2024).[17]

[17]Qualitatively, the dynamics following a positive transfer shock are broadly consistent with those observed following a government consumption expenditure shock across the three regimes. The impulse response results to a positive transfer shock

These results suggest that when the monetary and fiscal authorities coordinate to stabilize public debt, the effects of a government expenditure shock are relatively balanced. The coexistence regime delivers a balanced increase in inflation and public debt, while also achieving a higher output. In contrast, Regime M effectively controls inflation but does so at the expense of a weaker output performance and a minimal reduction in public debt. Given South Africa's mounting fiscal pressures and prolonged period of sluggish economic growth, the coexistence regime emerges as a more desirable policy mix, offering a solution to economic growth stability while simultaneously managing both public debt and inflation effectively.

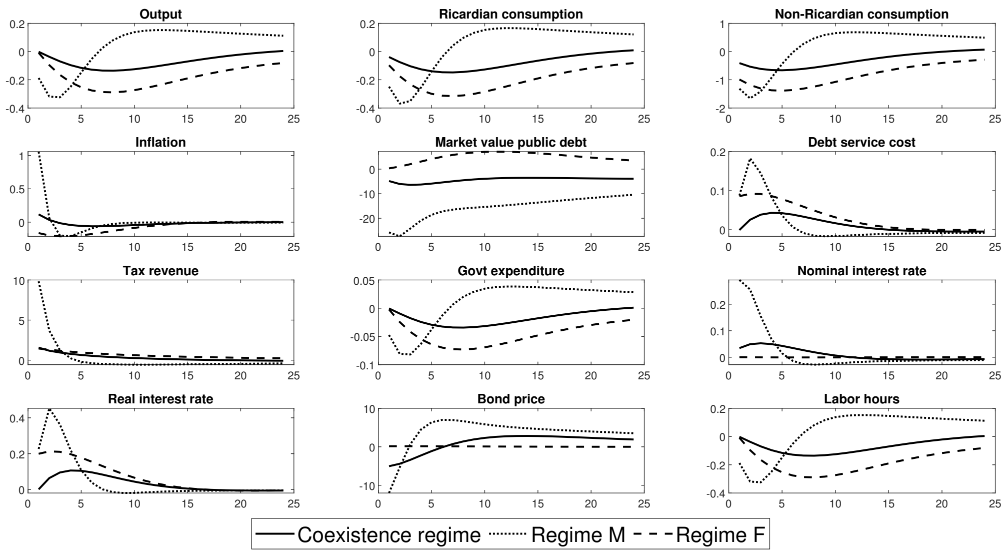


Figure 5: Responses of the main variables to a positive tax revenue shock under three policy regimes: coexistence regime (solid line); Regime M (dotted line); and Regime F (dashed line). Responses are in percentage deviations from steady state.

Figure 5 presents the impulse responses of the key variables to a positive tax revenue shock. Under Regime M, the increase in tax revenue reduces household disposable income, thereby reducing both Ricardian and non-Ricardian consumption. Ricardian consumption decreases more strongly than non-Ricardian consumption. As a result, output declines in response to reduced aggregate demand, but subsequently rebounds after seven quarters. However, inflation increases more strongly, leading to a more pronounced monetary tightening through higher nominal interest rates. The higher inflation response to a positive tax revenue shock under Regime M reflects fiscal valuation effects rather than demand-side pressures. Under regime M, higher taxes substantially improve fiscal solvency and lead to a sharp and persistent decline in the real market value of public debt. The sharp decline in the real value of public debt requires an adjustment in the price level to restore equilibrium in the government budget constraint. Consequently, bond prices initially fall but subsequently increase, while both real interest rates and debt service costs increase. Although the monetary authority responds aggressively - resulting in the largest increase in real interest rates - price stickiness delays disinflation in the short run. Higher tax revenue also induces a sharper contraction in labor supply, which gradually recovers after about seven quarters.

Under Regime F, tax revenue increases only marginally, which can be intuitively explained by the fiscal

are available upon request.

authority's inaction regarding tax adjustments. As a result, declines in Ricardian and non-Ricardian consumption and output are relatively moderate but persistent, compared to Regime M. Inflation, as well as nominal interest rates and bond prices, remain largely unresponsive, as the monetary authority does not adjust interest rates in response to inflation dynamics. In contrast, real interest rates and debt service costs increase moderately, resulting in a marginal increase in the market value of public debt. Labor supply also decreases in line with the dynamics in output.

Under the coexistence regime, the increase in tax revenue is more or less the same as that under Regime F. However, the contractionary effects on Ricardian and non-Ricardian consumption, output, and labor supply are much less pronounced than those observed under Regime F. Likewise, the increases in inflation and nominal interest rates are more subdued compared to those under Regime M, leading to a more moderate decline in bond prices, as the monetary authority only partially responds to inflation. Consequently, real interest rates and debt service costs increase only marginally compared to the two standard regimes, while the dynamics in public debt are broadly balanced between them, in line with the dynamics in bond prices. As the results show, debt service cost plays an important role in shaping the dynamics of public debt.

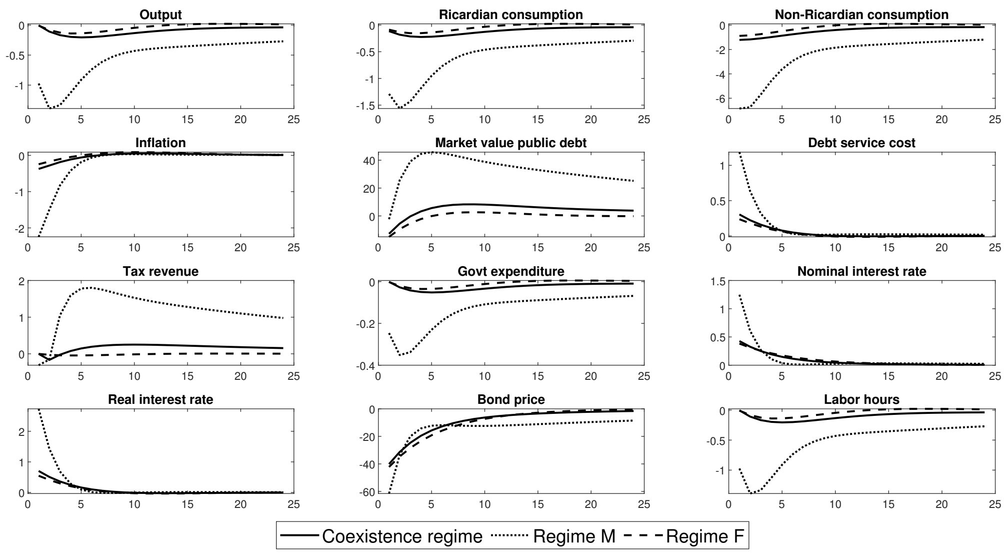


Figure 6: Responses of the main variables to a contractionary monetary policy shock under three policy regimes: coexistence regime (solid line); Regime M (dotted line); and Regime F (dashed line). Responses are in percentage deviations from steady state.

We now turn to the effects of a positive monetary policy shock. Figure 6 presents the impulse responses of the key variables to a contractionary monetary policy shock under the threepolicy regimes. Under regime M, the shock results in a more pronounced increase in real interest rates and debt service costs, while bond prices decline more strongly due to the increase in nominal interest rates. The market value of public debt increases more strongly and persistently as a result of higher debt service costs. Tax revenue also increases more strongly as the fiscal authority adjusts future taxes to stabilize the debt. This shock also induces a stronger contraction in the real economy, as evidenced by significant declines in Ricardian and non-Ricardian consumption, output, inflation, and labor hours, with non-Ricardian consumption decreasing more strongly than Ricardian consumption. These amplified responses stem from the monetary authority's commitment to maintaining price stability, combined with the fiscal authority's commitment to adjusting future taxes that stabilize public debt. As a result, the positive wealth effect from higher interest income is eliminated, thereby dampening aggregate demand. The transmission of monetary policy shock under Regime M aligns with the standard NK-DSGE in the literature (see, e.g., Leeper and Leith, 2016).

In contrast, under Regime F, the contractionary monetary policy shock has a minimal impact on key macroeconomic variables. The absence of the monetary authority's commitment to price stability results in only a moderate increase in interest rates and debt service costs. Additionally, since households do not anticipate future tax adjustments, the positive wealth effect from relatively higher interest income moderates the contractionary effects of the shock on the real economy. Inflation barely decreases, as higher inflation is necessary for debt stabilization under Regime F.[18] However, the market value of public debt decreases only marginally, while tax revenue remains unchanged, as the fiscal authority does not respond to debt dynamics.

Under the coexistence regime, the dynamics of most variables are closely consistent with those observed under Regime F, both qualitatively and quantitatively, except for inflation, public debt, and tax revenue. While inflation declines only slightly, it remains relatively balanced between the two standard regimes. Similarly, public debt initially declines before increasing marginally, falling between the two standard regimes. Tax revenue also increases only moderately as the fiscal authority partially stabilizes public debt. The results under the coexistence regime are also broadly in line with the findings in Smets and Wouters (2024).

These results suggest that, in the face of a contractionary monetary policy shock, both the coexistence regime and Regime F outperform Regime M by containing public debt without triggering inflation, while at the same time maintaining stable output. In contrast, while Regime M effectively achieves lower inflation, it does so at the cost of higher public debt as well as lower output, necessitating future fiscal adjustments to achieve debt sustainability. Such adjustments could be challenging in the current economic environment of limited fiscal space and persistently sluggish economic growth. Thus, the coexistence regime studied here appears to be a desirable policy option.

For robustness, we conduct a variance ratio analysis of the inflation-output and public debt-output trade-offs across the three policy regimes, to quantitatively evaluate which regime delivers the most balanced macroeconomic stabilization. The inflation-output variance ratio captures the cost of stabilizing inflation relative to output, while the public debt-output variance ratio measures the cost of stabilizing public debt relative to output. Thus, in both cases, a lower ratio indicates a more favourable stabilization outcome, whereas a higher ratio indicates costly inflation or public debt stabilization relative to output.

