



Endogenous Liquidity Creation in Bank-Centric Economies: A DSGE Analysis of Iran, Azerbaijan, and Armenia

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Highlights

- A DSGE model compares liquidity creation in Iran, Armenia, and Azerbaijan.
- A Liquidity Distribution Index (LDI) measures bank liquidity allocation.
- Nonlinear balance-sheet dynamics assess credit shocks.
- A small share of created liquidity goes to productive lending.
- Stronger credit allocation mechanisms are needed beyond interest-rate tools.

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Abstract

This study employs a calibrated Dynamic Stochastic General Equilibrium (DSGE) model to compare endogenous liquidity creation and its allocation in Iran, Armenia, and Azerbaijan over 2005–2024. It significantly contributes by introducing a structural Liquidity Distribution Indicator (LDI), measuring the share of bank-created liquidity allocated to firm lending. Countries are selected based on similar Liquidity Creation Intensity (LCI), defined as the ratio of central bank borrowing to total deposits. The model features a representative household and bank with financial frictions to analyze how balance sheet liquidity allocation affects the transmission of a –1% lending rate shock, interpreted as a relaxation of credit conditions before and after COVID-19. Calibrated to country-specific financial structures and solved using a fully nonlinear routine, the model generates impulse responses from nonlinear transition dynamics. Results show that before COVID-19, banks in Iran and Armenia allocated a relatively small share of liquidity to firm lending, with Azerbaijan displaying a similar pattern driven by state-dominated intermediation. Although post-COVID liquidity support temporarily increased lending shares, structural banking features continued to constrain effective monetary transmission. Overall, interest rate policy alone appears insufficient to mitigate risks from concentrated liquidity allocation; strengthening credit allocation mechanisms and banking intermediation is essential for macro-financial stability.

1. Introduction

The banking sector plays a pivotal role in shaping macro-financial stability, particularly in bank-centric economies where commercial banks are the primary channel for financial resource allocation. In such systems, endogenous credit creation, rather than traditional financial intermediation, dominates capital formation. Endogenous liquidity creation—defined as the expansion of bank

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balance sheets through simultaneous loan issuance and deposit creation—directly influences credit allocation, internal liquidity propagation, and financial system resilience (Werner, 2014; Jakab & Kumhof, 2015; McLeay et al., 2014).

A central issue associated with endogenous liquidity creation concerns how newly created liquidity is allocated within the banking system's balance sheet. Liquidity allocation refers to the proportion of created liquidity transmitted to the real sector through lending relative to the share retained within the banking system as reserves or internal buffers. When a relatively small portion of balance sheet capacity is directed toward lending, a larger share of created liquidity remains within the banking system. Such balance sheet configurations can weaken credit transmission and increase macro-financial vulnerabilities during periods of financial stress (BIS, 2020; IMF, 2021; Chenarani et al., 2023; Sundaresan & Xiao, 2023). In this vein, Sundaresan and Xiao (2023) demonstrate that liquidity buffers, while intended to mitigate risk, can act as an implicit tax on banking activities, potentially crowding out bank lending and altering the distribution of liquidity within the banking system.

Dynamic Stochastic General Equilibrium (DSGE) models offer a structured framework for analyzing these mechanisms by incorporating financial frictions, endogenous money creation, and bank balance sheet interactions (Christiano et al., 2005; Chenarani et al., 2023; Ahmadyan, 2024). While these models are widely used to study credit dynamics in advanced economies (Gerali et al., 2010; Dib, 2010), relatively little is known about how endogenous liquidity creation and liquidity allocation operate in emerging bank-dominant economies. Recent studies have also applied DSGE models to examine banking sector balance-sheet fragility and its macroeconomic consequences in Iran's bank-based financial system (Chenarani et al., 2023).

