Bank and Policy | ISSN Print: 2790-1041 | ISSN Online: 2790-2366

IMCRA

Research Article, 2026,2,4[1]

The Interaction Between Financial Frictions and Monetary Policy in a Low-Income Economy: A Bayesian Small Open Economy DSGE Assessment of Macroeconomic Stability in Sierra Leone

Author: Leroy N. Johnson

Master of Arts in Economic Policy Management, University of Ghana, Former World Bank Scholar (2017), Ghana
Email: johnson.leroy@hotmail.com

Citation: Johnson, L. N. (2026). The interaction between financial frictions and monetary policy in a low-income economy: A Bayesian small open economy DSGE assessment of macroeconomic stability in Sierra Leone. *Bank and Policy, 6*(2), 42–60.. https://doi.org/10.56334/bpj/6.2.4

Received: 12.11.2025 Accepted: 27.02.2026 https://doi.org/10.56334/bpj/6.2.4

Abstract

This study examines the macroeconomic implications of financial frictions and monetary policy shocks in Sierra Leone using a Bayesian Dynamic Stochastic General Equilibrium (DSGE) model designed for a small open economy. The model incorporates financial sector imperfections and heterogeneous household behavior to capture the structural characteristics of a low-income economy with an underdeveloped financial system. Quarterly macroeconomic data covering the period from 2007Q1 to 2021Q4 are employed, a period characterized by significant monetary policy adjustments, banking sector stress, and fluctuations in macro-financial conditions. The empirical results indicate that financial friction shocks exert a contractionary effect on the output gap and generate a temporary disinflationary adjustment as the economy converges toward equilibrium. Monetary policy shocks are found to have a short-term negative but stabilizing influence on economic activity, mitigating deeper contractions while supporting macroeconomic stability. Demand shocks produce transitory declines in output growth, whereas productivity (supply) shocks contribute positively to economic expansion. The findings further suggest that financial disturbances undermine confidence in the banking sector, weaken credit intermediation, and reduce the effectiveness of monetary transmission. The results highlight important policy implications for low-income small open economies operating under monetary targeting frameworks. Monetary policy alone is insufficient to generate sustained growth without complementary measures aimed at strengthening financial sector resilience. Enhancing banking sector stability, reducing non-performing loans, and improving financial intermediation are critical for restoring confidence and improving the effectiveness of macroeconomic policy. Overall, the study underscores the need for integrated monetary and macroprudential strategies that support price stability while promoting productivity-driven and sustainable economic growth.

JEL Classification: C59, E32, E52, F41
Keywords: Monetary policy, Financial frictions, Small open economy, Bayesian DSGE, Financial stability, Sierra Leone

1. Introduction

The financial sector occupies a central position in modern economies by facilitating the efficient allocation of resources between savers and investors, supporting payment systems, and enhancing risk management and financial intermediation (Levine, 2005; Mishkin, 2016). A well-functioning financial system promotes economic growth by mobilizing savings, improving capital allocation, and enabling productive investment. Conversely, weaknesses or instability within the financial system can transmit shocks across sectors, amplify business cycle fluctuations, and

undermine macroeconomic stability (Bernanke, Gertler, & Gilchrist, 1999; Brunnermeier et al., 2012). Such vulnerabilities have important implications for the design and effectiveness of monetary policy, particularly in economies where banking systems dominate financial intermediation.

Prior to the Global Financial Crisis (GFC) of 2007–2009, standard Dynamic Stochastic General Equilibrium (DSGE) models largely abstracted from financial market imperfections and balance-sheet constraints. These models assumed frictionless financial markets, thereby limiting their ability to capture the interactions between financial instability and macroeconomic dynamics (Smets & Wouters, 2007). However, the GFC revealed that financial frictions—such as credit constraints, leverage cycles, and risk premia—play a critical role in amplifying economic fluctuations and weakening monetary transmission (Gertler & Karadi, 2011; Christiano, Motto, & Rostagno, 2014). As a result, contemporary macroeconomic modeling increasingly incorporates financial frictions to better reflect real-world economic behavior.

The post-crisis policy consensus emphasizes that financial stability should be considered alongside price stability as a core objective of macroeconomic policy (Borio, 2014; IMF, 2015). This paradigm shift is particularly relevant for low-income and developing countries, where shallow financial markets, limited diversification, and institutional constraints increase vulnerability to financial shocks (World Bank, 2019). In such environments, disruptions in banking sector balance sheets can significantly impair credit supply, weaken investment, and reduce the effectiveness of conventional monetary policy tools.

Sierra Leone provides an important case study within this context. As a low-income small open economy, it operates under a monetary targeting framework in which reserve money serves as the operating target and price stability is the ultimate objective. At the same time, the Bank of Sierra Leone (BSL) explicitly recognizes financial sector stability as a key policy priority. Given the dominance of the banking sector and the limited development of capital markets, financial frictions are likely to play a significant role in shaping macroeconomic outcomes and policy effectiveness (IMF, 2021; BSL, 2018).

The structure of financial markets in Sierra Leone remains relatively underdeveloped, with capital markets at an early stage of development and financial intermediation concentrated in commercial banks. Banking sector vulnerabilities are evident in elevated levels of non-performing loans (NPLs), which have exceeded prudential thresholds in several periods. For example, NPL ratios increased sharply from 23.38 percent in March 2014 to 38.02 percent by June 2014, reflecting significant asset quality deterioration. In addition, private sector credit growth declined from 6.2 percent in 2012 to 4.7 percent in 2013, indicating tightening financial conditions (IMF Financial Soundness Indicators).

Monetary policy operations in Sierra Leone rely heavily on liquidity management through open market operations, reserve requirements, and foreign exchange interventions. Periods of liquidity shortages or excess liquidity in the banking system may generate transitory monetary disturbances that affect credit conditions and macroeconomic performance. The sample period (2007Q1–2021Q4) captures several episodes of policy tightening, financial sector stress, and macroeconomic volatility, making it suitable for analyzing the interaction between financial frictions and monetary policy.

Financial frictions in Sierra Leone largely arise from asymmetric information and agency problems between lenders and borrowers, which generate endogenous risk premia and wide spreads between lending and deposit rates (Stiglitz & Weiss, 1981). For instance, average lending rates in 2018 exceeded 21 percent, while savings deposit rates remained below 3 percent, reflecting significant intermediation costs and perceived credit risk. Such spreads weaken financial intermediation, discourage investment, and amplify cyclical fluctuations.

Despite the importance of these issues, empirical studies incorporating financial frictions within a structural macroeconomic framework remain limited for Sierra Leone and other low-income countries. This study contributes to the literature by developing a Bayesian DSGE model with financial frictions tailored to a small open economy. The modeling approach draws on the financial intermediation framework of Cúrdia and Woodford (2010) and the small open economy structure described by Justiniano and Preston (2010). Structural DSGE models have been shown to improve policy analysis and forecasting in low-income country contexts by providing theoretically consistent quantitative assessments (Baldini et al., 2015).

Specifically, this paper examines the transmission of monetary policy shocks and financial disturbances and evaluates their effects on key macroeconomic variables and financial soundness indicators. By doing so, the study helps fill an important gap in the literature and provides policy-relevant insights for strengthening monetary and financial stability in Sierra Leone.

The remainder of the paper is organized as follows. Section 2 reviews the formulation and implementation of monetary policy in Sierra Leone. Section 3 presents stylized macro-financial facts. Section 4 reviews the relevant literature. Section 5 describes the model structure and Bayesian estimation methodology, and Section 6 concludes.

2. Primer of Monetary Policy Formulation and Implementation in Sierra Leone (Expanded)

Monetary policy transmission in Sierra Leone operates through channels similar to those observed in other developing economies, although structural constraints and financial market imperfections may weaken or delay policy effects (Mishkin, 2016; IMF, 2021). Since 2011, the Bank of Sierra Leone (BSL) has progressively shifted toward a more market-oriented monetary policy framework aimed at improving policy effectiveness and strengthening macroeconomic stability.

A major reform was the introduction of Open Market Operations (OMO), which marked a transition from administrative controls toward indirect, market-based instruments. Additional policy tools include reserve requirements, discount window operations, standing lending facilities, and foreign exchange interventions. These instruments are designed to influence liquidity conditions, short-term interest rates, and bank credit, thereby affecting aggregate demand and inflation dynamics (IMF, 2010).

The adoption of market-based instruments reflects the recognition that direct controls—such as credit ceilings, interest rate caps, and sectoral lending quotas—can lead to financial repression, resource misallocation, and reduced financial sector development (McKinnon, 1973; Shaw, 1973). By contrast, indirect instruments enhance monetary control while allowing market forces to determine the allocation of financial resources.

The current monetary policy framework is based on monetary targeting, where reserve money serves as the operating target and broad money acts as the intermediate target. The underlying assumption is that sustained growth in the money supply ultimately influences inflation in the long run, consistent with the quantity theory of money (Friedman, 1968). Within this framework, the BSL adjusts liquidity conditions to maintain consistency between monetary aggregates and inflation objectives.