The impulse response analysis shows that the coexistence regime delivers more balanced outcomes by mitigating the effects of shocks and avoiding the more extreme adjustments associated with either Regime M or Regime F. To complement this dynamic evidence, we also report variance ratios of inflation-to-output and public debt-to-output, which provide a quantitative perspective on how the coexistence regime moderates volatility trade-offs.

The results presented in Table 4 show that Regime M yields the lowest inflation–output variance ratio (0.368), compared to a moderate ratio under the coexistence regime (0.463) and a relatively higher ratio

[18] The implication is that Regime F is associated with high inflation that stabilizes public debt. This finding is consistent with previous studies (see, e.g., Leeper and Leith, 2016).

under Regime F (0.546). This suggests that Regime M better stabilizes inflation relative to output. This, however, comes at a significant cost in terms of higher public debt volatility, as the public debt–output variance ratio under Regime M is substantially higher (29.48) than under the coexistence regime (3.552) and Regime F (3.789). These results suggest that while Regime M is effective in anchoring inflation, it does so at the expense of significant debt volatility. In contrast, Regime F achieves comparatively greater debt stabilization, but at the cost of greater inflation volatility relative to output. The coexistence regime, however, offers a more balanced outcome, combining moderate inflation stability with relatively low debt volatility. Overall, the coexistence regime appears to mitigate the trade-offs observed in Regime M and Regime F, thereby delivering a more balance inflation and public debt trade-off. These results are consistent with the evidence from the impulse response analysis.

Table 4: Variance ratio analysis.

	Regime M	Coexistence regime	Regime F
Inflation-output variance ratio	0.368	0.463	0.546
Public debt-output variance ratio	29.48	3.552	3.789

6 Historical shock decomposition

This section discusses the historical shock decomposition of selected macroeconomic variables for the coexistence regime, over the estimated sample period 1994Q1-2024Q4.[19] Following the literature, we group the shocks into four categories. Fiscal policy shocks include government consumption expenditure, transfer, and tax revenue shocks. Monetary policy shocks include the interest rate shock. Demand shocks include the term premium and preference shocks. Supply shocks include technology and price markup shocks (see, e.g., Bianchi et al., 2023; Smets and Wouters, 2024).

In Figure 7 and Table 5, the results show that output dynamics are largely driven by supply and demand shocks over the sample period, while monetary and fiscal shocks contribute to a lesser extent. These findings are broadly in line with the literature (see, e.g., Bianchi et al., 2023; Smets and Wouters, 2024). The contribution of fiscal policy shocks is particularly evident between 2008 and 2013, accounting for about 11% of output fluctuations, and contributing positively to output dynamics. This reflects the significant fiscal stimulus measures during the GFC. A similar pattern emerged during the pandemic, when fiscal policy shocks contributed positively to output fluctuations (about 6.8%), reflecting expansionary fiscal policy measures. In the post-pandemic period, however, the contribution turned negative, (approximately 8.6%), consistent with increasing fiscal constraints in the current economic environment. In contrast, monetary policy shocks contributed negatively to output fluctuations between 1996 and 2009, a period characterized by relatively high interest rates. Between 2014 and 2024, the shocks' contribution to output fluctuations became positive, albeit negligible (averaging about 6.1%), amidst a relatively low-interest rate environment. While the contribution of monetary policy shocks remained positive in the post-pandemic period, it declined, reflecting a shift to

[19] Here, we focus on variables relevant to analyzing public debt and inflation dynamics.

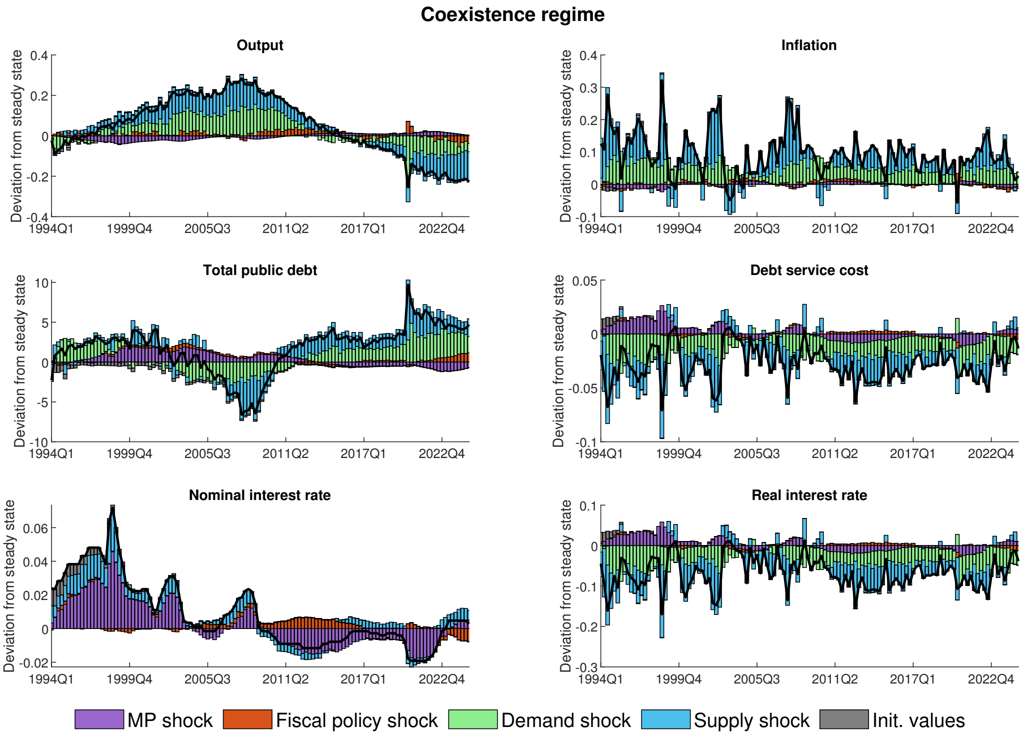


Figure 7: Coexistence regime: Historical shock decomposition of output, inflation, market value of public debt, debt service costs, nominal interest rate, and real interest rate over the period 1994Q1-2024Q4. The variables are plotted in terms of percent deviation from steady state.

monetary tightening.

Similarly, inflation dynamics are largely driven by demand and supply shocks, with monetary and fiscal policy shocks playing a limited role. The contribution of monetary policy shocks to inflation fluctuations averaged about 6.5% across the three episodes, while fiscal policy shocks accounted for about 5.8%. While supply shocks were influential during the pre-GFC, their contribution to inflation dynamics became increasingly significant between 2007-2009 (about 44.6%) and 2020-2021 (about 38.7%), at the peak of the GFC and the pandemic. This finding is in line with Liu (2013), showing that supply-side shocks dominated inflation dynamics in South Africa during the GFC period. The results in Figure 7 further show that monetary policy shocks appear to contribute negatively to inflation dynamics between 1994 and 1998, reflecting the role of high interest rates in controlling non-fiscal inflation. Both monetary and fiscal policy shocks contributed positively to inflation dynamics between 2009-2014 and 2020-2022, reflecting the impact of expansionary policy measures implemented during these crisis periods. However, the contribution of these shocks turned negative in the post-pandemic period, suggesting a shift towards policy tightening.

The results also show that dynamics of public debt and debt service costs over the sample period are mainly driven by demand and supply shocks, with supply shocks playing a dominant role in debt dynamics during both the GFC (about 53.9%) and the pandemic (about 47.9%) periods. Monetary policy shocks also contributed significantly (averaging about 11.5% across the three episodes), while fiscal policy shocks contributed only to a lesser extent (averaging about 4.7%). Specifically, monetary policy shocks contributed positively to the dynamics of both public debt and debt service costs between 1996 and 2010, reflecting the amplification of the debt service cost channel in a high-interest rate environment. Between 2014 and 2021, the contribution of monetary policy shocks to these variables turned negative, reflecting the moderation of the debt service cost channel in a relatively low-interest rate environment. Fiscal policy shocks contribute positively to public debt dynamics between 2020 and 2024, a period marked by a sharp increase in public debt, amid constrained fiscal space.

Monetary policy shocks contributed positively to nominal interest rate dynamics between 1994-2003 and 2007-2008, reflecting a period of a high-interest rate environment, while the contribution turned negative between 2010 and 2022, consistent with a relatively low-interest rate environment. The shocks' contribution to nominal interest rate fluctuations became positive again in the post-pandemic period, reflecting the shift to monetary tightening. In contrast, real interest rate dynamics are primarily driven by demand, supply, and monetary policy shocks, while the contribution of fiscal policy shocks is negligible, consistent with the drivers of inflation and nominal interest rates fluctuations.

Table 5: Average variance share by shock category.

	GFC				Covid				Post-Covid			
Variables	MP	FP	Demand	Supply	MP	FP	Demand	Supply	MP	FP	Demand	Supply
Output	5.8	11.9	40.1	42.4	6.4	6.8	43.2	43.5	7.2	8.6	30.8	53.4
Inflation	6.1	5.2	44.0	44.6	8.8	8.1	44.4	38.7	4.6	4.1	37.4	53.9
Public debt	13.0	4.0	25.8	53.9	6.5	2.1	42.9	47.9	15.1	7.9	45.3	31.2
Debt service cost	15.4	4.1	40.0	40.2	22.2	3.9	39.4	34.5	9.0	3.5	51.3	36.2
Nominal interest rate	50.4	22.0	1.4	25.6	75.0	7.1	0.7	17.1	45.8	18.1	1.5	34.6
Real interest rate	15.2	4.1	39.6	41.2	19.7	3.7	40.0	36.6	8.3	3.5	51.5	36.7

Note: MP denotes monetary policy, FP denotes fiscal policy, and GFC denotes global financial crisis.

Table 5 provides a summary of the average variance shares by shock category across key macroeconomic variables. Overall, demand and supply shocks dominate macroeconomic fluctuations, jointly accounting for roughly 70-90% of the variance in output and inflation across all subperiods. In particular, supply shocks alone explain between 38% and 54% of inflation variability, while demand shocks contribute about 37% to 44%, indicating that inflation dynamics are largely driven by real-side disturbances. For public debt dynamics, supply shocks are also the primary driver during crisis periods, contributing about 54% during the GFC and 48% during the pandemic, while demand shocks account for an additional 26-45%. In contrast, monetary policy shocks play a secondary but non-negligible role, contributing on average around 5-9%, particularly through the debt service cost channel. Similarly, fiscal policy shocks explain a share (generally below 10%) of the variation in debt and inflation. This dominance of supply shocks is further confirmed in the decomposition of inflation and debt components (Table 6), where price markup shocks account for a large share of both fiscal and non-fiscal inflation dynamics.