A key gap in the literature is the absence of a structural measure of liquidity allocation within the representative bank's balance sheet—specifically, an indicator capable of capturing the distribution of created liquidity between lending to the real sector and liquidity retained internally as buffers. Existing DSGE banking frameworks predominantly rely on aggregate indicators such as total loans, broad money, or credit-to-GDP ratios. These measures cannot reveal whether macro-financial shocks lead to liquidity concentration, dilution, or internal rebalancing within bank balance sheets. This limitation restricts our ability to identify liquidity allocation channels in emerging economies and constrains cross-country comparisons of balance sheet structures and their responses to credit disturbances. The lack of such a structural indicator is particularly consequential in bank-centric emerging markets, where credit provision and internal liquidity management play a critical role in shaping macro-financial outcomes.

Iran, Armenia, and Azerbaijan represent three bank-centric emerging economies in which commercial banks serve as the main suppliers of credit to the real sector. These economies differ in several macroeconomic and institutional dimensions, including economic size, external exposure, natural resource

dependence, and monetary arrangements. This study does not assume structural similarity across their broader macroeconomic environments. Instead, it focuses on a shared characteristic: differences in how bank-created liquidity is allocated between lending and balance sheet buffers within their banking sectors. This feature provides a coherent basis for examining how a standardized credit condition shock propagates through their respective financial systems.

Importantly, this study does not model or compare monetary policy regimes across the three economies. The shock introduced in the model is a credit condition shock rather than a conventional monetary policy shock. It affects the effective lending rate faced by borrowers and captures changes in banks' internal funding conditions, risk premia, and liquidity constraints. This distinction is particularly relevant for Iran, where formal interest rate instruments do not operate as independent monetary policy tools.

This paper makes three main contributions. First, it introduces a structural Liquidity Distribution Index (LDI), which measures the share of bank-created liquidity allocated to lending within the representative bank's balance sheet. This indicator provides a tractable measure of liquidity allocation dynamics in a DSGE framework with endogenous credit creation. Second, the study extends the DSGE-based framework of endogenous liquidity creation developed in [Tavakolian et al. \(2023\)](#) to a comparative cross-country setting involving Iran, Armenia, and Azerbaijan. Third, the model is calibrated using national banking statistics for each country, allowing an assessment of how a standardized credit condition shock propagates through different banking sector structures and influences liquidity allocation dynamics.

The remainder of the paper is organized as follows. Section 2 introduces the theoretical foundations of endogenous liquidity creation and distribution. Section 3 develops the DSGE modelling framework with integrated banking-sector dynamics. Section 4 summarizes the comparative literature and institutional features of the banking systems in Iran, Armenia, and Azerbaijan. Section 5 outlines the broader research background. Section 6 details the DSGE model structure and methodology. Section 7 assesses the model's empirical performance. Section 8 describes the fully nonlinear solution approach. Section 9 presents the equilibrium conditions and steady-state results. Section 10 concludes with implications for banking-sector resilience and macro-financial stability.

2. Theoretical Framework

In the banking literature, endogenous liquidity creation refers to the process through which banks do not merely intermediate pre-existing funds but instead expand their balance sheets through simultaneous loan issuance and deposit creation. [Werner \(2014\)](#), in an empirical case study of a Japanese bank's balance sheet, demonstrates that when a bank grants a loan it simultaneously records an equivalent deposit in the borrower's account, without first transferring funds from existing deposits. [Jakab and Kumhof \(2015\)](#) similarly argue that, contrary to the traditional loanable-funds view, bank lending creates matching assets and

liabilities within the banking system rather than reallocating pre-existing liquidity. [McLeay, Radia, and Thomas \(2014\)](#), in a Bank of England Quarterly Bulletin article, further describe this mechanism as the central process through which modern money is created.

This bank-centric perspective forms the theoretical basis of the present model. Within this framework, credit supply conditions—rather than exogenous policy rate rules—play the central role in driving banking sector dynamics and the internal propagation of liquidity within the financial system. The model focuses on the core mechanisms of bank balance sheet expansion and credit allocation and does not attempt to represent the full macroeconomic structure of the economy.

2.1 Liquidity Distribution

While endogenous liquidity creation determines the overall scale of liquidity in the system, the allocation of this liquidity within banks' balance sheets shapes how effectively financial systems absorb shocks. Recent studies show that liquidity regulation, reserve remuneration, and internal liquidity buffers significantly influence how bank-created liquidity is allocated across balance sheets, often crowding out productive lending despite continued credit creation ([Sundaresan & Xiao, 2023](#)).