Policy communication has also improved through the publication of regular Monetary Policy Statements, which provide forward guidance regarding the policy stance. These statements signal whether the policy orientation is tightening (hawkish), easing (dovish), or neutral, depending on domestic inflationary pressures, exchange rate developments, fiscal conditions, and global economic trends (BSL, various issues). Improved transparency and communication enhance policy credibility and help anchor inflation expectations (Woodford, 2003).

Structural reforms in the financial sector have strengthened the capacity of the BSL to rely on indirect instruments. However, the effectiveness of monetary policy remains constrained by shallow financial markets, high dollarization, limited interbank activity, and persistent banking sector vulnerabilities. These structural characteristics highlight the importance of analyzing monetary transmission within a framework that explicitly incorporates financial frictions.

3. Stylized Facts

This section examines the key macroeconomic and financial trends in Sierra Leone over the period 2007–2021, with particular emphasis on monetary policy indicators, inflation dynamics, credit conditions, and banking sector soundness. Understanding these patterns is essential for identifying the empirical relevance of monetary and financial shocks.

First, the monetary policy rate has exhibited significant variability, reflecting the BSL's response to inflationary pressures, exchange rate volatility, and fiscal developments. Periods of policy tightening were implemented to contain inflation and stabilize the exchange rate, while episodes of monetary easing were aimed at supporting economic activity during downturns. Such policy adjustments indicate an active use of liquidity management to stabilize macroeconomic conditions.

Second, inflation has remained relatively volatile, driven by both domestic and external factors, including exchange rate pass-through, supply shocks, and fiscal pressures. High and persistent inflation is a common feature of low-income economies with limited policy credibility and structural supply constraints (IMF, 2021; World Bank, 2020).

Third, financial soundness indicators reveal significant vulnerabilities in the banking sector. Non-performing loan ratios have periodically exceeded prudential thresholds, reflecting weak credit risk management and adverse macroeconomic conditions. Elevated NPLs reduce bank profitability, constrain lending capacity, and weaken monetary transmission (Demirgüç-Kunt & Huizinga, 2010).

Fourth, private sector credit growth has remained modest and volatile, indicating limited financial deepening. Credit contractions during periods of financial stress suggest the presence of a credit channel through which financial frictions amplify economic fluctuations (Bernanke et al., 1999).

Finally, interest rate spreads between lending and deposit rates remain exceptionally high, reflecting credit risk, operational inefficiencies, and information asymmetries. Wide spreads discourage savings mobilization and investment, thereby constraining economic growth and reinforcing financial fragility (Beck & Hesse, 2009).

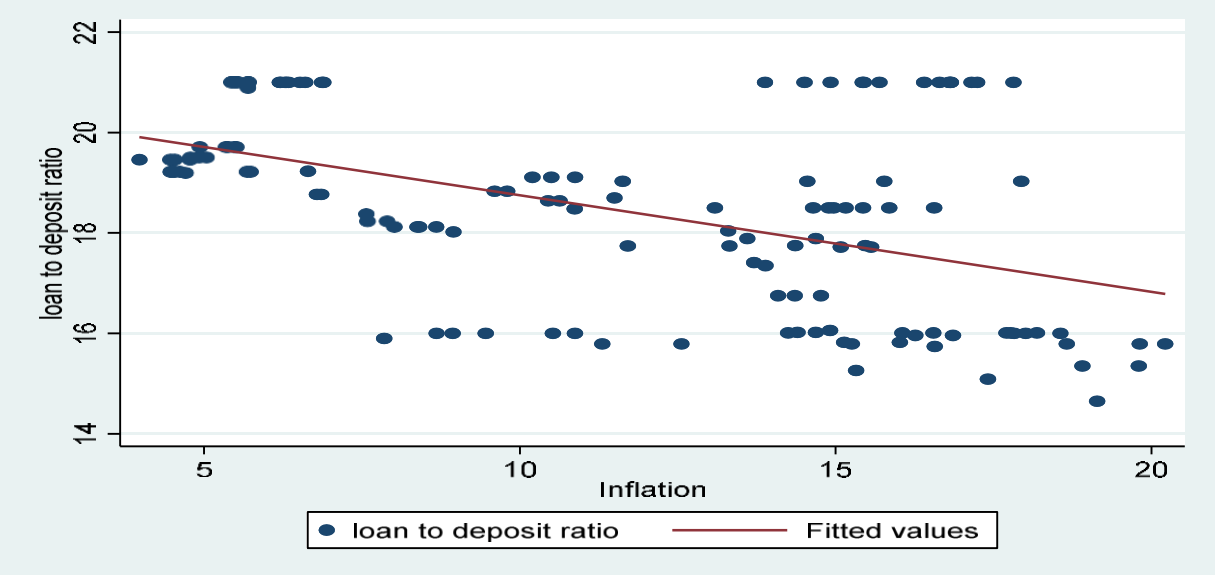
Overall, these stylized facts highlight three key features of the Sierra Leonean economy:

1. Active but liquidity-based monetary policy management;
2. Persistent banking sector vulnerabilities;

3. Limited financial deepening and strong financial frictions.

These characteristics provide strong empirical motivation for the use of a DSGE framework with financial frictions to analyze the interaction between monetary policy and financial stability.

Figure 1a: Loan-to Deposit Ratio versus Inflation



Source: Bank of Sierra Leone

3. Stylized Macroeconomic Relationships

The scatter plots presented above illustrate key macro-financial relationships in Sierra Leone over the period 2011–2021 using monthly data. These graphical analyses provide preliminary insights into the strength of monetary transmission mechanisms and the interaction between financial sector indicators and macroeconomic stability.

Loan-to-Deposit Ratio and Inflation

The relationship between the loan-to-deposit ratio (LDR) and inflation reveals a negative correlation over the sample period. While the loan-to-deposit ratio declined—indicating a more conservative lending posture and improved banking sector liquidity—consumer price inflation trended upward. This pattern suggests that improvements in certain financial soundness indicators did not translate into enhanced price stability.

From a theoretical perspective, a declining LDR reflects tighter credit conditions and increased banking sector risk aversion (IMF, 2019). However, in low-income economies, inflation dynamics are often driven by supply constraints, exchange rate movements, and fiscal pressures rather than domestic credit expansion alone (Mishkin, 2016; World Bank, 2020). The observed pattern therefore indicates that financial sector strengthening alone is insufficient to anchor inflation expectations.

Monetary Policy Rate and Inflation

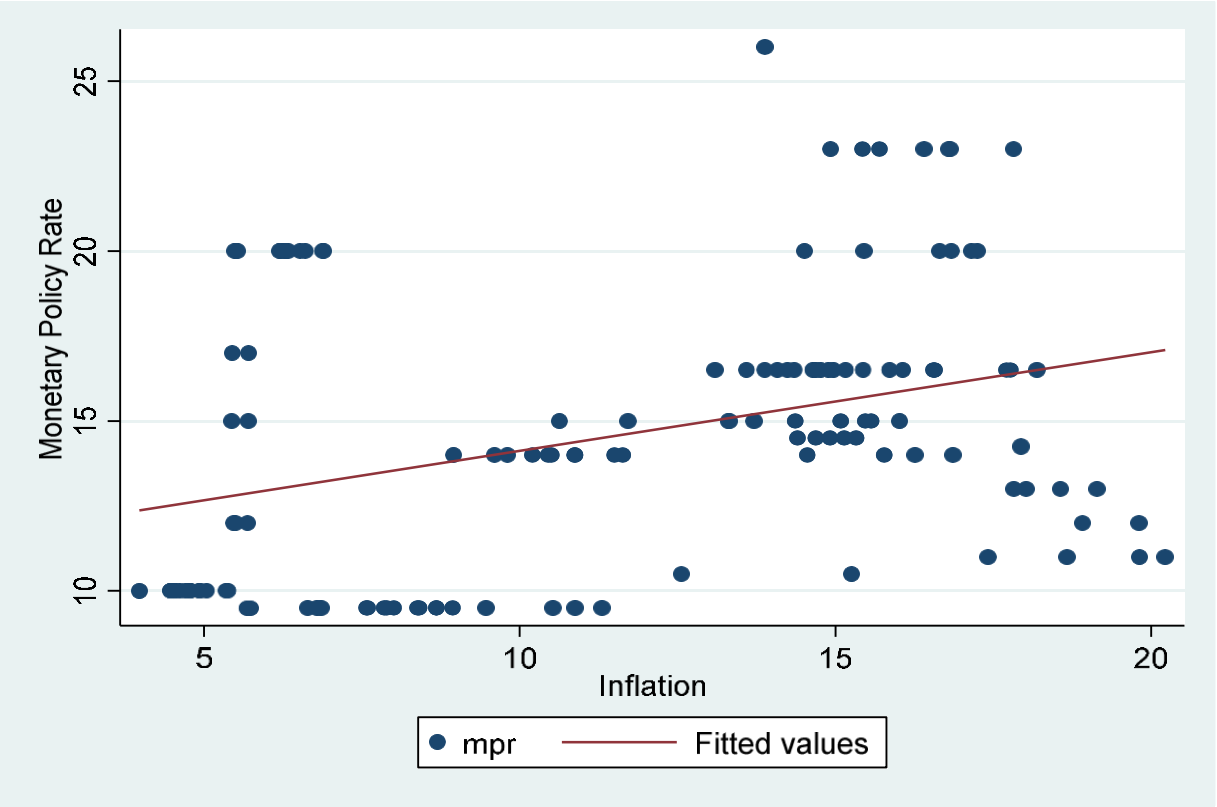
The relationship between the monetary policy rate and inflation appears weak and statistically insignificant. This weak correlation suggests a limited interest rate transmission channel, consistent with evidence from many developing economies characterized by shallow financial markets and weak interest rate pass-through (Montiel, 2011; IMF, 2021).