7 Shock decomposition of public debt and inflation components

More relevant for the coexistence regime is the shock decomposition of the two components of public debt: backed and unbacked, and the associated inflation components: non-fiscal and fiscal. Fiscal and monetary policies have distinct mechanisms for stabilizing backed and unbacked public debt, with each component influencing non-fiscal and fiscal inflation, respectively. Consequently, the contribution of various shocks to these components of public debt and inflation are likely to differ, thereby motivating this analysis.

To better understand the specific drivers of each component, we present the decomposition analysis based on individual shocks. Figure 8 and Table 6 show that while price markup shocks are most important in driving both components of inflation and public debt, policy shocks also make a notable contribution. Monetary policy shocks significantly contributed to the positive fluctuations in backed public debt between 1994 and 2011 (about 23.7%), a period characterized by relatively high interest rates. In line with the monetary authority's commitment to stabilizing non-fiscal inflation and the high-interest rate environment, both monetary policy and price markup shocks contributed to the overall moderation of non-fiscal inflation during the same period (about 24.4% and 41.9%, respectively). In contrast, between 2016 and 2021, a period largely characterized by relatively low interest rates, the contribution of monetary policy shocks to fluctuations in the backed public debt became smaller (about 10.5%) and negative. Price markup shocks had a negative but more significant contribution, while government consumption, transfer, and tax revenue shocks contributed positively to backed public debt fluctuations. During the post-pandemic period (2022-2024), the negative contribution of monetary policy shocks became more substantial, while that of price markup shocks declined, reflecting the shift to monetary tightening. Between 2011 and 2021, fluctuations in the associated non-fiscal inflation were mainly driven by price markup shocks (about 36.2%), monetary policy shocks (about 26.8%), and fiscal policy shocks (government consumption, transfer and tax revenue, totalling 36.8%). These drivers had a positive effect during this period but turned negative during the post-pandemic period of monetary tightening and non-fiscal inflation moderation.

Regarding unbacked public debt and the associated fiscal inflation, fluctuations in the unbacked public debt are primarily driven by preference and price markup shocks, with term premium shocks also making a notable positive contribution. While both price markup and preference shocks contributed to negative fluctuations in the unbacked public debt during the peak of the GFC (2007-2009), their influence turned positive between 2012 and 2024, with a significant increase during the pandemic. The acceleration of unbacked public debt led to positive fluctuations in fiscal inflation over the same period, primarily driven by price markup and term premium shocks. Effectively, with unsustainable high public debt, households demand higher compensation to hold long-term bonds, which in turn drives inflation through a positive wealth effect. The important roles of price markup and term premium shocks in driving inflation fluctuations are also observed in the US (Smets and Wouters, 2024). However, the authors also find that fiscal policy shocks played a notable role in the US, especially in the 1970s.

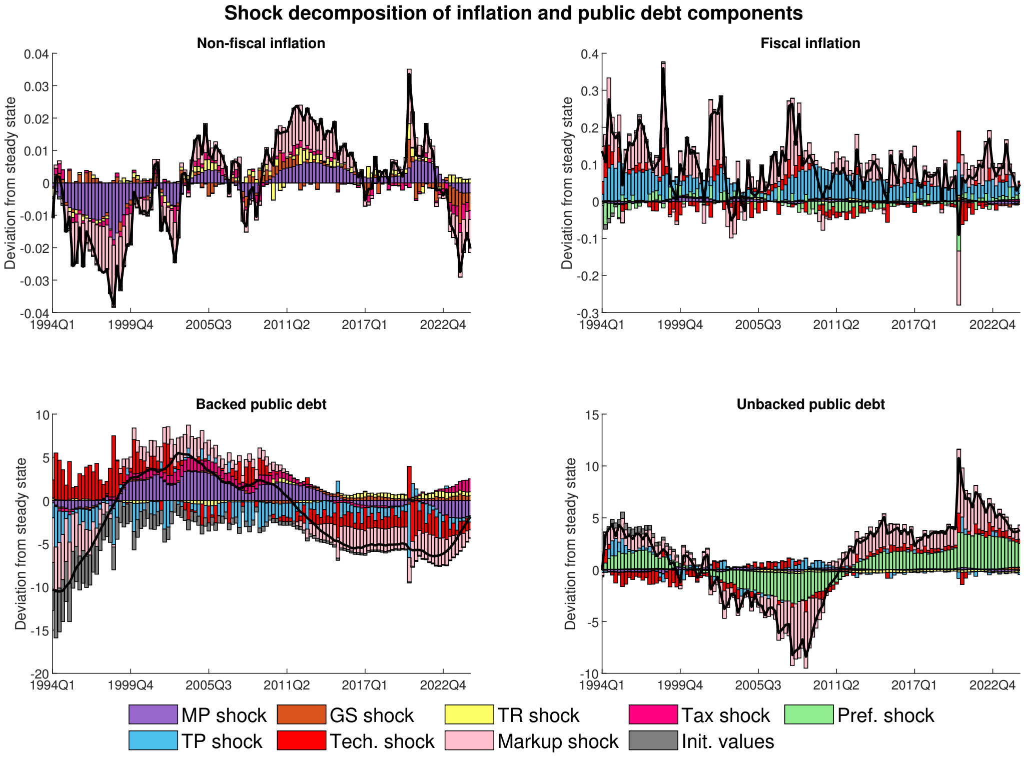


Figure 8: Coexistence regime: Shock decomposition of fiscal and non-fiscal inflation, and backed and unbacked market value of public debt over the period 1994Q1-2024Q4. The variables are plotted in terms of percentage deviation from steady state.

Table 6: Average variance share by individual shocks: Components of public debt and inflation.

	Non-fiscal inflation		Fiscal inflation		Backed public debt		Unbacked public debt	
Shocks	GFC	Covid	GFC	Covid	GFC	Covid	GFC	Covid
Monetary policy shock	24.4	26.8	1.9	2.3	23.7	10.5	2.4	1.8
Govt. expenditure shock	13.9	19.0	1.2	1.7	3.0	3.4	1.6	0.7
Transfers shock	11.8	9.5	1.5	1.2	3.1	5.6	3.0	2.2
TRev shock	7.6	8.3	0.6	0.8	9.5	3.0	0.3	0.1
Preference shock	0.4	0.1	12.5	12.0	7.1	1.4	39.3	42.6
Term premium shock	0.0	0.0	42.4	26.2	24.4	16.3	6.9	4.4
Technology shock	0.0	0.0	10.8	15.3	16.1	26.3	7.2	8.9
Price markup shock	41.9	36.2	29.0	40.6	13.1	33.5	49.4	39.2

Note: GFC denotes global financial crisis.

Table 6 shows clear differences in the drivers of non-fiscal and fiscal inflation, as well as across components of public debt. For non-fiscal inflation, price markup shocks account for approximately 36-42% of the variance, making them the dominant source of fluctuations, while monetary policy shocks contribute around 24-27%, and fiscal shocks (government spending, transfers, and tax revenue) jointly explain about 35-37%. In contrast, fiscal inflation is driven primarily by price markup shocks, together with preference shocks and term premium shocks, which jointly account for the majority of its variation. A similar pattern emerges for public debt: backed debt dynamics are more influenced by monetary, term premium, technology, and price markup shocks, whereas unbacked debt is largely driven by price markup and preference shocks, particularly during periods of rising fiscal pressures. Overall, while markup shocks are central across all variables, non-fiscal inflation is more strongly associated with monetary policy, whereas fiscal inflation and unbacked debt are primarily shaped by preference and term premium shocks in addition to markup disturbances.

The conclusion from this decomposition analysis is that in South Africa, while supply shocks significantly influence the dynamics of public debt and inflation, the contribution of policy shocks remains equally important. These findings highlight the critical roles of monetary and fiscal authorities in shaping the dynamics of public debt and inflation. Given the monetary authority's commitment to controlling non-fiscal inflation and the fiscal authority's commitment to stabilizing backed public debt, monetary policy shocks play a dominant role in influencing backed debt and non-fiscal inflation by dampening supply-side effects of price markup shocks. In contrast, considering that the monetary authority does not respond to fiscal inflation, price markup shocks (supply-side effect) dominate the positive fluctuations in fiscal inflation, reflecting the absence of a dampening effect from monetary policy shocks.[20]

8 Subsample analysis: Pre- vs. post-GFC

The 2007/08 GFC marked a significant structural break in the macroeconomic landscape of most economies, including the South African economy (see Figures 1 and 2). While the pre-GFC period was characterized by favorable macroeconomic conditions, the post-GFC period has been marked by adverse conditions such as unprecedented high public debt, constrained fiscal space, economic downturn, and high inflation in the post-pandemic period. This shift may influence the propagation of monetary and fiscal policy shocks to inflation and other key macroeconomic variables, warranting further exploration.

This section examines the impulse responses of key macroeconomic variables to government consumption expenditure and monetary policy shocks under the coexistence regime, comparing the pre-GFC (1994Q1-2008Q4) and post-GFC (2009Q1-2024Q4) periods.[21] The estimated parameter governing the proportion of monetary and fiscal policy shocks influencing unbacked public debt (ζ) differs between the two periods, with an estimated posterior mean of 0.368 in the pre-GFC period compared to 0.426 in the post-GFC period. These results imply a higher degree of fiscal backing of approximately 63% in the pre-GFC period compared to 57% in the post-GFC period, reflecting the different fiscal conditions between the two periods.[22]

Figure 9 presents the impulse responses to a positive government consumption shock. The results show that the qualitative dynamics of the variables remain consistent between the two periods, reflecting the robustness of the results from the estimated full sample model. However, notable differences in the magnitude of the responses emerge. The results show that the initial increases in government consumption and tax revenue are relatively more pronounced during the post-GFC period than the pre-GFC period, reflecting adverse fiscal conditions. The shock, therefore, has a relatively stronger expansionary effect on non-Ricardian

[20] The important role of supply-side effect (cost-channel) of monetary policy shocks in the context of South Africa is also emphasized in Liu (2013).