In this context, shocks to lending conditions—arising from changes in bank risk perceptions, funding constraints, or regulatory adjustments—may propagate asymmetrically depending on how bank-created liquidity is distributed across the banking system's balance sheet. The analysis in this study therefore focuses on how credit condition disturbances within the banking sector are transmitted through banks' balance sheets and liquidity positions, rather than on the effects of conventional monetary policy shocks depending on how bank-created liquidity is distributed across the banking system's balance sheet ([Sundaresan & Xiao, 2023](#)).

3. DSGE-Based Theoretical Modelling

3.1 DSGE Framework and the Banking Sector

Dynamic Stochastic General Equilibrium (DSGE) models provide a structured analytical environment for studying the interaction between microeconomic optimization and aggregate economic dynamics under uncertainty. While conventional DSGE frameworks typically rely on an explicit monetary policy rule to anchor interest rate dynamics, the present model departs from this approach by abstracting from a Taylor-type rule and instead emphasizing the endogenous role of the banking sector in shaping credit conditions.

The integration of banking sectors into DSGE models has followed two main strands. The first introduces credit and balance sheet frictions, as in [Gerali et al. \(2010\)](#), who embed banking dynamics into a euro-area DSGE model. Recent DSGE applications emphasize banking-sector balance-sheet vulnerabilities and endogenous credit conditions, particularly in emerging and bank-dominated economies. Studies focusing on the Iranian banking system show that balance-

sheet insolvency and credit frictions can be effectively analyzed within a DSGE framework (Chenarani et al., 2023; Ahmadyan, 2024).

3.2 Integrating Liquidity Creation and Distribution into DSGE

Recent contributions extend DSGE models to incorporate both the process of bank liquidity creation and the way in which this liquidity is allocated across the components of the banking sector's balance sheet. In these frameworks, the bank's lending decisions are shaped not only by capital adequacy, prudential constraints, and liquidity requirements, but also by state variables capturing the internal composition of bank-created liquidity—namely, the distribution between productive lending and liquidity buffers such as reserves. Tavakolian, Nakhli, and Fallahi (2023) apply this balance-sheet-based approach to the Iranian banking system and show that imbalances in the allocation of liquidity alter both the magnitude and the transmission path of credit disturbances namely, the distribution between productive lending and liquidity buffers such as reserves (Sundaresan & Xiao, 2023).

A central feature of the model used in this study is that it does not include a Taylor-type interest rate rule. Instead, the lending rate emerges as the effective cost of bank credit, determined endogenously by the bank's balance sheet position and its assessment of risk. Shocks to the lending rate therefore capture credit condition disturbances—unexpected changes in funding costs, regulatory actions, or shifts in risk perceptions—rather than deliberate monetary policy interventions. This specification enables the model to examine the transmission of bank-created liquidity and credit disturbances across different banking systems without imposing similarity in monetary policy frameworks or macroeconomic structures.

Although the existing DSGE literature incorporates banking frictions and, more recently, endogenous liquidity creation, these frameworks largely rely on aggregate indicators such as total loans, broad liquidity, or credit spreads. What remains missing is a structural measure that tracks how newly created liquidity is allocated within the representative bank's balance sheet—specifically, the distribution between productive lending and internal liquidity buffers. The absence of such a measure limits the ability of existing models to distinguish between credit expansions that support real-sector activity and those that accumulate as non-productive liquidity within the banking system. This limitation is particularly consequential in bank-dominated emerging economies, where the efficiency of liquidity allocation critically shapes the transmission of credit disturbances. The present study addresses this gap by introducing a balance-sheet-based Liquidity Distribution Index (LDI) within a DSGE framework featuring endogenous credit creation.