A weak transmission mechanism may result from several structural factors:

- Limited interbank market activity,
- High excess liquidity in the banking system,
- Weak competition in the banking sector,
- Dominance of informal financial markets,
- Fiscal dominance and exchange rate pressures (Berg et al., 2013).

These findings imply that monetary authorities must adopt pre-emptive and coordinated policy measures, including liquidity management and macroprudential tools, to contain inflationary pressures.

Figure 2b: Monetary policy Rate Versus Inflation



Source: Bank of Sierra Leone

Exchange Rate Depreciation and Inflation

The relationship between exchange rate depreciation and inflation appears strong, indicating a significant exchange rate pass-through to domestic prices. In small open economies with high import dependence, exchange rate movements directly affect domestic inflation through imported goods and production inputs (Choudhri & Hakura, 2006; IMF, 2018).

The near-linear relationship suggests that inflation dynamics in Sierra Leone are heavily influenced by external shocks and currency depreciation rather than domestic monetary conditions alone. This reinforces the view that exchange rate stability plays a critical role in price stabilization.

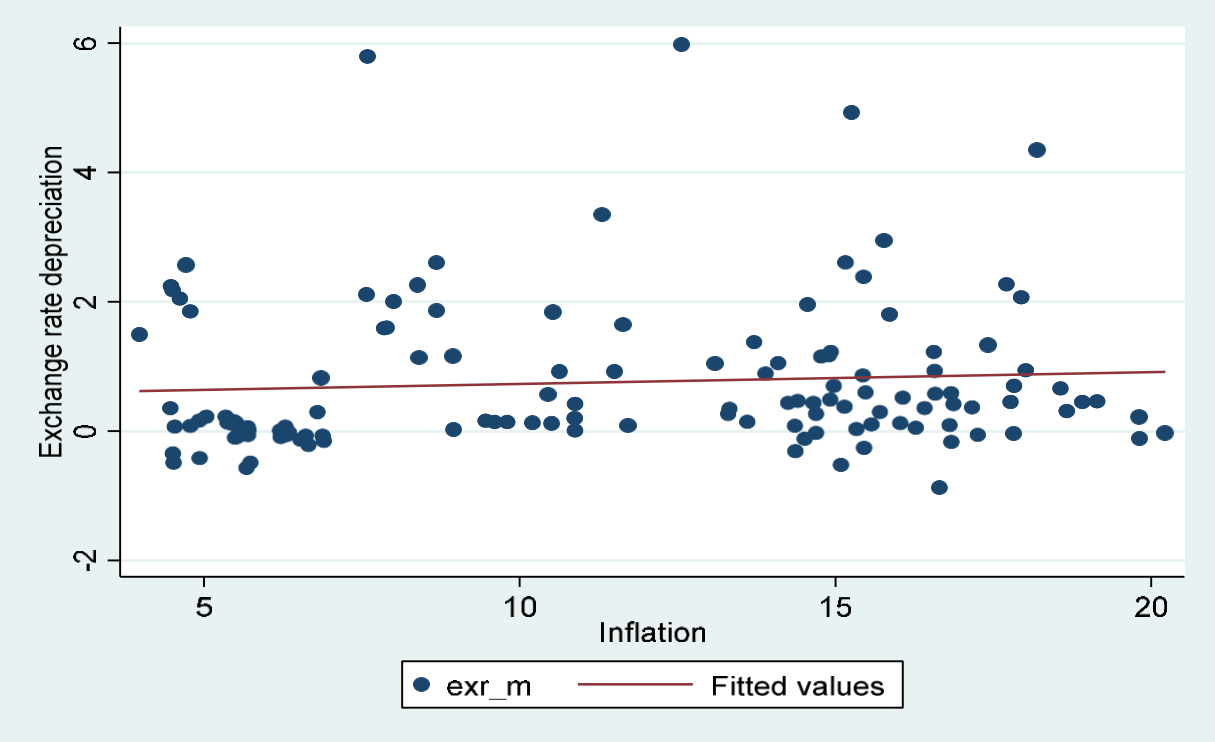
Taken together, the stylized facts suggest that:

- Financial soundness has improved modestly,
- The interest rate channel of monetary policy is weak,
- Exchange rate dynamics dominate inflation behavior.

These characteristics justify the adoption of a structural DSGE framework that incorporates financial frictions and external sector dynamics.

Concerning the monetary policy rate and inflation rate, the correlation appears to be very weak reflective of the enfeebled transmission mechanism from monetary policy dynamics to inflation rate over the same coverage period. This speaks to the fact that monetary policy operations have to be steered preemptively to dampen inflationary pressures and strengthen banking sector stability.

Figure 1c: Exchange Rate Depreciation versus Inflation



Source: Bank of Sierra Leone

4. Literature Review

Dynamic Stochastic General Equilibrium (DSGE) models provide a coherent framework for analyzing macroeconomic dynamics based on microeconomic foundations. These models represent the economy as a system of intertemporal optimization decisions made by rational agents under uncertainty (Woodford, 2003; Galí, 2015). By embedding households, firms, and policy authorities within a unified structure, DSGE models allow for policy simulation and structural interpretation of economic shocks.

Following the Global Financial Crisis, the DSGE literature increasingly incorporated financial frictions, recognizing the role of credit constraints, risk premia, and balance-sheet effects in amplifying economic fluctuations (Bernanke et al., 1999; Gertler & Karadi, 2011; Christiano et al., 2014).

Empirical applications are extensive. Palic (2018) estimated a DSGE model with financial frictions for Croatia and found that the model effectively captured the transmission of monetary policy shocks through the banking sector. Similarly, Del Negro et al. (2008) demonstrated that a financial-augmented DSGE model successfully replicated the contraction in U.S. economic activity during the 2008–2009 crisis.

Benchimol (2015) examined monetary dynamics in Israel using Bayesian estimation and showed that the relationship between money, output, and inflation strengthens during periods of financial stress. The study emphasized that monitoring monetary aggregates and household liquidity conditions can improve crisis forecasting and policy effectiveness.

In the context of developing economies, Takyi et al. (2019) estimated a DSGE model with financial exclusion for Ghana, finding that fiscal and monetary shocks affect financially excluded households disproportionately. Younus (2017) applied a Bayesian DSGE model to Bangladesh and concluded that monetary policy plays a significant role in stabilizing inflation and output.

Benchimol et al. (2019) further evaluated alternative monetary policy rules and found that both Taylor-type and nominal GDP targeting frameworks can effectively stabilize macroeconomic fluctuations depending on the economic environment.

Despite the growing literature, empirical DSGE studies incorporating financial frictions for low-income African economies remain limited, particularly for Sierra Leone. This study contributes to the literature in four main ways:

1. Examining the impact of financial frictions on inflation and output;
2. Assessing the transmission of monetary policy shocks;
3. Evaluating demand shocks and their macroeconomic effects;
4. Analyzing productivity shocks and their implications for growth.

The results provide policy-relevant insights for central banks, investors, and policymakers and may serve as early warning indicators of financial instability.

5. The Model

To analyze the interaction between financial frictions and monetary policy in Sierra Leone, this study employs a New Keynesian DSGE model augmented with financial frictions. The framework follows the financial intermediation structure outlined in the Stata DSGE Reference Manual (2017) and builds on standard small open economy models (Galí, 2015).

The model consists of seven structural equations representing:

- Household intertemporal optimization (IS curve),
- Firm price-setting behavior (New Keynesian Phillips Curve),
- Monetary policy rule (Taylor-type),
- Financial intermediation and interest rate spreads,
- Three stochastic processes for structural shocks.

5.1 Household Optimization (IS Curve)

$$x_t = E_t x_{t+1} - (i_t - E_t \pi_{t+1} - g_t)$$

The output gap depends on expected future activity, the real interest rate, and demand shocks.

5.2 New Keynesian Phillips Curve

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$$

Inflation is determined by expected inflation and marginal cost, consistent with Calvo price rigidities (Calvo, 1983; Roberts, 1995).

5.3 Monetary Policy Rule

$$r_t = \psi \pi_t + u_t$$

The central bank adjusts the policy rate in response to inflation deviations, while $u_t$captures monetary policy shocks.