[21] For the sake of space, we report impulse response results only for government consumption (fiscal policy shock) and monetary policy shocks. Results for other shocks are available upon request.

[22] Subsample posterior estimates for the remaining parameters are reported in Appendix F.

consumption, output, and labor supply during the post-GFC period compared to the pre-GFC period. At the same time, the contractionary effects of the shock on Ricardian consumption are relatively stronger during the post-GFC period. While the increase in inflation is more or less the same across the periods, nominal interest rates increase by less during the post-GFC period. This reflects the relatively low-interest rate environment and limited policy space during the post-GFC period, which necessitated a more gradual monetary policy tightening. As a result, bond prices decline less during the post-GFC period compared to the pre-GFC period.

Real interest rates and debt service costs initially decline but subsequently increase more or less the same magnitude between the two periods. The consistent dynamics in debt service costs broadly align with the developments in the data between the two periods. The relatively low and declining market value of public debt, combined with high interest rates during the pre-GFC period, is equivalent to the unprecedented high and rising market value of public debt combined with relatively low interest rates during the post-GFC period. This broadly explains the similarity in debt service costs dynamics between the periods. However, the initial decline in the market value of public debt is relatively less and subsequently recovers more quickly during the post-GFC period than the pre-GFC period, in line with the dynamics in bond prices.

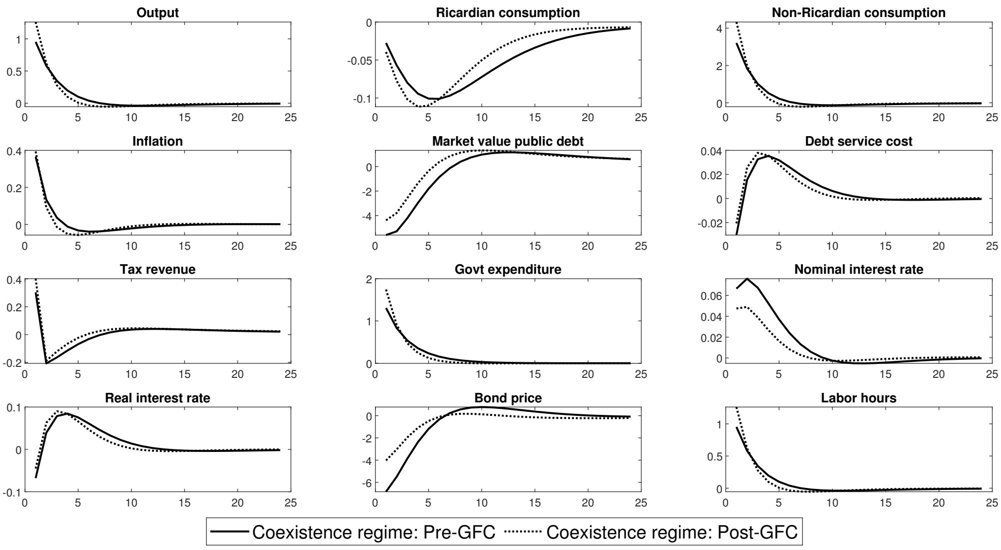


Figure 9: Responses of the main variables to an expansionary government consumption expenditure shock under the coexistence regime pre vs. post GFC: Pre-GFC (solid line); and post-GFC (dotted line). Responses are in percentage deviations from steady state.

Turning to monetary policy shocks, Figure 10 presents the impulse responses to a contractionary monetary policy shock. The results show nominal interest rate increases less strongly during the post-GFC period compared to the pre-GFC period, reflecting a more cautious stance by the authorities to prevent further disruptions to the already fragile economic conditions.[23] As a result, the contractionary effects of the shock on the real economy are moderate during the post-GFC period, with smaller declines in Ricardian and non-Ricardian consumption, output, and inflation. Thus, following a contractionary monetary policy shock,

[23]The monetary authority's cautious stance during the post-GFC period is evidenced by a relatively lower estimated value of monetary policy response to non-fiscal inflation i.e. $\alpha_{\Pi}^{AM} = 1.48$, compared to an estimate of $\alpha_{\Pi}^{AM} = 1.51$ during the pre-GFC period.

increases in real interest rates and debt service costs are smaller during the post-GFC period compared to the pre-GFC period. Similarly, following a contractionary monetary policy shock, the initial decline in the market value of public debt during the post-GFC period is moderate, as inflation and bond prices decline only slightly. Thereafter, the debt recovers less strongly in line with a relatively modest increase in debt service costs. Reflecting these debt dynamics, tax revenue increases moderately during the post-GFC period compared to the pre-GFC period. These findings suggest that following a contractionary monetary policy shock, the debt service cost channel is more pronounced during the pre-GFC period and less pronounced during the post-GFC period, reflecting differences in the interest rate environment between the two periods.

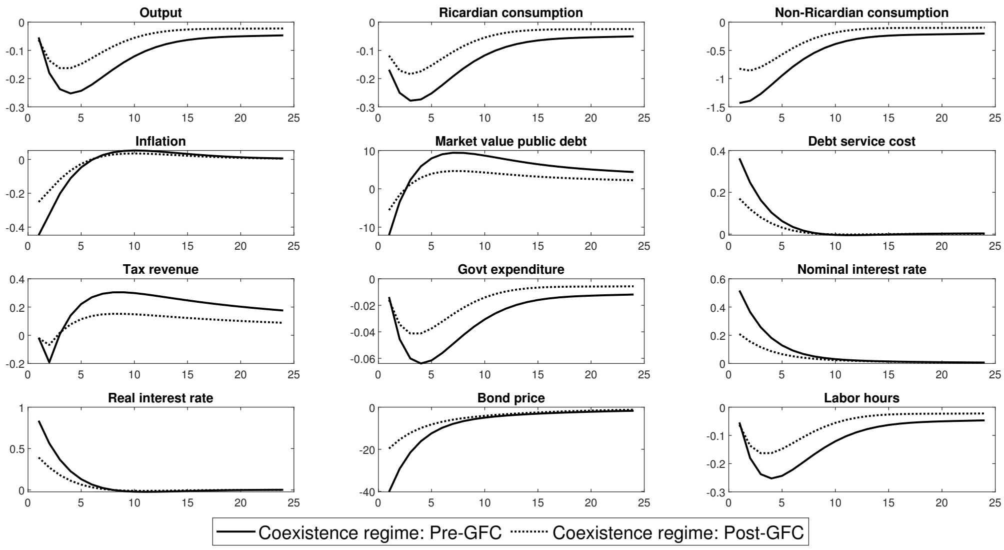


Figure 10: Responses of the main variables to a contractionary monetary policy shock under the coexistence regime pre vs. post GFC: Pre-GFC (solid line); and post-GFC (dotted line). Responses are in percentage deviations from steady state.

It is evident that initial macroeconomic conditions, particularly fiscal conditions and the interest rate environment, play a significant role in the transmission of policy shocks to the economy in a mixed policy regime. Following a positive government consumption shock, dynamics in public debt are different between the pre- and post-GFC periods, primarily influenced by varying fiscal conditions between the two periods. Favourable fiscal conditions (pre-GFC period) reduce borrowing needs, as government consumption increases modestly, thereby contributing to a relatively larger initial decline and a more moderate subsequent increase in public debt. Conversely, adverse fiscal conditions (post-GFC period) increase borrowing needs, as government consumption increases more strongly, resulting in a smaller initial decline and a relatively larger subsequent increase in public debt. When the economy is faced by a contractionary monetary policy, different dynamics in public debt are mainly influenced by distinct interest rate environment between the pre- and post-GFC periods, as evidenced by different dynamics in inflation, real interest rates and debt service costs between the two periods. While public debt initially declines more strongly under the pre-GFC period than under the post-GFC period, reflecting the dynamics in bond prices, the subsequent increase in public debt is also more pronounced under the pre-GFC period, driven by a stronger debt service cost channel. In contrast, under the post-GFC period, the subsequent increase in public debt is more moderate, as the debt service cost channel is less pronounced. Thus, the subsample analysis underscores the significant role of the debt service cost channel.

9 Conclusion

This paper examines the role of a coexistence regime in shaping the interaction between moneary and fiscal policy in South Africa, with particular focus on the dynamics of public debt and inflation. We find that, when monetary and fiscal authorities jointly contribute to the stabilization of public debt, as in the coexistence regime, the macroeconomic effects of policy shocks are more balanced. Relative to Regime M and Regime F, the coexistence regime is more effective in managing both inflation and public debt while supporting more stable output outcomes.

From a policy perspective, these findings suggest that neither strict monetary dominance nor fiscal dominance is well suited to the current macroeconomic environment. Instead, a policy framework in which fiscal policy provides partial but credible support for debt stabilization, while monetary policy remains responsive to inflationary pressures, can deliver more balanced macroeconomic outcomes. Operationally, this implies that fiscal policy should aim to maintain a credible path for debt stabilization, even if full adjustment through future surpluses is constrained by limited fiscal space. At the same time, monetary policy should take into account fiscal conditions when assessing inflation dynamics, particularly in an environment of elevated public debt.

Given South Africa's current macroeconomic context, characterized by limited fiscal space and persistent growth challenges, a cautious and coordinated policy approach is essential. While recent improvements in inflation have allowed for some monetary easing, underlying fiscal pressures remain significant. In this environment, the coexistence regime provides a useful framework for understanding how joint policy efforts can stabilize both inflation and public debt without imposing excessive costs on economic activity. Overall, the findings underscore that effective macroeconomic stabilization in South Africa depends not only on the stance of individual policies, but on the way monetary and fiscal authorities interact in practice.

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A The production sector

A.1 The final-goods producing firm

The representative final-goods firm aggregates differentiated intermediate goods ($Y_t(j)$) into a homogeneous final good (Y_t). The aggregation is given as:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\theta_t - 1}{\theta_t}} dj \right)^{\frac{\theta_t}{\theta_t - 1}}, \tag{24}$$

where $\theta_t > 1$ is a time-varying elasticity of substitution among differentiated intermediate goods, which represents price mark-up shock and evolves as follows:

$$log(\theta_t) = (1 - \rho_\theta) log(\theta) + \rho_\theta log(\theta_{t-1}) + \epsilon_t^\theta, \tag{25}$$

where θ denotes steady state value for the elasticity of substitution for intermediate goods.