4. Comparative Literature: Iran, Armenia, and Azerbaijan

4.1 Banking-Sector Characteristics

Iran, Armenia, and the Republic of Azerbaijan are commonly described as bank-dominated emerging financial systems in which commercial banks serve as

the primary channel of credit provision to the real economy. Assessments by the [International Monetary Fund \(IMF, 2021\)](#) and the [World Bank \(2022\)](#) emphasize the central role of banking institutions in financial intermediation across these economies. In such systems, changes in banks' balance sheet conditions, regulatory liquidity requirements, and funding structures can significantly influence the availability of credit.

Despite notable differences in economic size, institutional frameworks, and macroeconomic structures—including variations in oil dependence, exchange rate regimes, and external financial linkages—the banking sectors of these economies share several operational characteristics that motivate comparative analysis. Reports by the [Asian Development Bank \(ADB, 2020\)](#) note that in many emerging markets, liquidity conditions within banking systems are often unevenly reflected in banks' balance sheet structures, potentially affecting the transmission of credit disturbances.

These observations do not imply structural homogeneity across broader macroeconomic environments. Rather, they provide a basis for examining how credit condition disturbances propagate through the balance sheet structures of bank-dominated financial systems that share certain operational features.

4.2 Research Gap and Contribution

To the best of our knowledge, no DSGE-based framework has introduced a structural indicator capable of measuring the allocation of bank-created liquidity within balance sheets in a cross-country setting. While a substantial body of research has applied DSGE models to advanced economies—such as [Gerali et al. \(2010\)](#) and [Dib \(2010\)](#)—comparative analyses of liquidity-allocation dynamics within bank balance sheets in emerging bank-dominated economies remain limited.

This study extends the DSGE-based framework of endogenous liquidity creation and liquidity distribution developed by [Tavakolian, Nakhli, and Fallahi \(2023\)](#) to a cross-country context by calibrating separate models for Iran, Armenia, and the Republic of Azerbaijan using country-specific banking data. The objective is not to assume structural similarity across the three economies but to examine how credit condition shocks are transmitted through banking systems that operate under different institutional and macroeconomic environments. By focusing on the banking sector as the common analytical core, the framework enables a comparison of credit-transmission dynamics while acknowledging broader structural heterogeneity across countries.

4.3 Liquidity Creation under Double-Entry Accounting (T-Accounts)

Liquidity creation in the model follows the standard double-entry accounting structure of bank balance sheets. Each new loan issued by a commercial bank simultaneously generates a bank asset (loans) and a corresponding liability (deposits), consistent with the endogenous-money

mechanism. Thus, credit expansion does not require pre-existing funds; deposits are created as the direct counterpart of bank lending.

The banking sector consists of a central bank and commercial banks. When lending activity results in reserve shortfalls due to interbank settlement or regulatory requirements, banks obtain settlement balances from the central bank. In accounting terms, this appears as an increase in central bank claims on banks and a corresponding increase in bank reserves. Within the model, these balances are treated as residual clearing items required for payment settlement and reserve compliance, rather than as discretionary monetary policy instruments.

Because the baseline framework abstracts from loan amortization, liquidity circulates through deposits generated by new lending. The model therefore focuses on how bank lending endogenously creates liquidity and how settlement requirements influence its allocation between loans, deposits, and reserve balances.

5. Research Background

A growing body of economic literature emphasizes that liquidity in modern banking systems is not passively derived from prior savings but is created endogenously through banks' balance sheet operations. This perspective—often referred to as the bank credit creation view—highlights the active role of banks in generating deposits through lending decisions rather than merely reallocating existing resources. Within the context of the Iranian economy, [Oskouei & Shakeri \(2021\)](#) provide empirical evidence that banks are capable of expanding liquidity independently of external funding sources. Similarly, [Nasiri et al. \(2022\)](#) show that macro-financial variables such as exchange rates, oil prices, and interest rates significantly influence bank deposits and liquidity creation, with credit expansion at the center of this process.