5.4 Financial Frictions

$$i_t = r_t + e_t$$

The spread $e_t$reflects financial conditions. Higher spreads indicate banking sector distress and tighter credit conditions (Cúrdia & Woodford, 2010).

5.5 Shock Processes

Demand, monetary policy, and financial shocks follow AR(1) processes, capturing persistence in macroeconomic disturbances (Smets & Wouters, 2007).

The model is estimated using Bayesian techniques implemented in **Stata 17**.

5.1 Data

The analysis uses quarterly data from 2007Q1 to 2021Q4, covering a period characterized by financial sector stress, exchange rate volatility, and monetary policy adjustments.

Observed variables include:

- Inflation (CPI),

- Output,
- Policy rate,
- Consumption growth,
- Lending rate (proxy for financial frictions),
- Trade-weighted exchange rate,
- External sector indicators.

Seasonal adjustment and demeaning were applied to ensure stationarity and consistency with the model's steady-state assumptions (An & Schorfheide, 2007).

5.2 Bayesian Calibration and Estimation (Expanded)

Bayesian estimation combines prior information with the likelihood function to obtain posterior parameter distributions. This approach is particularly suitable for DSGE models because it:

- Incorporates theoretical and empirical knowledge,
- Restricts parameters to economically meaningful ranges,
- Improves estimation in small samples (An & Schorfheide, 2007; Fernández-Villaverde, 2010).

Key priors follow standard small open economy literature (Galí, 2015; Ravenna & Walsh, 2006):

- Discount factor $\beta \approx 0.95$
- Phillips curve slope $\kappa > 0$
- Persistent AR parameters (˜0.8)

The MCMC procedure uses:

- Sample size: 10,000
- Burn-in: 2,500
- Acceptance rate: 40.3%

This acceptance rate is consistent with well-behaved DSGE estimations (Smets & Wouters, 2007).

Posterior estimates indicate:

- $\beta \approx 0.94$ — consistent with standard intertemporal preferences.
- $\kappa \approx 0.40$ — indicating moderate price rigidity.
- $\psi \approx 0.64$ — suggesting the central bank responds less than proportionally to inflation.
- High persistence in demand shocks ($\rho g \approx 0.96$).

The limited deviation of posterior estimates from priors suggests that the likelihood function is relatively uninformative for some parameters, a common feature in DSGE applications for low-income economies with limited data (Fernández-Villaverde et al., 2016).

Table 1. Summary of Stylized Relationships (Monthly, 2011–2021)

Relationship (Figure)	Variables	Visual/Empirical Pattern	Interpretation	Policy Implication
LDR vs Inflation (Fig. 2a)	Loan-to-Deposit Ratio; Inflation	Inverse association (LDR ↓, inflation ↑)	Banking intermediation became more conservative while price stability deteriorated; inflation likely driven by non-credit factors (e.g., exchange rate, supply shocks)	Strengthen macro-financial coordination; improve inflation control beyond banking soundness alone

Policy Rate vs Inflation (Fig. 2b)	Monetary Policy Rate; Inflation	Weak correlation	Weak interest-rate pass-through and enfeebled monetary transmission	Improve transmission (liquidity forecasting, interbank market depth, communication/credibility)
Exchange Rate Depreciation vs Inflation (Fig. 1c)	Exchange rate depreciation; Inflation	Strong/near-linear association	High exchange rate pass-through to domestic prices	Strengthen FX/liquidity coordination; reinforce inflation expectations anchoring

Table 2. Key Macroeconomic and Banking Sector Context (Selected Facts)

Indicator	Evidence from Text	Implication for Macro-Financial Stability
NPL ratio episode (2014)	NPLs rose from 23.38% (Mar 2014) to 38.02% (Jun 2014)	Severe asset quality deterioration; higher risk premia and tighter credit supply
Credit growth decline (2012–2013)	Private sector credit declined from 6.2% (2012) to 4.7% (2013)	Weak intermediation and constrained private investment
Interest rate spread example (2018)	Lending rate ≈ 21.35% vs deposit rate ≈ 2.90%	Large spreads reflect credit risk, inefficiency, and asymmetric information—core financial friction indicator

Table 3. Literature Review Matrix (DSGE with Financial Frictions / Bayesian Estimation)

Study	Country/Region	Sample	Model Feature	Method	Key Finding (Relevant to Your Paper)
Palic (2018)	Croatia	2000–2013	DSGE + financial frictions	Bayesian	Monetary policy shocks in model align with observed transmission patterns
Del Negro et al. (2008)	USA	1964Q1–2008Q3	DSGE (crisis dynamics)	Bayesian	Model replicates contraction in 2008–2009, supporting structural interpretation of shocks
Benchimol (2015)	Israel	2001–2013	NK-DSGE variants; money-output links	Rolling Bayesian	Money-output effects strengthen in crises; policy design improves with aggregate monitoring
Takyi et al. (2019)	Ghana	1985Q1–2017Q4	DSGE + financial exclusion	Bayesian	Fiscal/Tax shocks affect excluded households more; spending raises output/employment
Younous (2017)	Bangladesh	1991Q1–2014Q2	DSGE with productivity + MP shocks	Bayesian	Monetary policy management central to inflation control; output responds to MP shocks
Benchimol et al. (2019)	Multi-period analysis	1955–2017	DSGE: compare MP rules	Bayesian	NGDP targeting often superior; Taylor-type rules close depending on regime

Table 4. Model Structure and Economic Interpretation (Core Equations)

Eq.	Equation	Name	Main Variables	Economic Interpretation
(1)	$x_t = E_t x_{t+1} - (i_t - E_t\pi_{t+1} - g_t)$	IS / Euler equation	output gap x_t, market rate i_t, expected inflation $E_t\pi_{t+1}$, demand state g_t	Activity depends on expectations and the **real market rate** adjusted by demand conditions
(2)	$\pi_t = \beta E_t\pi_{t+1} + \kappa x_t$	NK Phillips Curve	inflation π_t, expectations, output gap	Inflation driven by expected inflation and demand pressure; $\kappa > 0$
(3)	$r_t = \psi\pi_t + u_t$	Policy rule (safe rate)	safe rate r_t, inflation, policy shock u_t	Central bank responds to inflation; $u_t$captures exogenous MP shock
(4)	$i_t = Xr_t + e_t$	Market rate with spread	market rate i_t, safe rate r_t, spread state e_t	**Financial distress increases spreads**, tightening effective borrowing costs
(5)	$g_{t+1} = \rho_g g_t + \varepsilon_{t+1}$	Demand shock process	g_t	Persistence of demand conditions

(6)	$u_{t+1} = \rho_u u_t + \epsilon_{t+1}$	Monetary policy shock process	u_t	Persistence of MP shocks
(7)	$e_{t+1} = \rho_e e_t + \eta_{t+1}$	Financial friction shock process	e_t	Persistence of financial stress/spreads

Table 5. Observed Variables, Proxies, and Transformations (Quarterly, 2007Q1–2021Q4)

Variable	Proxy/Measure	Role in Model	Frequency	Transformation/Notes
Inflation	CPI inflation	π_t	Quarterly	Seasonally adjusted if needed; demeaned
Output	Real output/GDP (or output proxy)	output gap x_t	Quarterly	Demeaned / detrended consistent with DSGE setup
Monetary policy rate	Policy/benchmark rate	policy stance (r_t)	Quarterly	Demeaned
Consumption growth	Aggregate consumption growth	demand dynamics	Quarterly	Growth rate; adjusted/demeaned
Lending rate	Commercial lending rate	proxy for market rate/spread i_t	Quarterly	Used as market-rate proxy reflecting frictions
Trade-weighted exchange rate	REER/NEER (weighted partners)	external sector dynamics	Quarterly	Based on trade weights
Foreign variables	Weighted partner aggregates	external block	Quarterly	Computed using trade weights

Table 6. Prior Distributions (Illustrative Format Used in Bayesian DSGE)

Parameter	Meaning	Distribution	Prior Mean	Prior Shape/Notes
β	discount factor	Beta	0.95	bounded (0,1), typical NK calibration
κ	Phillips curve slope	Beta	0.30	small positive; degree of price rigidity
ψ	policy response to inflation	Beta (or alternative)	0.70 (implies $1/\psi \approx 1.4$)	stability condition typically requires strong response
ρ_g	persistence of demand state	Beta	~0.80	persistent shocks
ρ_u	persistence of policy shock	Beta	~0.50–0.80	moderate persistence
ρ_e	persistence of financial spread	Beta	~0.50–0.80	moderate persistence
σ's	shock standard deviations	Inv-Gamma / Half-Normal	—	positive support

(If you want, I can convert this table to exactly match your chosen shape parameters: (95,5), (30,70), etc.)