The final-good firm's profit maximization problem is below:

$$\max_{Y_t(j)} \left[P_t \left(\int_0^1 Y_t(j)^{\frac{\theta_t - 1}{\theta_t}} dj \right)^{\frac{\theta_t}{\theta_t - 1}} - \left(\int_0^1 P_t(j) Y_t(j) dj \right) \right], \tag{26}$$

where $P_t(j)$ is the price of differentiated intermediate goods and P_t the price of final goods.

The following market demand function for the intermediate goods is obtained from the firm's profit maximization problem:

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\theta_t} Y_t. \tag{27}$$

The price of final good is aggregated as follows:

$$P_t = \left(\int_0^1 P_t(j)^{1-\theta_t} dj \right)^{\frac{1}{1-\theta_t}}. \tag{28}$$

A.2 The intermediate-goods producing firms

A continuum of intermediate-goods producing firms index by j use labor ($N_t(j)$) and linear technology (Z_t) to produce differentiated intermediate goods, based on the following production function:[24]

[24] For simplicity, capital is ignored in the standard NK-DSGE model specification (see, e.g., Gali and Monacelli, 2005; Walsh, 2010).

$$Y_t(j) = Z_t N_t(j), \tag{29}$$

where technology (Z_t) denotes an exogenous technological process that is stationary in the growth rate $\lambda_{z,t} = Z_t/Z_{t-1}$:

$$log(\lambda_{z,t}) = (1-\rho_{\lambda_z})log(\lambda_z) + \rho_{\lambda_z} log(\lambda_{z,t-1}) + \epsilon_t^{\lambda_z}, \tag{30}$$

where λ_z denotes the steady state growth rate of technology. $\rho_{\lambda_z} \in (0,1)$ is the persistent parameter of the technology shock, wherein $\epsilon_t^{\lambda_z} \sim N(0, \sigma_z^2)$ is normally distributed with zero mean and variance σ_z^2.

The intermediate-goods producing firm seeks to minimise the costs:

$$\frac{W_t}{P_t} N_t(j), \tag{31}$$

and is subject to the constraint:

$$Z_t N_t(j) \geq (P_t(j)/P_t)^{-\theta_t} Y_t. \tag{32}$$

We derive the following first-order condition for $N_t(j)$ from the firm's minimization problem:

$$w_t = \lambda_t^i \frac{Y_t(j)}{N_t(j)}, \tag{33}$$

where the Lagrangian multiplier for the production function $\lambda_t^i = \frac{MC_t}{P_t} = mc_t$ denotes the intermediate firm's real marginal cost.

A continuum of intermediate-goods producing firms operate in a monopolistically competitive market and face Rotemberg (1982) type quadratic adjustment costs when setting their prices $(P_t(j))$ (see, e.g., **?**An and Schorfheide, 2007):

$$\frac{\Omega_p}{2} \left(\frac{P_t(j)}{\Pi P_{t-1}(j)} - 1 \right)^2 Y_t, \tag{34}$$

where the parameter Ω_p measures the size of the adjustment cost, and Π denotes steady-state gross inflation..

Thus, the intermediate-goods producing firm chooses optimal $P_t(j)$ by solving the problem:

$$\max_{P_t(j)} E_t \sum_{t=0}^{\infty} \Lambda_t \left[\left(\frac{P_t(j)}{P_t} \right)^{1-\theta_t} Y_t - \frac{MC_t}{P_t} \left(\frac{P_t(j)}{P_t} \right)^{-\theta_t} Y_t - \frac{\Omega_p}{2} \left(\frac{P_t(j)}{\Pi P_{t-1}(j)} - 1 \right)^2 Y_t \right], \tag{35}$$

Given a symmetric equilibrium, the firm's optimal pricing decision gives us the following optimal price:

$$1 = \frac{\theta_t}{\theta_t - 1} mc_t - \frac{\Omega_p}{\theta_t - 1} \left[\left(\frac{\Pi_t}{\Pi} - 1 \right) \frac{\Pi_t}{\Pi} - \left(\frac{\Lambda_{t+1}}{\Lambda_t} \right) \left(\frac{\Pi_{t+1}}{\Pi} - 1 \right) \left(\frac{\Pi_{t+1}}{\Pi} \right) \left(\frac{Y_{t+1}}{Y_t} \right) \right], \tag{36}$$

where Λ_t is the stochastic discount factor defined as: $\Lambda_t = \beta \frac{\lambda_{t+1}}{\lambda_t}$.

The firm's profit equation is defined as:

$$\frac{\Psi_t}{P_t} = Y_t - \frac{W_t}{P_t} N_t(j) - \frac{\Omega_p}{2} \left(\frac{P_t}{\Pi P_{t-1}} - 1 \right)^2 Y_t, \tag{37}$$

where $Y_t(j) = Y_t$ and $P_t(j) = P_t$ in a symmetric equilibrium.

B System of Non-linear model equations - Coexistence regime

The actual economy in the present paper consists of a complete set of non-linear equations for 22 variables, $\tilde{y}_t$, N_t, N_t^r, N_t^{nr}, $\tilde{c}_t$, $\tilde{c}_t^r$, $\tilde{c}_t^{nr}$, R_t, $\tilde{w}_t$, $\tilde{\psi}_t$, $\tilde{b}_t^m$, $\tilde{d}_t$, Q_t^m, $\tau_{n,t}$, $\tilde{\tau}_t$, $\tilde{g}_t$, $\tilde{g}_t^c$, $\tilde{tr}_t$, Π_t, mc_t, $\tilde{\lambda}_t$, $\tilde{\Lambda}_t$ and five AR(1) exogenous shocks: ξ_t^τ), ξ_t^c, ξ_t^{tp}, θ_t, $\lambda_{z,t}$, and three iid shocks: ϵ_t^{gc}, ϵ_t^{tr}, and ϵ_t^R:

$$\tilde{\Lambda}_t = \beta \frac{\tilde{\lambda}_{t+1}}{\lambda_{z,t}\tilde{\lambda}_t}, \tag{B.1}$$

$$\tilde{\lambda}_t = \xi_t^c \frac{\left(\tilde{c}_t^r - \frac{h\tilde{c}_{t-1}^r}{\lambda_{z,t}}\right)^{-\sigma}}{1+\tau_c}, \tag{B.2}$$

$$1 = \beta E_t\left[\left(\frac{\tilde{\lambda}_{t+1}}{\lambda_{z,t}\tilde{\lambda}_t}\right)\left(\frac{R_t}{\Pi_{t+1}}\right)\right], \tag{B.3}$$

$$1 = \beta E_t\left[\left(\frac{\tilde{\lambda_{t+1}}}{\lambda_{z,t}\tilde{\lambda}_t}\right)\left(\frac{1+\rho Q_{t+1}^m}{(Q_t^m e^{\xi_t^{tp}})}\right)\left(\frac{1}{\Pi_{t+1}}\right)\right], \tag{B.4}$$

$$\tilde{w}_t = \frac{\chi(N_t^r)^\eta}{\tilde{\lambda}_t(1-\tau_{n,t})}, \tag{B.5}$$

$$\tilde{w}_t = \frac{\chi(N_t^{nr})^\eta}{\tilde{\lambda}_t}, \tag{B.6}$$

$$N_t = (1-\mu)N_t^r + \mu N_t^{nr}, \tag{B.7}$$

$$(1+\tau_c)\tilde{c}_t^r + (Q_t^m e^{\xi_t^{tp}})\tilde{b}_t^m = (1+\rho Q_t^m)\frac{\tilde{b}_{t-1}^m}{\Pi_t\lambda_{z,t}} + (1-\tau_{n,t})\tilde{w}_t N_t^r + \tilde{\psi}_t, \tag{B.8}$$

$$(1+\tau_c)\tilde{c}_t^{nr} = \tilde{w}_t N_t^{nr} + \tilde{tr}_t, \tag{B.9}$$

$$\tilde{c}_t = (1-\mu)\tilde{c}_t^r + \mu\tilde{c}_t^{nr}, \tag{B.10}$$

$$\tilde{y}_t = N_t, \tag{B.11}$$

$$\tilde{w}_t = mc_t\frac{\tilde{y}_t}{N_t}, \tag{B.12}$$

$$\tilde{\psi}_t = \tilde{y}_t - \tilde{w}_t N_t - \frac{\Omega_p}{2}\left(\frac{\Pi_t}{\Pi} - 1\right)^2 y_t, \tag{B.13}$$

$$1 = \frac{\theta_t}{\theta_t - 1}mc_t - \frac{\Omega_p}{\theta_t-1}\left[\left(\frac{\Pi_t}{\Pi}-1\right)\frac{\Pi_t}{\Pi} - \left(\frac{\tilde{\Lambda}_{t+1}}{\lambda_{z,t}\tilde{\Lambda}_t}\right)\left(\frac{\Pi_{t+1}}{\Pi}-1\right)\left(\frac{\Pi_{t+1}}{\Pi}\right)\left(\frac{\lambda_{z,t}\tilde{y}_{t+1}}{\tilde{y}_t}\right)\right], \tag{B.14}$$

$$(Q_t^m e^{\xi_t^{tp}})\tilde{b}_t^m + \tilde{\tau}_t = (1+\rho Q_t^m)\frac{\tilde{b}_{t-1}^m}{\Pi_t\lambda_{z,t}} + \tilde{g}_t^c + \tilde{tr}_t, \tag{B.15}$$

$$\tilde{\tau}_t = \tau_c\tilde{c}_t + \tau_{n,t}\tilde{w}_t N_t^r, \tag{B.16}$$

$$g_t = g_t^c + tr_t, \tag{B.17}$$

$$\frac{\tilde{g}_t^c}{\tilde{y}_t} = (1-\rho_{g^c})\frac{\tilde{g}^c}{\tilde{y}} + \rho_{g^c}\frac{\tilde{g}_{t-1}^c}{\tilde{y}_{t-1}} + \epsilon_t^{g^c}, \tag{B.18}$$

$$\frac{\tilde{tr}_t}{\tilde{y}_t} = (1-\rho_{tr})\frac{\tilde{tr}}{\tilde{y}} + \rho_{tr}\frac{\tilde{tr}_{t-1}}{\tilde{y}_{t-1}} + \epsilon_t^{tr}, \tag{B.19}$$

$$\frac{\tilde{\tau}_t}{\tilde{y}_t} = \frac{\tilde{\tau}}{\tilde{y}}\left(\frac{\tilde{d}_{t-1}}{\tilde{d}_{t-1}^f}\right)^{\delta_\tau^{PF}}\left(\frac{\tilde{d}_{t-1}^f}{\tilde{d}}\right)^{\delta_\tau^{AF}} e^{\xi_t^\tau}, \tag{B.20}$$

$$\tilde{d}_{t-1} = \frac{Q^m_{t-1}\tilde{b}^m_{t-1}}{\tilde{y}_{t-1}}, \tag{B.21}$$