Although these studies confirm the endogenous nature of liquidity creation, they primarily focus on aggregate liquidity measures such as total loans, bank credit, or broad money aggregates. Consequently, they provide limited insight into how newly created liquidity is allocated within banks' balance sheets. In many macroeconomic models, the mechanisms governing the use of bank-created liquidity are highly stylized or reduced to simple proportional rules. This simplification prevents a structural assessment of how liquidity is distributed between productive lending, liquid assets, and internal liquidity buffers. While the banking and finance literature has long emphasized the importance of balance sheet composition and asset-liability allocation (e.g., [Carpenter & Demiralp, 2006](#); [Homar et al., 2015](#)), these insights have largely remained within institutional or partial-equilibrium analyses and have rarely been incorporated into DSGE frameworks.

Within the domestic theoretical literature, [Amirali et al. \(2023\)](#) represent an important step by introducing balance-sheet-based mechanisms into a DSGE model of the Iranian banking system. Their study analyzes how institutional characteristics of banks influence aggregate liquidity creation. Although this

contribution advances the modeling of banking sector behavior, it does not explicitly address how the liquidity created by the banking system is allocated within bank balance sheets, nor how such allocation affects the transmission of credit policy shocks.

Another strand of literature examines the macroeconomic implications of liquidity hoarding, balance sheet expansion, and concentration risks. [Chari et al. \(2014\)](#) show that the internal retention of liquidity and the accumulation of low-productivity assets within banks can weaken the transmission of credit to the real economy. Empirical evidence for Iran similarly indicates that a significant portion of liquidity expansion is absorbed by non-productive balance sheet items rather than being directed toward real-sector lending ([Islamic Parliament Research Center, 2018](#)). Nevertheless, even DSGE models that incorporate endogenous money creation generally treat liquidity creation as a homogeneous aggregate and abstract from its internal distribution across balance sheet categories.

Importantly, existing research has not integrated two key dimensions within a single macroeconomic framework: endogenous liquidity creation and the allocation of liquidity within bank balance sheets. In particular, no DSGE-based study has introduced a structural indicator capable of measuring the share of newly created liquidity allocated to productive lending relative to liquidity retained internally. As a result, the interaction between credit expansion, liquidity allocation, and macro-financial transmission remains insufficiently explored, especially in bank-dominated economies.

This study addresses these gaps by developing a bank-centered DSGE model in which the allocation of bank-created liquidity is modeled as an explicit balance sheet mechanism. The model introduces a Liquidity Distribution Index (LDI) that measures the proportion of newly created liquidity directed toward productive lending relative to liquidity absorbed as internal buffers. By embedding this indicator within the DSGE structure, the framework jointly captures liquidity creation and liquidity distribution in a dynamic and internally consistent manner. This approach enables a structural analysis of credit shocks, liquidity allocation patterns, and macro-financial transmission channels across banking systems, providing a comparative perspective for Iran, Armenia, and the Republic of Azerbaijan.

6. DSGE Model Specification and Methodology

The modelling framework in this study builds on the DSGE banking model developed by [Tavakolian et al. \(2023\)](#) and extends it to capture not only endogenous liquidity creation but also the allocation of bank-created liquidity across balance sheet components. To achieve this, the model adopts a sequential, balance-sheet-driven representation of banking activity in which transactions are recorded dynamically and the system's behavioral equations arise endogenously from the accounting structure. In addition, following [Forlati and Lambertini \(2014\)](#), the framework incorporates an installment-based debt repayment

mechanism, while the modelling of default probabilities and their macro-financial implications draws on the conceptual insights of [Hristova \(2017\)](#).

In line with the bank-centric nature of the framework, the financial variables in the household problem—such as the return on deposits (i_t, i_t^d) and money balances M_t —do not function as monetary policy instruments. Instead, they represent equilibrium prices and quantities determined by commercial banks' balance sheet dynamics, funding conditions, and the liquidity allocation mechanisms described in Section 6.1.1 and 6.1.2. Importantly, the model does not include a policy interest rate, a monetary policy rule, or any mechanism through which the central bank actively sets the policy stance. The interest rates that appear in household constraints therefore correspond to:

- the effective remuneration of deposits, determined by banks' funding structures, and
- the implicit cost of bank credit, arising from liquidity creation and risk-pricing mechanisms.