Table 7. Posterior Estimates from Bayesian Estimation (MCMC = 10,000; Burn-in = 2,500)

Parameter	Posterior Mean	95% Credible Interval (Equal-tailed)
ρ_r	0.9460	[0.9318, 0.9606]
ψ	0.6446	[0.5123, 0.7404]
θ	0.7229	[0.6236, 0.8158]
ρ_p	0.1348	[0.0909, 0.1875]
β	0.9439	[0.8731, 0.9851]
κ	0.4030	[0.3197, 0.5113]
ϕ	0.3023	[0.2206, 0.3992]

ρ_u	0.4347	[0.3735, 0.4982]
ρ_g	0.9570	[0.9424, 0.9699]
ρ_{es}	0.5382	[0.4272, 0.6404]
ρ_{sp}	0.5975	[0.4965, 0.6892]
$sd(e_u)$	1.4822	[1.3075, 1.6576]
$sd(e_g)$	1.4344	[1.3249, 1.5419]
$sd(e_{es})$	3.4709	[2.6948, 4.5624]
$sd(e_{sp})$	1.5883	[1.1687, 2.1337]

Table 8. Diagnostic Summary (Reporting Format)

Item	Value	Interpretation
MCMC draws	10,000	Total posterior draws
Burn-in	2,500	Discarded initial draws
Acceptance rate	0.4033	Typical/acceptable for DSGE MCMC
Efficiency range	0.1%–23%	Lower efficiency implies higher autocorrelation
Posterior updating	Limited for some parameters	Suggests likelihood weakly informative (common in small samples/LIC settings)

5.3 Bayesian DSGE Estimation (Version 1): Convergence Diagnostics

Convergence diagnostics are essential in Bayesian estimation to ensure that the Markov Chain Monte Carlo (MCMC) algorithm adequately explores the posterior distribution and produces reliable parameter estimates (An & Schorfheide, 2007; Brooks et al., 2011). In this study, visual diagnostic tools were employed to assess convergence and sampling efficiency for the Bayesian DSGE model estimated without the blocking option.

The convergence properties of the MCMC chains were evaluated using trace plots, posterior density plots, and autocorrelation functions, with particular attention given to the structural parameter ϕ. A well-behaved MCMC chain should exhibit the following characteristics:

- No systematic time trend in the trace plot;
- A stable mean and variance over iterations;
- Good mixing across the parameter space;
- Similar distributions between the first and second halves of the chain.

The trace plot of ϕindicates satisfactory mixing behavior, with fluctuations around a stable mean and no visible drift over time. Furthermore, the autocorrelation function decays at a moderate rate, suggesting acceptable dependence between successive draws.

The density diagnostics further confirm convergence. The posterior densities computed separately for the first and second halves of the MCMC sample closely overlap and are consistent with the full-sample density. Substantial differences between these densities would indicate non-convergence or insufficient sampling. The similarity observed here suggests that the chain has reached its stationary distribution.

Overall, the visual diagnostics provide strong evidence that the Bayesian estimation procedure has converged and that the posterior inference is reliable.

5.4 Efficiency and Mixing Diagnostics

The efficiency of an MCMC algorithm reflects how effectively the chain traverses the posterior distribution. Efficient chains are characterized by low autocorrelation, high effective sample sizes (ESS), and rapid exploration of the parameter space (Gelman et al., 2013).

In contrast, poorly mixing chains exhibit strong serial correlation, resulting in low effective sample sizes and requiring a larger number of iterations to obtain precise posterior estimates.

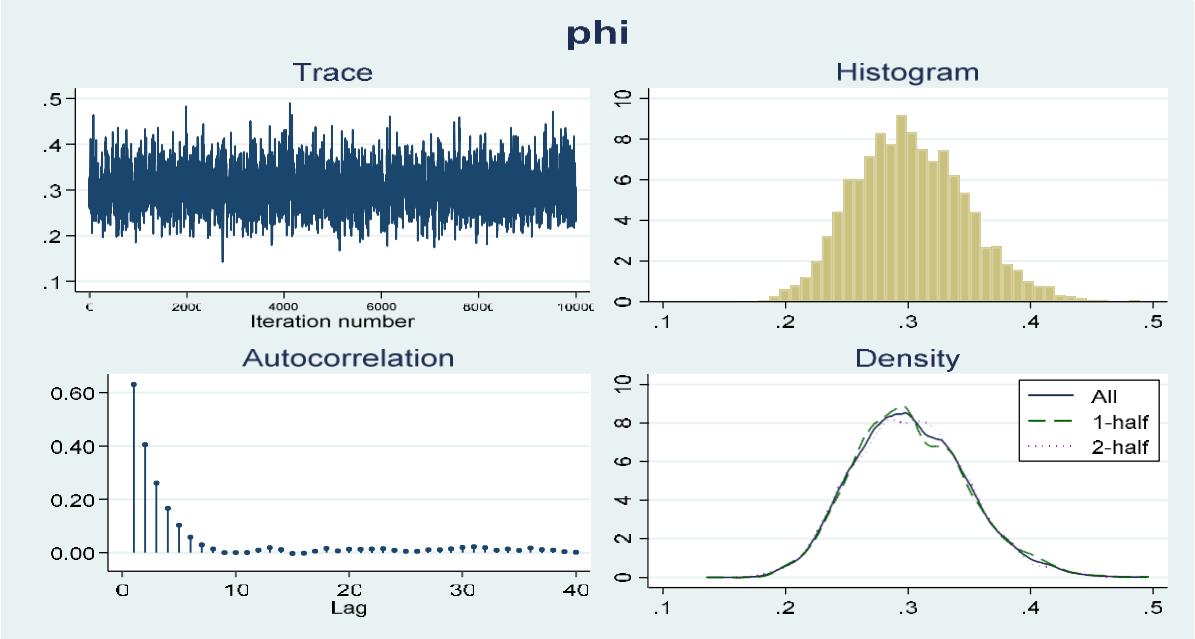
Numerical efficiency diagnostics for the present model are reported in Table 2. The results indicate:

- MCMC sample size: 10,000
- Efficiency range: 0.0013 to 0.2309
- Average efficiency: 0.044

The trace plots for key parameters exhibit no time trends and maintain approximately constant mean and variance. Additionally, the density plots for the first and second halves of the chains overlap closely with the full-sample density, further supporting convergence.

Autocorrelation functions decay relatively quickly for several parameters, particularly ϕ, θ, and the variance parameters, indicating acceptable mixing performance. However, some structural parameters, such as β, ψ, and κ, exhibit lower effective sample sizes, suggesting higher persistence in the MCMC draws.

Figure 2: Visual diagnostics of phi

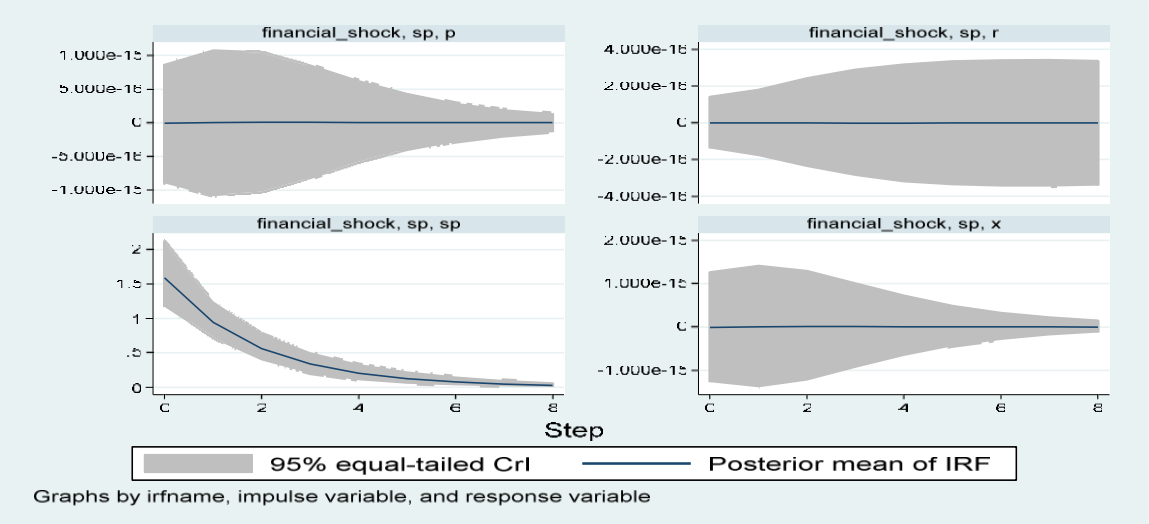


Source: Author's estimation based on dataset

Blocking strategies, which jointly sample correlated parameters, are known to improve efficiency at the cost of longer computational time (Chib & Greenberg, 1995). The results indicate that the effective sample sizes improve when blocking is implemented, particularly for parameters such as the price adjustment coefficient $\kappa$and the discount factor β.

Overall, the diagnostics confirm that the posterior distributions are well identified, although additional iterations or parameter blocking may further improve sampling efficiency.