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R}\left[\left(\frac{\Pi_t}{\Pi^f_t}\right)^{\alpha^{AM}_\pi}\left(\frac{\Pi^f_t}{\Pi}\right)^{\alpha^{PM}_\pi}\right]^{1-\rho_R} e^{\epsilon^R_t}. \tag{B.22}$$

The AR(1) exogenous shocks:

$$\log(\xi^c_t) = \rho_c \log(\xi^c_{t-1}) + \epsilon^c_t, \tag{B.23}$$

$$\xi^\tau_t = \rho_\tau \xi^\tau_{t-1} + \epsilon^\tau_t, \tag{B.24}$$

$$\xi^{tp}_t = \rho_{tp}\xi^{tp}_{t-1} + \epsilon^{tp}_t, \tag{B.25}$$

$$log(\lambda_{z,t}) = (1-\rho_{\lambda_z})log(\lambda_z) + \rho_{\lambda_z}log(\lambda_{z,t-1}) + \epsilon^{\lambda_z}_t, \tag{B.26}$$

$$log(\theta_t) = (1-\rho_\theta)log(\theta) + (\rho_\theta)log(\theta_{t-1}) + \epsilon^\theta_t. \tag{B.27}$$

Measurement equations:

$$\tilde{c}^{obs}_t = log(\tilde{c}_t) - log(\tilde{c}_{t-1} + log(\lambda_{z,t}), \tag{B.28}$$

$$(\tilde{g}^c_t)^{obs} = log(\tilde{g}^c_t) - log(\tilde{g}^c_{t-1}) + log(\lambda_{z,t}), \tag{B.29}$$

$$\tilde{tr}^{obs}_t = log(\tilde{tr}_t) - log(\tilde{tr}_{t-1}) + log(\lambda_{z,t}), \tag{B.30}$$

$$\tilde{\tau}^{obs}_t = log(\tilde{\tau}_t) - log(\tilde{\tau}_{t-1}) + log(\lambda_{z,t}), \tag{B.31}$$

$$(\tilde{b}^m_t)^{obs} = log(\tilde{b}^m_t) - log(\tilde{b}^m_{t-1}) + log(\lambda_{z,t}), \tag{B.32}$$

$$\Pi^{obs}_t = \Pi_t, \tag{B.33}$$

$$R^{obs}_t = log(R_t) - log(R_{t-1}), \tag{B.34}$$

$$Q^{obs}_t = log(Q_t) - log(Q_{t-1}). \tag{B.35}$$

$$\tag{B.36}$$

The actual economy is supplemented by a shadow economy that pins down unbacked public debt and fiscal inflation. The shadow economy consists of a set of non-linear equations for 22 variables, $\tilde{y}^f_t$, N^f_t, $(N^r_t)^f$, $(N^{nr}_t)^f$, $\tilde{c}^f_t$, $(\tilde{c}^r_t)^f$, $(\tilde{c}^{nr}_t)^f$, R^f_t, $\tilde{w}^f_t$, $\tilde{\psi}^f_t$, $(\tilde{b}^m_t)^f$, $\tilde{d}^f_t$, $(Q^m_t)^f$, $\tau^f_{n,t}$, $\tilde{\tau}^f_t$, $\tilde{g}^f_t$, $(\tilde{g}^c_t)^f$, $\tilde{tr}^f_t$, Π^f_t, mc^f_t, $\tilde{\lambda}^f_t$, $\tilde{\Lambda}^f_t$:

$$\tilde{\Lambda}^f_t = \beta\frac{\tilde{\lambda}^f_{t+1}}{\lambda^f_{z,t}\tilde{\lambda}^f_t}, \tag{B.37}$$

$$\tilde{\lambda}^f_t = \xi^c_t\frac{\left((\tilde{c}^r_t)^f - \frac{h(\tilde{c}^r_{t-1})^f}{\lambda^f_{z,t}}\right)^{-\sigma}}{1+(\tau_c)^f}, \tag{B.38}$$

$$1 = \beta E_t\left[\left(\frac{\tilde{\lambda}^f_{t+1}}{\lambda^f_{z,t}\tilde{\lambda}^f_t}\right)\left(\frac{R^f_t}{\Pi^f_{t+1}}\right)\right], \tag{B.39}$$

$$1 = \beta E_t\left[\left(\frac{\tilde{\lambda}^f_{t+1}}{\lambda^f_{z,t}\tilde{\lambda}^f_t}\right)\left(\frac{1+\rho(Q^m_{t+1})^f}{((Q^m_t)^f e^{\xi^{tp}_t})}\right)\left(\frac{1}{\Pi^f_{t+1}}\right)\right], \tag{B.40}$$

$$\tilde{w}_t^f = \frac{\chi((N_t^r)^f)^\eta}{\tilde{\lambda}_t^f(1-\tau_{n,t}^f)}, \tag{B.41}$$

$$\tilde{w}_t^f = \frac{\chi((N_t^{nr})^f)^\eta}{\tilde{\lambda}_t(1-\tau_{n,t}^f)}, \tag{B.42}$$

$$N_t^f = (1-\mu)(N_t^r)^f + \mu(N_t^{nr})^f, \tag{B.43}$$

$$(1+\tau_c^f)(\tilde{c}_t^r)^f + ((Q_t^m)^f e^{\xi_t^{tp}})(\tilde{b}_t^m)^f = (1+(\rho Q_t^m)^f)\frac{(\tilde{b}_{t-1}^m)^f}{\Pi_t^f \lambda_{z,t}^f} + (1-\tau_{n,t}^f)\tilde{w}_t^f N_t^f + \tilde{\psi}_t^f, \tag{B.44}$$

$$(1+\tau_c^f)(\tilde{c}_t^{nr})^f = (1-\tau_{n,t}^f)\tilde{w}_t^f N_t^f + \tilde{tr}_t^f, \tag{B.45}$$

$$\tilde{c}_t^f = (1-\mu)(\tilde{c}_t^r)^f + \mu(\tilde{c}_t^{nr})^f, \tag{B.46}$$

$$\tilde{y}_t^f = N_t^f, \tag{B.47}$$

$$\tilde{w}_t^f = mc_t^f \frac{\tilde{y}_t^f}{N_t^f}, \tag{B.48}$$

$$\tilde{\psi}_t^f = \tilde{y}_t^f - \tilde{w}_t^f N_t^f - \frac{\Omega_p}{2}\left(\frac{\Pi_t^f}{\Pi} - 1\right)^2 \tilde{y}_t^f, \tag{B.49}$$

$$1 = \frac{\theta_t}{\theta_t - 1} mc_t^f - \frac{\Omega_p}{\theta_t - 1}\left[\left(\frac{\Pi_t^f}{\Pi} - 1\right)\frac{\Pi_t^f}{\Pi} - \left(\frac{\tilde{\Lambda}_{t+1}^f}{\lambda_{z,t}^f \tilde{\Lambda}_t^f}\right)\left(\frac{\Pi_{t+1}^f}{\Pi} - 1\right)\left(\frac{\Pi_{t+1}^f}{\Pi}\right)\left(\frac{\lambda_{z,t}^f \tilde{y}_{t+1}^f}{\tilde{y}_t^f}\right)\right], \tag{B.50}$$

$$((Q_t^m)^f e^{\xi_t^{tp}})(\tilde{b}_t^m)^f + \tilde{\tau}_t^f = (1+\rho(Q_{t+1}^m)^f)\frac{(\tilde{b}_{t-1}^m)^f}{\Pi_t^f \lambda_{z,t}^f} + (\tilde{g}_t^c)^f + \tilde{tr}_t^f, \tag{B.51}$$

$$\tilde{\tau}_t^f = \tau_c \tilde{c}_t^f + \tau_{n,t}^f \tilde{w}_t{}^f N_t^f, \tag{B.52}$$

$$g_t^f = (g_t^c)^f + tr_t^f, \tag{B.53}$$

$$\frac{(\tilde{g}_t^c)^f}{\tilde{y}_t^f} = (1-\rho_{g^c})\frac{\tilde{g}^c}{\tilde{y}} + \rho_{g^c}\frac{(\tilde{g}_{t-1}^c)^f}{\tilde{y}_{t-1}^f} + \zeta\epsilon_t^{g^c}, \tag{B.54}$$

$$\frac{\tilde{tr}_t^f}{\tilde{y}_t^f} = (1-\rho_{tr})\frac{\tilde{tr}}{\tilde{y}} + \rho_{tr}\frac{\tilde{tr}_{t-1}^f}{\tilde{y}_{t-1}^f} + \zeta\epsilon_t^{tr}, \tag{B.55}$$

$$\frac{\tilde{\tau}_t^f}{\tilde{y}_t^f} = \frac{\tilde{\tau}}{\tilde{y}}\left(\frac{\tilde{d}_{t-1}^f}{\tilde{d}}\right)^{\delta_\tau^{AF}} e^{\zeta\xi_t^\tau}, \tag{B.56}$$

$$\tilde{d}_{t-1}^f = \frac{(Q_{t-1}^m)^f(\tilde{b}_{t-1}^m)^f}{\tilde{y}_{t-1}^f}, \tag{B.57}$$

$$\frac{R_t^f}{R} = \left(\frac{R_{t-1}^f}{R}\right)^{\rho_R}\left[\left(\frac{\Pi_t^f}{\Pi}\right)^{\alpha_\pi^{PM}}\right]^{1-\rho_R} e^{\zeta\xi_t^R}. \tag{B.58}$$