Accordingly, all financial flows relevant to household optimization are generated endogenously through banking sector transactions, without direct policy intervention.

A DSGE model is employed because the research question is fundamentally structural and mechanism-based. The objective is not only to assess whether bank-driven credit conditions—captured through the Loan-to-Deposit Imbalance (LDI)—affect economic activity, but also to identify the precise channels through which these effects operate. A DSGE framework provides micro-founded interactions among households, firms, and the banking sector, enabling us to trace how credit supply disturbances propagate through investment, production, default risk, and consumption. These mechanisms cannot be adequately captured by reduced-form econometric approaches.

Furthermore, several key banking features examined in this study—such as default risk, balance sheet constraints, and the amplification role of LDI—are inherently nonlinear. A nonlinear (global) solution technique is therefore required, since linearization would eliminate the state-dependent amplification effects central to the research question. Finally, the study compares Iran, Armenia, and Azerbaijan within a unified analytical structure. The DSGE approach provides a consistent way to map cross-country differences in banking systems through steady-state ratios and structural parameters.

For these reasons, a nonlinear DSGE model offers the most coherent and analytically suitable methodology for examining how liquidity creation, liquidity allocation, and credit conditions interact across different banking systems.

6.1 Households

The economy is populated by a representative, infinite-horizon household that maximizes lifetime utility within a real-side New Keynesian structure. Diverging from standard models, this framework is embedded in a bank-centric environment where financial variables are determined endogenously through

banking dynamics rather than a monetary policy rule. The household's preferences are defined by consumption, real money balances, and labor supply, formulated as:

$$Max E \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t - H_t)^{1-\sigma}}{1-\sigma} - 1 + \frac{1}{1-b} \left(\frac{M_t}{P_t} \right)^{1-b} - \chi \frac{L_t^{1+\eta}}{1+\eta} \right] \quad (1)$$

where C_t is consumption, H_t denotes habit persistence, L_t is labor hours, and $\frac{M_t}{P_t}$ represents real money balances. Parameters β , σ , b , η , and χ denote the discount factor, coefficient of relative risk aversion, elasticity of money demand, inverse Frisch elasticity, and labor supply weight, respectively. Crucially, M_t represents deposit money endogenously created by commercial banks rather than central bank-issued base money.

6.1.1 Investment and Capital Dynamics

The household provides capital to firms and earns rental income. The budget constraint, in its reduced form, incorporates investment expenditures and the costs associated with capital utilization:

$$c_t + m_t + b_t + I_t = W_t L_t + \frac{m_{t-1}}{(1+\pi_t)} + (1 + i_{t-1}) \frac{b_{t-1}}{(1+\pi_t)} + (r_t^k k_{t-1} A_t - \psi(A_t) k_{t-1}) \quad (2)$$

where r_t^k is the return on capital, $A_t \in [0,1]$ is the utilization rate, and $\psi(A_t)$ represents the cost of utilization. The interest rates i_t and i_t^d reflect effective returns on financial claims supplied by banks and are not policy-controlled. Capital evolves according to:

$$k_t = (1 - \delta) k_{t-1} + I_t \left[1 - s \left(\frac{\varepsilon_t^I I_t}{I_{t-1}} \right) \right] \quad (3)$$

where δ is the depreciation rate, $\varepsilon_t^I I$ is an investment shock following an AR(1) process, and $S(\cdot)^1$ represents investment adjustment costs, capturing the transformation delay between investment and productive capital.

6.1.2 The Settlement Layer and Liquidity Constraints

A key feature of this model is the settlement layer transaction constraint. To purchase final goods, households must hold sufficient liquid balances in advance. This requirement is defined as:

$$P_t C_t \leq B_{t-1} + W_t L_t + M_t - T_t \quad (4)$$

Equation (4) signifies a structural settlement constraint rather than a policy-driven CIA requirement. Household liquidity is sourced from: (i) transferred current deposits (B_{t-1}), (ii) labor income ($W_t L_t$), and (iii) withdrawals from