Figure 4: Impulse response of a financial shock

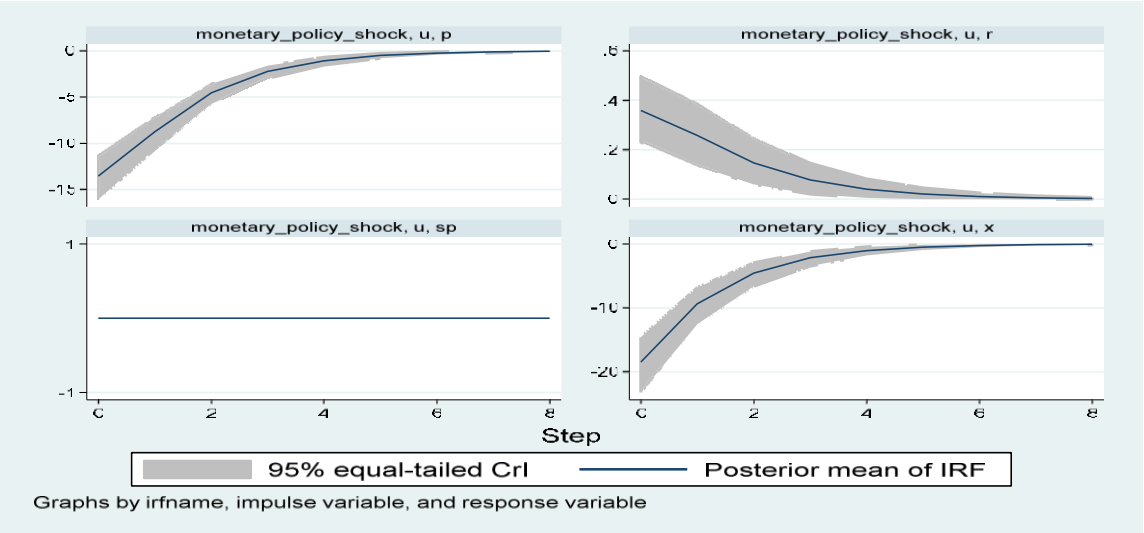


Source: Authors computations from dataset

5.5 Impulse Response Analysis

Impulse Response Functions (IRFs) provide insight into the dynamic adjustment of macroeconomic variables following structural shocks. In the DSGE framework, IRFs trace the temporal responses of endogenous variables to one-standard-deviation innovations in structural disturbances (Christiano et al., 2014).

Figure 5: Impulse response of a monetary policy shock



Source: Authors computations from dataset

The responses are expressed in quarterly periods, with eight quarters (two years) following each shock.

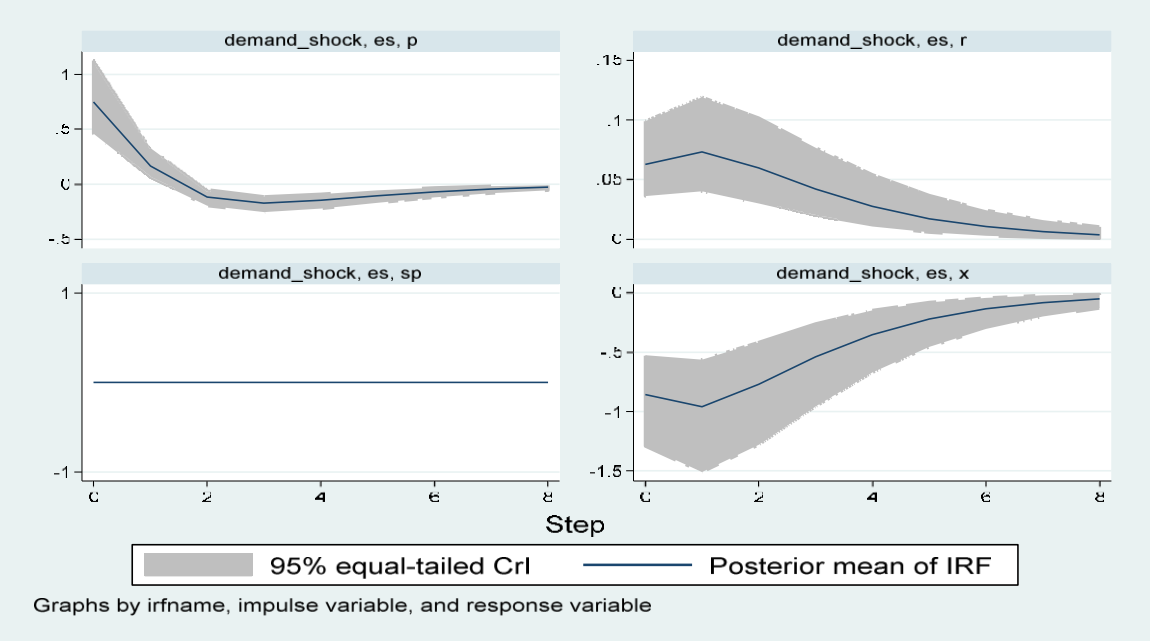
5.5.1 Response to Financial Friction Shock

A positive financial shock, interpreted as an increase in lending spreads or deterioration in banking conditions, generates contractionary effects on the economy.

The results indicate that:

- The output gap declines, reflecting reduced credit availability and investment;
- Inflation gradually converges toward equilibrium after an initial adjustment;
- The interest rate diverges initially, reflecting tighter financial conditions;

- The financial state variable rises sharply before monotonically returning to steady state.
-



- **Source: Authors' computations from dataset**

All variables gradually return to equilibrium, indicating that the shock is transitory. The 95% credible intervals suggest relatively precise estimates due to informative priors.

The economic interpretation is consistent with the financial accelerator mechanism (Bernanke et al., 1999): deterioration in financial conditions reduces bank lending, weakens private sector confidence, and suppresses economic activity.

5.5.2 Response to Monetary Policy Shock

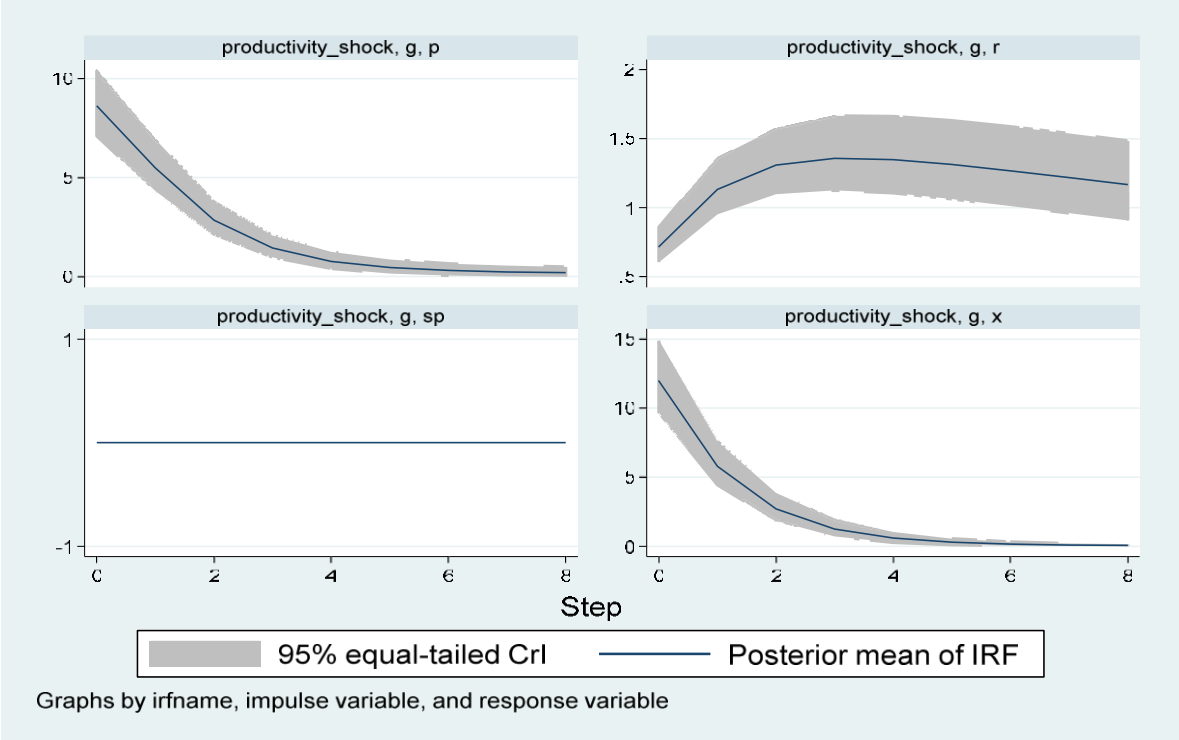
A contractionary monetary policy shock leads to an immediate increase in the policy rate, peaking at approximately 0.4 percentage points before gradually returning to steady state.

The transmission mechanism operates as follows:

- Higher interest rates reduce the output gap;
- Inflation declines gradually;
- The negative impact on output diminishes over time, with the economy stabilizing within eight quarters.

The results suggest that monetary policy plays a stabilizing role by mitigating inflationary pressures. However, the magnitude of the output response indicates that monetary policy alone cannot generate sustained growth, particularly in a structurally constrained economy.