C System of Non-linear Benchmark model equations - standard regimes

Under the two standard regimes, the model economy consists of a set of non-linear equations for 21 variables, $\tilde{y}_t$, N_t, N_t^r, N_t^{nr}, $\tilde{c}_t$, $\tilde{c}_t^r$, $\tilde{c}_t^{nr}$, R_t, $\tilde{w}_t$, $\tilde{\psi}_t$, $\tilde{b}_t^m$, $\tilde{d}_t$, Q_t^m, $\tau_{n,t}$, $\tilde{\tau}_t$, $\tilde{g}_t$, $\tilde{g}_t^c$, $\tilde{tr}_t$, Π_t, mc_t, $\tilde{\lambda}_t$, $\tilde{\Lambda}_t$, five AR(1) exogenous shocks, ξ_t^τ, ξ_t^c, ξ_t^{tp}, θ_t, $\lambda_{z,t}$, and three iid shocks: ϵ_t^{gc}, ϵ_t^{tr}, and ϵ_t^R:

$$\tilde{\Lambda}_t = \beta \frac{\tilde{\lambda}_{t+1}}{\lambda_{z,t}\tilde{\lambda}_t}, \tag{C.1}$$

$$\tilde{\lambda}_t = \xi_t^c \frac{\left(\tilde{c}_t^r - \frac{h\tilde{c}_{t-1}^r}{\lambda_{z,t}}\right)^{-\sigma}}{1+\tau_c}, \tag{C.2}$$

$$1 = \beta E_t \left[\left(\frac{\tilde{\lambda}_{t+1}}{\lambda_{z,t}\tilde{\lambda}_t} \right) \left(\frac{R_t}{\Pi_{t+1}} \right) \right], \tag{C.3}$$

$$1 = \beta E_t \left[\left(\frac{\tilde{\lambda_{t+1}}}{\lambda_{z,t}\tilde{\lambda}_t} \right) \left(\frac{1+\rho Q_{t+1}^m}{(Q_t^m e^{\xi_t^{tp}})} \right) \left(\frac{1}{\Pi_{t+1}} \right) \right], \tag{C.4}$$

$$\tilde{w}_t = \frac{\chi (N_t^r)^\eta}{\tilde{\lambda}_t (1-\tau_{n,t})}, \tag{C.5}$$

$$\tilde{w}_t = \frac{\chi (N_t^{nr})^\eta}{\tilde{\lambda}_t (1-\tau_{n,t})}, \tag{C.6}$$

$$N_t = (1-\mu) N_t^r + \mu N_t^{nr}, \tag{C.7}$$

$$(1+\tau_c)\tilde{c}_t^r + (Q_t^m e^{\xi_t^{tp}})\tilde{b}_t^m = (1+\rho Q_t^m)\frac{\tilde{b}_{t-1}^m}{\Pi_t \lambda_{z,t}} + (1-\tau_{n,t})\tilde{w}_t N_t + \tilde{\psi}_t, \tag{C.8}$$

$$(1+\tau_c)\tilde{c}_t^{nr} = (1-\tau_{n,t})\tilde{w}_t N_t + \tilde{tr}_t, \tag{C.9}$$

$$\tilde{c}_t = (1-\mu)\tilde{c}_t^r + \mu \tilde{c}_t^{nr}, \tag{C.10}$$

$$\tilde{y}_t = N_t, \tag{C.11}$$

$$\tilde{w}_t = mc_t \frac{\tilde{y}_t}{N_t}, \tag{C.12}$$

$$\tilde{\psi}_t = \tilde{y}_t - \tilde{w}_t N_t - \frac{\Omega_p}{2}\left(\frac{\Pi_t}{\Pi} - 1\right)^2 \tilde{y}_t, \tag{C.13}$$

$$1 = \frac{\theta_t}{\theta_t - 1} mc_t - \frac{\Omega_p}{\theta_t - 1}\left[\left(\frac{\Pi_t}{\Pi} - 1\right)\frac{\Pi_t}{\Pi} - \left(\frac{\tilde{\Lambda}_{t+1}}{\lambda_{z,t}\tilde{\Lambda}_t}\right)\left(\frac{\Pi_{t+1}}{\Pi} - 1\right)\left(\frac{\Pi_{t+1}}{\Pi}\right)\left(\frac{\lambda_{z,t}\tilde{y}_{t+1}}{\tilde{y}_t}\right) \right], \tag{C.14}$$

$$(Q_t^m e^{\xi_t^{tp}})\tilde{b}_t^m + \tilde{\tau}_t = (1+\rho Q_t^m)\frac{\tilde{b}_{t-1}^m}{\Pi_t \lambda_{z,t}} + \tilde{g}_t^c + \tilde{tr}_t, \tag{C.15}$$

$$\tilde{\tau}_t = \tau_c \tilde{c}_t + \tau_{n,t}\tilde{w}_t N_t^r, \tag{C.16}$$

$$g_t = g_t^c + tr_t, \tag{C.17}$$

$$\frac{\tilde{g}_t^c}{\tilde{y}_t} = (1-\rho_{g^c})\frac{\tilde{g}^c}{\tilde{y}} + \rho_{g^c}\frac{\tilde{g}_{t-1}^c}{\tilde{y}_{t-1}} + \epsilon_t^{g^c}, \tag{C.18}$$

$$\frac{\tilde{tr}_t}{\tilde{y}_t} = (1-\rho_{tr})\frac{\tilde{tr}}{\tilde{y}} + \rho_{tr}\frac{\tilde{tr}_{t-1}}{\tilde{y}_{t-1}} + \epsilon_t^{tr}, \tag{C.19}$$

$$\frac{\tilde{\tau}_t}{\tilde{y}_t} = \tau\left(\frac{\tilde{d}_{t-1}}{d}\right)^{\delta_\tau} e^{\xi_t^\tau}, \tag{C.20}$$

$$\tilde{d}_{t-1} = \frac{Q_{t-1}^m \tilde{b}_{t-1}^m}{\tilde{y}_{t-1}}, \tag{C.21}$$

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R}\left[\left(\frac{\Pi_t}{\Pi}\right)^{\alpha_\pi}\right]^{1-\rho_R} e^{\xi_t^R}. \tag{C.22}$$

The AR(1) exogenous shocks:

$$\log(\xi_t^c) = \rho_c \log(\xi_{t-1}^c) + \epsilon_t^c, \tag{C.23}$$

$$\xi_t^\tau = \rho_\tau \xi_{t-1}^\tau + \epsilon_t^\tau, \tag{C.24}$$

$$\xi_t^{tp} = \rho_{tp}\xi_{t-1}^{tp} + \epsilon_t^{tp}, \tag{C.25}$$

$$log(\lambda_{z,t}) = (1-\rho_{\lambda_z})log(\lambda_z) + \rho_{\lambda_z}log(\lambda_{z,t-1}) + \epsilon_t^{\lambda_z}, \tag{C.26}$$

$$log(\theta_t) = (1-\rho_\theta)log(\theta) + (\rho_\theta)log(\theta_{t-1}) + \epsilon_t^\theta. \tag{C.27}$$

D Data source

The data are primarily obtained from the SARB database, with labor force data obtained from Statistics South Africa(Stats SA) and the GDP deflator obtained from the FRED database.

1. **GDP deflator**: Gross domestic product deflator for South Africa, index, quarterly, seasonally adjusted (data code: $NGDPDSAIXZAQ$).

2. **Real private consumption** (c_t): Final consumption expenditure by households at constant prices, millions of South African rands, quarterly, seasonally adjusted at annual rate (data code: $KBP6007D$).

3. **Government consumption expenditure** (G_t^c): Final consumption expenditure by general government at constant prices, millions of South African rands, quarterly, seasonally adjusted at annual rate (data code: $KBP6008D$).

4. **Government transfers** (tr_t): Total government transfers in nominal terms, millions of South African rands, quarterly, not seasonally adjusted (data code: $KBP5729L$).

5. **Total tax revenue** (τ_t): The quarterly total national government tax revenue in nominal terms constructed as the sum of three-months total national government tax revenue, millions of South African rands, monthly, not seasonally adjusted (data code: $KBP4595M$).

6. **Total public debt** (B_t): Total gross loan debt of national government nominal value, millions of South African rands, quarterly, not seasonally adjusted (data code: $KBP4114M$).

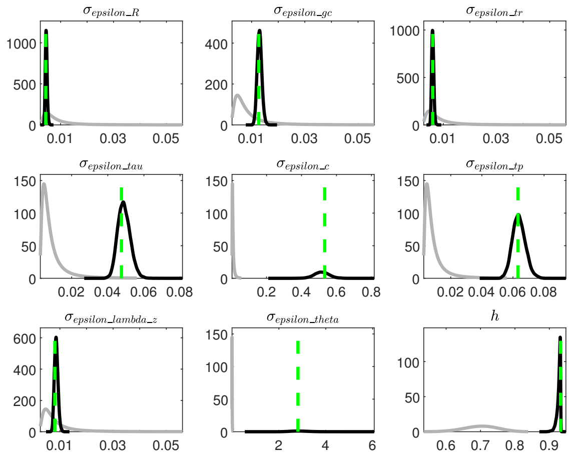
7. **CPI inflation** (π_t): Total consumer prices (All urban areas), percentage, quarterly (data code: $KBP7170Q$).

8. **Repo rate** (i_t): Repurchase rate, rate at which the private (sector) banks borrow rands from the SARB, annualized percentage, quarterly.