¹ $S(\cdot)$ is an investment adjustment cost function satisfying $S(0)=0$

investment deposits (M_t). Investment deposits (D_t) evolve based on bank-determined returns (i_t^d):

$$D_t = D_{t-1}(1 + i_{t-1}^d) - M_t \quad (5)$$

At the end of each period, current deposits (B_t) are replenished by the net surplus of income over consumption and the transfer of nominal profits from intermediate goods producers (Π_t^f), capital goods producers (Π_t^k), and commercial banks (Π_t^b):

$$B_t = B_{t-1} + W_t L_t + M_t - T_t - P_t C_t + \Pi_t^b + \vartheta \Pi_t^f + \Pi_t^k \quad (6)$$

where ϑ represents the household's share in intermediate firm profits. Combining these constraints yields the consolidated liquidity requirement (Eq. 6), illustrating that household consumption is constrained by the endogenous flow of bank returns and liquidity transfers.

6.1.3 First-Order Conditions (FOCs)

The household's optimization problem yields the following key first-order conditions (detailed derivations are provided in Appendix B):

Labor Supply:

$$w_t = \frac{\chi(i_t^n)}{(c_t - H_t)^{-\sigma}} \quad (7)$$

Money Demand:

$$m_t^{-b} = (c_t - H_t)^{-\sigma} \cdot \left(\frac{(1 + \pi_{t+1} - \beta)}{1 + \pi_{t+1}} \right) \quad (8)$$

Deposit Return (Fisher relation):

$$i_t^d = \frac{(1 + \pi_{t+1})}{\beta} - 1 \quad (9)$$

Capital Utilization:

$$(r_t^k k_{t-1} = \psi(A_t) k_{t-1}) \quad (10)$$

Bond Accumulation Equation:

$$b_t = \left(w_t \cdot l_t - \frac{m_t}{(1 + \pi_{t+1})} \right) + \frac{((-c_t - m_t - l_t))}{\frac{(1 + (1 + i_t) \cdot (k_t \cdot r_t \cdot z_t - \psi(A_t) \cdot k_t))}{(1 + \pi_{t+1})}} \quad (11)$$

In summary, the household operates within a fully bank-centric financial environment. All financial variables—money, deposit returns, and credit flows—emerge as endogenous outcomes of the banking sector's balance sheet dynamics, without reliance on a central bank policy rule or an exogenous policy rate.

6.2 Final Goods Producing Firm

A representative final-goods producer combines a continuum of differentiated intermediate inputs into a homogeneous final output using a standard Dixit–Stiglitz aggregator. The production technology is:

$$Y_t = \left[\int_0^1 \omega_j^Y \cdot Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (12)$$

In this formulation, $Y_t(j)$ denotes the output of intermediate variety j , ε is the constant elasticity of substitution across varieties, and ω_j^Y captures the relative weight of each differentiated good in final-goods production. The term ω_j^Y serves as a time-varying efficiency or quality shifter, reflecting how sector-specific productivity changes, input-quality differences, or reallocation effects driven by financial frictions alter the effective contribution of each variety to aggregate output. The evolution of these weights follows the weighted Dixit–Stiglitz structure used in Hristov (2017).

$$Y_t(j) = \left(\omega_j^Y \cdot \frac{P_t(j)}{P_t} \right)^{-\varepsilon} Y_t \quad (13)$$

This relationship shows that demand for intermediate goods depends negatively on their relative price and positively on total output. Using the zero-profit condition, the price of final goods is derived as:

$$P_t = \left[\int_0^1 \omega_j^Y \frac{\varepsilon-1}{\varepsilon} P_t(j) dj \right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (14)$$

Production and price-setting decisions in both final-goods and intermediate-goods sectors occur entirely within the real and bank-financed structure of the model and do not rely on any monetary-policy instrument or policy rate.