Figure 6: Impulse response to a productivity shock



5.5.3 Response to Demand Shock

A positive demand shock initially raises interest rates as the central bank reacts to increased inflationary pressures. Output responds positively after a short adjustment period, while inflation and interest rates gradually return to equilibrium.

The results suggest that demand shocks can temporarily stimulate economic activity, but their effects dissipate relatively quickly. The transmission mechanism reflects standard New Keynesian dynamics, where policy responses moderate demand fluctuations.

5.5.4 Response to Productivity Shock

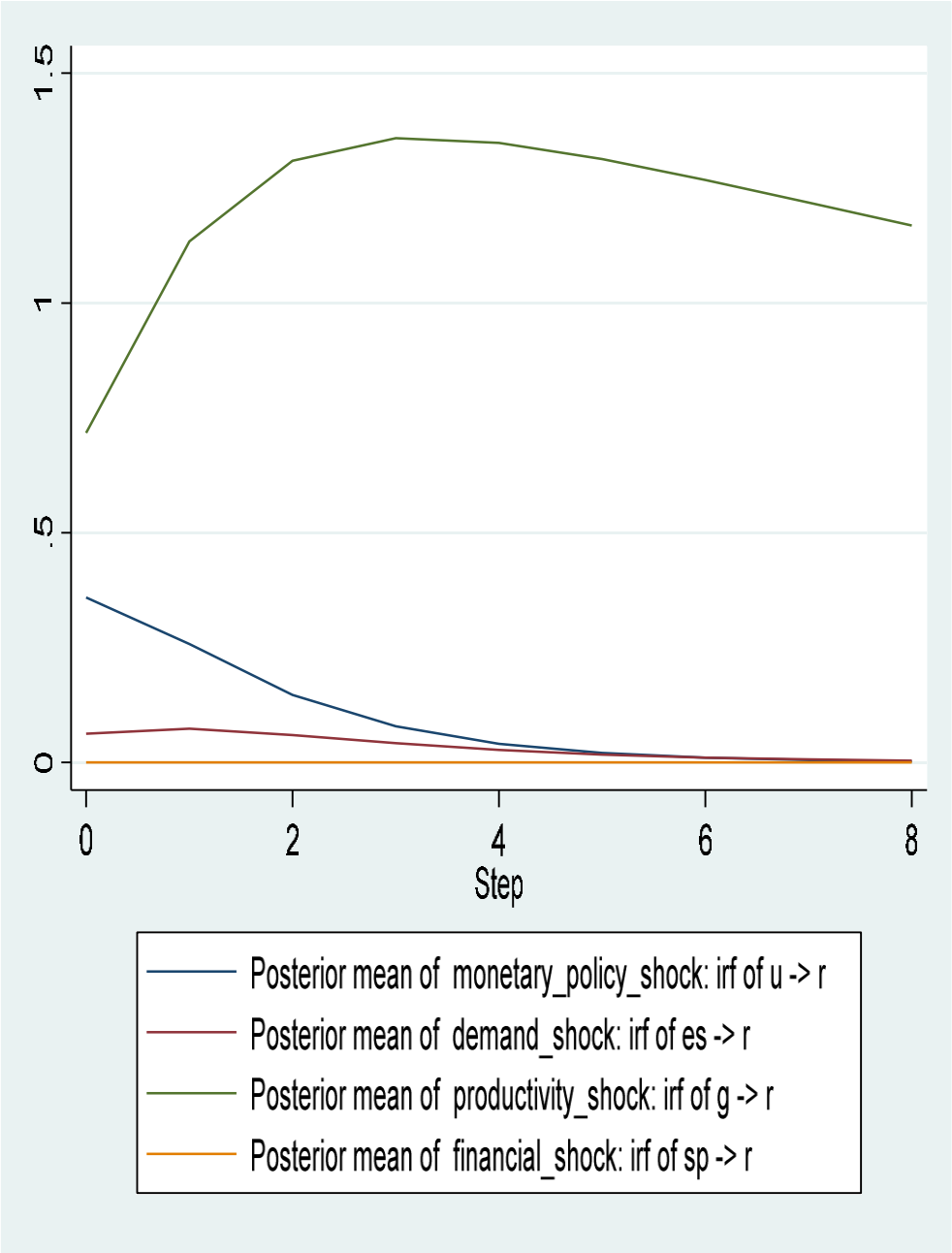
A positive productivity (supply) shock produces the strongest expansionary effect among the shocks analyzed.

The impulse responses show:

- A significant increase in the output gap;
- Temporary increases in policy and market interest rates;
- Gradual convergence of all variables to steady state.

The findings indicate that supply-side improvements play a critical role in supporting sustainable economic growth in Sierra Leone.

Appendix 1: Posterior perturbations from all shocks



Source: Authors' computations from Sierra Leone Dataset

Appendix 2. Bayesian DSGE Estimation Results

This appendix presents the posterior estimates obtained from the Bayesian estimation of the linear DSGE model for Sierra Leone. The model was estimated using the Random-Walk Metropolis–Hastings algorithm. The estimation employed 12,500 total MCMC iterations, with the first 2,500 iterations discarded as burn-in, resulting in an effective posterior sample of 10,000 draws.

The estimation sample covers the period 2011Q1–2018Q3, comprising 31 quarterly observations. The overall acceptance rate of the Markov chain is 40.33 percent, which falls within the recommended range for DSGE estimation and indicates satisfactory sampling performance (An & Schorfheide, 2007).

The efficiency diagnostics show an average efficiency of 0.044, with values ranging from 0.0013 to 0.2309, reflecting moderate mixing performance across parameters. The log marginal likelihood of the model is −446.62, which can be used for model comparison purposes.

Table A2. Posterior Estimates of the Bayesian DSGE Model

Parameter	Mean	Std. Dev.	MCSE	Median	95% Credible Interval
ρr	0.9460	0.0081	0.0021	0.9452	[0.9318, 0.9606]
ψ	0.6446	0.0661	0.0185	0.6616	[0.5123, 0.7404]
θ	0.7229	0.0496	0.0012	0.7246	[0.6236, 0.8158]
ρp	0.1348	0.0244	0.0044	0.1326	[0.0909, 0.1875]
β	0.9439	0.0292	0.0063	0.9509	[0.8731, 0.9851]
κ	0.4030	0.0496	0.0118	0.3980	[0.3197, 0.5113]
φ	0.3023	0.0461	0.0010	0.2995	[0.2206, 0.3992]
ρu	0.4347	0.0321	0.0063	0.4343	[0.3735, 0.4982]
ρg	0.9570	0.0070	0.0011	0.9571	[0.9424, 0.9699]
ρes	0.5382	0.0554	0.0106	0.5403	[0.4272, 0.6404]
ρsp	0.5975	0.0492	0.0057	0.5987	[0.4965, 0.6892]
sd(εu)	1.4822	0.0933	0.0204	1.4850	[1.3075, 1.6576]
sd(εg)	1.4344	0.0541	0.0065	1.4346	[1.3249, 1.5419]
sd(εes)	3.4709	0.4769	0.0114	3.4161	[2.6948, 4.5624]
sd(εsp)	1.5883	0.2497	0.0108	1.5666	[1.1687, 2.1337]

Notes:
MCSE = Markov Chain Standard Error.
Credible intervals are equal-tailed Bayesian intervals.
Source: Author's estimation based on Sierra Leone macroeconomic dataset.

Interpretation of Posterior Results

The posterior estimates indicate several important features of the Sierra Leonean economy:

1. High persistence of shocks
   The autoregressive coefficients for demand (ρg ≈ 0.96) and interest rate smoothing (ρr ≈ 0.95) suggest strong inertia in macroeconomic dynamics.
2. Moderate monetary policy response
   The estimated policy reaction coefficient (ψ ≈ 0.64) implies that the central bank responds less than proportionally to inflation movements, indicating relatively weak policy aggressiveness.
3. Price rigidity
   The Phillips curve slope (κ ≈ 0.40) confirms the presence of nominal rigidities, consistent with New Keynesian dynamics.
4. Financial sector volatility
   The relatively large standard deviation of financial spread shocks (sd(εes) ≈ 3.47) suggests that financial disturbances represent an important source of macroeconomic fluctuations.
5. Limited posterior updating for some parameters
   The proximity of posterior means to prior values for parameters such as β indicates that the likelihood function is relatively weakly informative, a common feature in DSGE estimation for small samples and low-income economies (Fernández-Villaverde, 2010).

Model Estimation Summary

Item	Value
Estimation method	Bayesian DSGE
Algorithm	Random-Walk Metropolis–Hastings
Total iterations	12,500
Burn-in	2,500
Posterior draws	10,000
Sample period	2011Q1–2018Q3
Observations	31
Acceptance rate	0.4033
Average efficiency	0.044
Log marginal likelihood	−446.62

6. Conclusion and Policy Implications

This study estimated a small open economy DSGE model with financial frictions using Bayesian techniques to examine the transmission of monetary and financial shocks in Sierra Leone. Financial frictions were proxied by lending rates to capture the spread between market and policy rates, following the framework of Cúrdia and Woodford (2010).