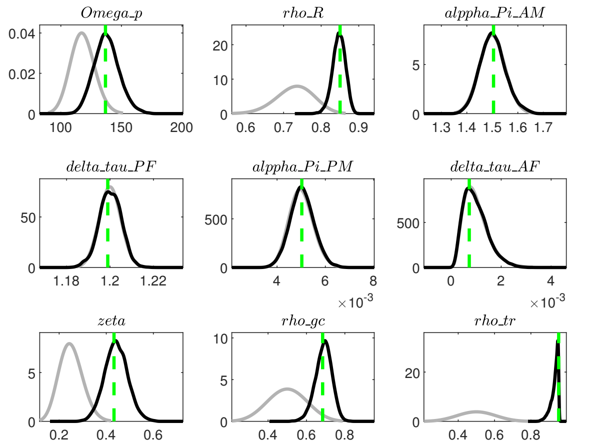
9. **Long-term bond yield** (tbl_t): 10-year bond yield, annualized percentage, quarterly (data code: $CMJM004A$).

E Prior and posterior density and MCMC convergence plots

E.1 Prior and posterior density plots

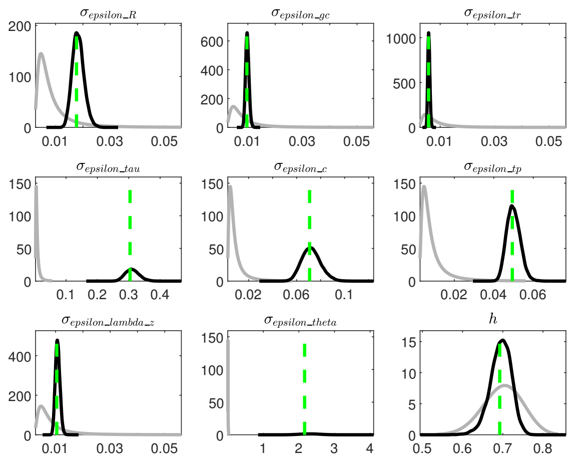


(a) Posterior 1

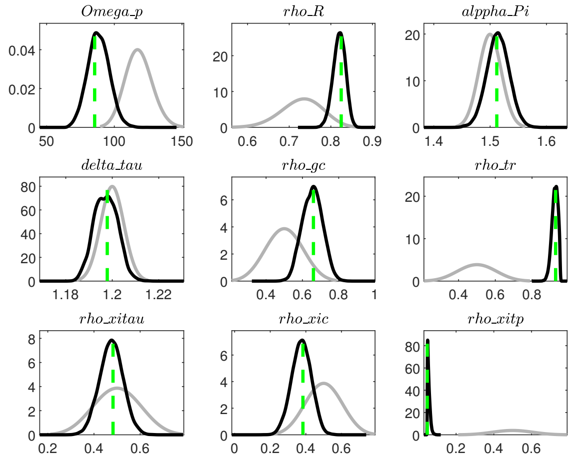


(b) Posterior 2

Figure E1: Prior vs posterior density under the coexistence regime.

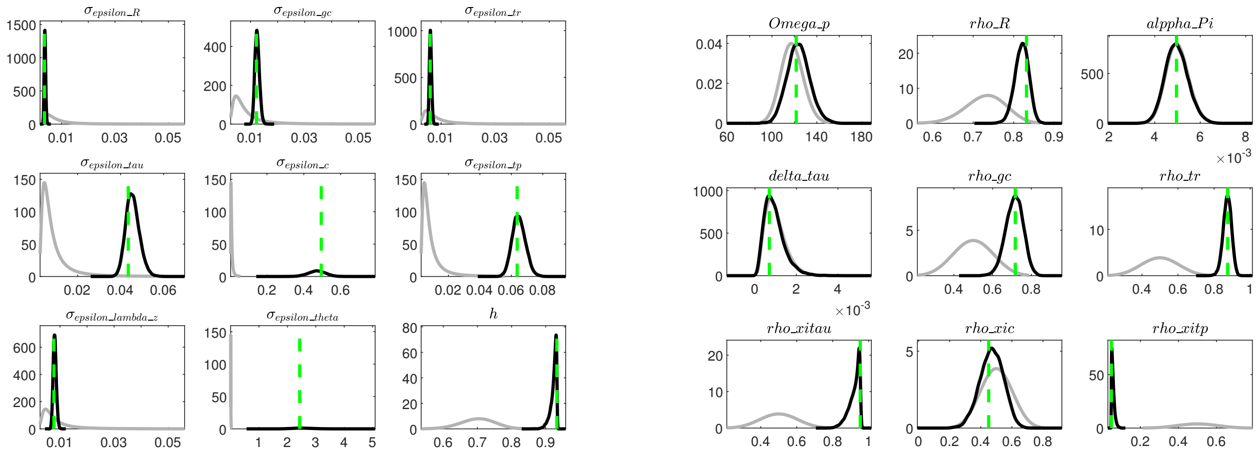


(a) Posterior 1



(b) Posterior 2

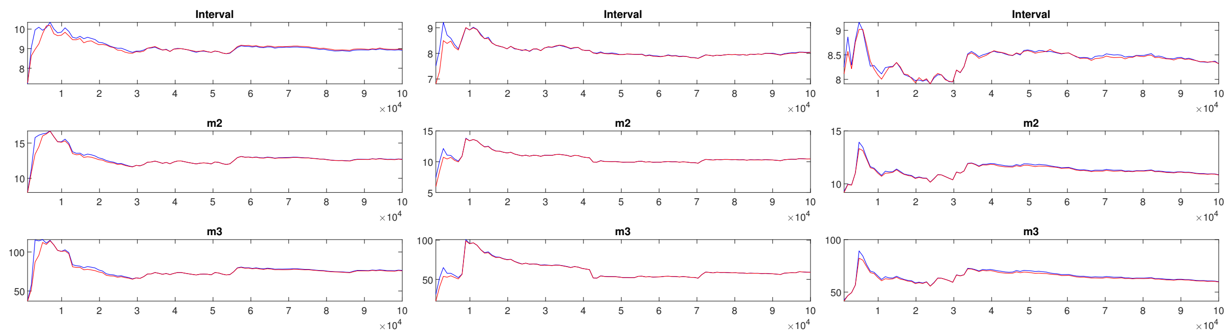
Figure E2: Prior vs posterior density under Regime M.



(a) Posterior 1 (b) Posterior 2

Figure E3: Prior vs posterior density under Regime F.

E.2 MCMC multivariate convergence diagnostic plot



(a) Coexistence regime (b) Regime M (c) Regime F

Figure E4: MCMC multivariate convergence diagnostics under the three regimes.

F Prior and posterior estimates: subsample analysis under the coexistence regime

Table 7: Prior and posterior distributions of estimated parameters:subsample analysis.

Prior distribution		Posterior distribution Pre-GFC		Posterior distribution Post-GFC	
Parameters	Mean, s.d.	Mean	95% interval	Mean	95% interval
Habit formation (h)	B (0.7, 0.05)	0.896	[0.844, 0.933]	0.844	[0.764, 0.921]
Rotemberg price adjustment (Ω_p)	G (118, 10.0)	121.0	[101.1, 140.3]	125.2	[105.0, 145.7]
Interest rate smoothing (ρ_R)	B (0.73, 0.05)	0.814	[0.751, 0.874]	0.854	[0.814, 0.892]
Monetary and fiscal policy parameters					
Monetary response to non-fiscal inflation (α_π^{AM})	G (1.5, 0.05)	1.511	[1.415, 1.611]	1.485	[1.390, 1.579]
Monetary response to fiscal inflation (α_π^{PM})	B (0.005, 0.0005)	0.005	[0.004, 0.006]	0.005	[0.004, 0.006]
Fiscal response to backed public debt (δ_τ^{PF})	G (1.2, 0.005)	1.200	[1.190, 1.209]	1.200	[1.190, 1.209]
Fiscal response to unbacked public debt δ_τ^{AF}	B (0.001, 0.0005)	0.001	[0.000, 0.002]	0.001	[0.000, 0.002]
Unbacked portion of shock parameter (ζ)	B (0.25, 0.05)	0.368	[0.261, 0.476]	0.426	[0.306, 0.542]
AR(1) persistence parameters					
Gov. consumption exp. shock (ρ_{gc})	B (0.5, 0.1)	0.636	[0.417, 0.808]	0.530	[0.399, 0.657]
Transfers shock (ρ_{tr})	B (0.5, 0.1)	0.877	[0.805, 0.945]	0.610	[0.479, 0.742]
Tax revenue shock (ρ_τ)	B (0.5, 0.1)	0.708	[0.493, 0.887]	0.732	[0.616, 0.835]
Preference shock (ρ_c)	B (0.5, 0.1)	0.482	[0.314, 0.651]	0.792	[0.687, 0.890]
Term premium shock (ρ_{tp})	B (0.5, 0.1)	0.076	[0.047, 0.108]	0.079	[0.047, 0.114]
Technology shock (ρ_{λ_z})	B (0.9, 0.1)	0.925	[0.909, 0.940]	0.920	[0.904, 0.935]
Price mark-up shock (ρ_θ)	B (0.5, 0.1)	0.516	[0.332, 0.694]	0.535	[0.367, 0.703]
S.d. of shocks					
Gov. consumption exp. shock (σ_{gc})	IG (0.01, 0.1)	0.011	[0.008, 0.013]	0.014	[0.012, 0.017]
Transfers shock (σ_{tr})	IG (0.01, 0.1)	0.004	[0.004, 0.005]	0.007	[0.006, 0.008]
Tax revenue shock (σ_τ)	IG (0.01, 0.1)	0.057	[0.044, 0.070]	0.041	[0.033, 0.049]
Monetary policy shock (σ_R)	IG (0.01, 0.1)	0.006	[0.004, 0.007]	0.002	[0.002, 0.003]
Preference shock (σ_c)	IG (0.01, 0.1)	0.380	[0.240, 0.522]	0.397	[0.253, 0.569]
Term premium shock (σ_{tp})	IG (0.01, 0.1)	0.067	[0.056, 0.080]	0.062	[0.051, 0.073]
Technology shock (σ_{λ_z})	IG (0.01, 0.1)	0.011	[0.008, 0.013]	0.011	[0.008, 0.013]
Price mark-up shock (σ_θ)	IG (0.01, 0.1)	2.962	[2.113, 3.832]	1.885	[1.350, 2.452]

Note: B denotes beta, G denotes gamma, and s.d. denotes standard deviation. The posterior densities are obtained using the Random-Walk Metropolis algorithm. For each regime, two parallel MCMC (Markov Chain Monte Carlo) chains are generated, each consisting of 100,000 draws.