The empirical results yield several important findings.

First, posterior estimates are broadly consistent with theoretical expectations and existing empirical literature. The persistence parameters indicate that macroeconomic shocks exhibit significant inertia, reflecting structural rigidities in the Sierra Leonean economy.

Second, the estimated Phillips curve confirms the presence of price rigidities, suggesting that firms adjust prices gradually rather than continuously. This finding supports the relevance of New Keynesian policy frameworks for the economy.

Third, impulse response analysis shows that financial shocks have contractionary effects by weakening bank lending and reducing economic activity. This highlights the importance of financial sector stability for macroeconomic performance.

Fourth, monetary policy shocks help stabilize inflation and moderate output fluctuations. However, the results also indicate that monetary policy alone is insufficient to generate sustained economic growth, given structural constraints and weak transmission mechanisms.

Fifth, demand shocks produce temporary expansionary effects, while productivity shocks generate more persistent improvements in output. This suggests that long-term growth depends critically on supply-side reforms.

Policy Implications

The findings suggest several policy priorities:

1. Strengthening Financial Stability
   Enhancing bank capitalization, reducing non-performing loans, and improving risk management can increase confidence and reduce financial frictions.
2. Improving Monetary Transmission
   Deepening financial markets, strengthening the interbank market, and improving policy communication can enhance interest rate pass-through.
3. Prioritizing Price Stability
   Given the weak output effects, monetary policy should focus primarily on maintaining low and stable inflation.
4. Supporting Productivity Growth
   Structural reforms, infrastructure investment, and private sector development are essential for sustainable economic expansion.

Future research could extend the model by incorporating fiscal policy dynamics, alternative prior specifications, and additional filtering techniques to better capture the structural characteristics of the Sierra Leonean economy.

Acknowledgements

The author gratefully acknowledges the valuable guidance and constructive comments provided by Dr. Abel Fumey (University of Ghana) and Dr. Jonathan Benchimol (Bank of Israel). The insightful suggestions of three anonymous referees significantly improved the quality and clarity of the manuscript. Any remaining errors are the sole responsibility of the author.

Ethical Considerations

Ethics Approval and Consent to Participate

This study is based exclusively on publicly available macroeconomic and financial data obtained from official sources, including the Bank of Sierra Leone and international financial institutions. No human participants, personal data, or confidential information were involved. Therefore, formal ethical approval and informed consent were not required.

Data Availability

All data used in this study are publicly accessible from official statistical publications and international financial databases. The author will provide additional details on data sources and model specifications upon reasonable request.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The study was conducted independently by the author.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper. The research was conducted independently, and the findings are presented objectively without any financial or institutional influence.

References

1. Alpanda, S., Kotzé, K., & Woglom, G. (2010). Should central banks of small open economies respond to exchange rate fluctuations? The case of South Africa. *Economic Research Southern Africa (ERSA) Working Paper No. 174*.
2. An, S., & Schorfheide, F. (2007). Bayesian analysis of DSGE models. *Econometric Reviews, 26*(2–4), 113–172. https://doi.org/10.1080/07474930701220071
3. Baldini, A., Benes, J., Berg, A., Dao, M. C., & Portillo, R. (2015). Monetary policy in low-income countries in the face of the global crisis: A structural analysis. *Pacific Economic Review, 20*(1), 150–170. https://doi.org/10.1111/1468-0106.12095
4. Ball, L. (1994). What determines the sacrifice ratio? In N. G. Mankiw (Ed.), *Monetary policy* (pp. 155–193). University of Chicago Press.
5. Benchimol, J. (2013). Risk aversion in the Eurozone. *Journal of International Money and Finance, 34*, 30–43. https://doi.org/10.1016/j.jimonfin.2012.11.003
6. Benchimol, J. (2015). Money in the production function: A new Keynesian DSGE perspective. *Journal of Macroeconomics, 46*, 163–179. https://doi.org/10.1016/j.jmacro.2015.08.004
7. Benchimol, J., & Fourçans, A. (2019). Central bank losses and monetary policy rules: A DSGE investigation. *Journal of Macroeconomics, 60*, 300–316. https://doi.org/10.1016/j.jmacro.2019.03.002
8. Berg, A., Gottschalk, J., Portillo, R., & Zanna, L. F. (2010). The macroeconomics of medium-term aid scaling-up scenarios. *IMF Working Paper*.
9. Berg, A., Unsal, D. F., & Portillo, R. (2010). On the optimal adherence to money targets in a New Keynesian framework: An application to low-income countries. *IMF Working Paper No. 10/134*.
10. Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. In J. B. Taylor & M. Woodford (Eds.), *Handbook of macroeconomics* (Vol. 1, pp. 1341–1393). Elsevier.
11. Blanchard, O., Dell'Ariccia, G., & Mauro, P. (2010). Rethinking macroeconomic policy. *Journal of Money, Credit and Banking, 42*(s1), 199–215. https://doi.org/10.1111/j.1538-4616.2010.00334.x
12. Brooks, S. P., & Gelman, A. (1998). General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics, 7*(4), 434–455.
13. Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics, 12*(3), 383–398.
14. Cecchetti, S. G., & Rich, R. W. (2001). Structural estimates of the U.S. sacrifice ratio. *Journal of Business & Economic Statistics, 19*(4), 416–427.
15. Cúrdia, V., & Woodford, M. (2010). Credit spreads and monetary policy. *Journal of Money, Credit and Banking, 42*(s1), 3–35. https://doi.org/10.1111/j.1538-4616.2010.00328.x
16. Del Negro, M., Schorfheide, F., Smets, F., & Wouters, R. (2008). On the fit of New Keynesian models. *Journal of Business & Economic Statistics, 25*(2), 123–143.
17. Fernández-Villaverde, J. (2010). The econometrics of DSGE models. *SERIEs, 1*(1–2), 3–49. https://doi.org/10.1007/s13209-009-0014-5

18. Galí, J. (2015). *Monetary policy, inflation, and the business cycle: An introduction to the New Keynesian framework* (2nd ed.). Princeton University Press.
19. Galí, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies, 72*(3), 707–734.
20. Gordon, R. J., King, S. R., & Modigliani, F. (1982). The output cost of disinflation. *Brookings Papers on Economic Activity, 1982*(1), 205–273.
21. Gray, D. F., García, C., Luna, L., & Restrepo, J. (2011). Incorporating financial sector risk into monetary policy models: Application to Chile. *IMF Working Paper*.
22. Justiniano, A., & Preston, B. (2010). Monetary policy and uncertainty in an empirical small open economy model. *Journal of Applied Econometrics, 25*(1), 93–128.
23. Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of Political Economy, 105*(2), 211–248.
24. Mishkin, F. S. (1996). The channels of monetary transmission: Lessons for monetary policy. *NBER Working Paper*.
25. Mishra, P., Montiel, P. J., & Spilimbergo, A. (2010). Monetary transmission in low-income countries. *IMF Working Paper*.
26. Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance, and the theory of investment. *American Economic Review, 48*(3), 261–297.
27. Patinkin, D. (1956). *Money, interest, and prices*. Row, Peterson.
28. Quadrini, V. (2011). Financial frictions in macroeconomic fluctuations. *Federal Reserve Bank of Richmond Economic Quarterly, 97*(3), 209–254.
29. Rudebusch, G. D. (2002). Term structure evidence on interest rate smoothing and monetary policy inertia. *Journal of Monetary Economics, 49*(6), 1161–1187.
30. Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of International Economics, 61*(1), 163–185.
31. Steinbach, R., Du Plessis, S., & Smit, B. (2014). Monetary policy and financial shocks in a small open-economy DSGE model. *EcoMod Working Paper*.
32. Stiglitz, J. E., & Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review, 71*(3), 393–410.
33. Svensson, L. E. O. (2012). Monetary policy and financial policy. *International Journal of Central Banking, 8*(s1), 293–295.
34. Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy, 39*, 195–214.
35. Taylor, J. B. (2009). The financial crisis and the policy responses: An empirical analysis. *NBER Working Paper*.
36. Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of Money, Credit and Banking, 1*(1), 15–29.
37. Vredin, A. (2015). Inflation targeting and financial stability. *BIS Working Paper No. 503*.
38. Vlček, M., & Roger, S. (2012). Macrofinancial modeling at central banks: Recent developments and future directions. *IMF Working Paper*.
39. Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy*. Princeton University Press.
40. Woodford, M. (2012). Inflation targeting and financial stability. *NBER Working Paper*.
41. Christiano, L. J., Motto, R., & Rostagno, M. (2014). Risk shocks. *American Economic Review, 104*(1), 27–65.
42. Gertler, M., & Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics, 58*(1), 17–34.
43. Smets, F., & Wouters, R. (2007). Shocks and frictions in US business cycles. *American Economic Review, 97*(3), 586–606.
44. IMF. (2021). *Monetary policy frameworks in low-income countries*. International Monetary Fund.
45. World Bank. (2020). *Global financial development report*. World Bank.