6.2.1 Intermediate Goods Producing Firms

Intermediate-goods producers operate under monopolistic competition and finance part of their production through bank-provided credit. The cost of such financing reflects prevailing credit conditions in the banking sector and enters firms' repayment obligations through an effective lending rate i_t^l . This rate is

determined within the banking system's balance-sheet dynamics and does not represent a policy-controlled interest rate.

a. Production Function

A continuum of intermediate-goods firms indexed by $j \in [0,1]$ operates in monopolistic competition. The production function for firm j is defined as:

$$Y_{j,t} = Z_{j,t} K_{j,t-1}^\alpha L_{j,t-1}^{1-\alpha} \quad (15)$$

For the production of final goods $Y_{j,t}$, firms employ labor input $L_{j,t-1}$ from households and purchase capital input $K_{j,t-1}$ from capital goods producers.

It is assumed that the firm-specific productivity follows a continuous uniform distribution density function $f(\omega_j^Y)$ over $[\underline{\omega}^Y, \bar{\omega}^Y]$ (Agénor et al, 2014).

$$\omega_j^Y \sim \text{uniform}[\underline{\omega}^Y, \bar{\omega}^Y] \quad E[\omega_j^Y] = 1 \quad (16)$$

(b): Default Threshold under Bank Financing Conditions.

A firm defaults on its contractual repayment obligations when net operating revenues are insufficient to meet wage payments, price adjustment costs, and repayment commitments to banks.

$$P_t Z_{j,t} K_{j,t-1}^\alpha L_{j,t-1}^{1-\alpha} - W_t L_{j,t} - PAC_{j,t} < (\Phi_d + i_{t-1}^l) DEBT_{j,t-1} \quad (17)$$

Here, The parameter $\Phi_d \in (0,1)$ captures the contractual repayment structure by determining the fraction of principal that becomes due in each period, i_{t-1}^l denotes the effective lending rate applied to outstanding bank credit, reflecting prevailing credit conditions and bank funding costs rather than a policy rate.

This lending rate is fully determined inside the banking sector's balance-sheet mechanism and is not set by a monetary authority.

$DEBT_{j,t-1}$ denotes the outstanding bank credit, while $\phi_d \in (0,1)$ represents the fraction of overdue installments relative to total debt. Following Ireland (2007) and Ascari et al. (2012), it is assumed that prices are indexed to long-term inflation and past inflation. Accordingly, the price adjustment cost is defined as follows:"

$$PAC_{j,t} = \frac{\theta}{2} \left(\frac{P_{j,t}}{P_{j,t-1} (\Pi_{t-1}^{fe})^\mu (\bar{\Pi} fe)^{1-\mu}} - 1 \right)^2 P_t Y_t \quad (18)$$

In this equation, θ governs the degree of price rigidity, Π_{t-1}^{fe} denotes past inflation used for indexation, and $\bar{\Pi}$ is the long-run inflation target. The parameter $\mu \in [0,1]$ determines the relative weight of past inflation versus the inflation target.

According to this, the midpoint for default and non-default is based on a value of the specific shock, which is determined as follows:

$$\tilde{\omega}_t^Y = \frac{W_t L_t + PAC + (\Phi_d + i_{t-1}^l) DEBT_{t-1}}{P_t Z_t K_{t-1}^\alpha L_{t-1}^{1-\alpha}} \quad (19)$$

An increase in bank financing costs i_{t-1}^l or repayment obligations shifts the default threshold upward, increasing the probability of firm insolvency. Labor input is predetermined within the period, so the wage bill $W_t L_t$ corresponds to the labor hired one period earlier.

According to equation (19), an increase in the firm's costs—which include debt to the bank, wage expenses, inventorying a portion of goods as raw materials, and price adjustment costs—along with a decrease in production leads to a higher likelihood of debt default.

The profit function for firm j is determined based on the following condition¹:

$$\Pi_{j,t}^f = \{[P_{j,t} Y_{j,t} - w_t l_{j,t} - PAC_{j,t} - (\Phi_d + i_{t-1}^l) DEBT_{j,t-1}] \text{ No default}\} \quad (20)$$

0 default

In fact, the firm maximizes the following profit function based on the midpoint of default:

$$\max E_0 \left[\sum_{t=0}^{\infty} \beta^t \int_{\tilde{\omega}_{j,t}^Y}^{\bar{\omega}^Y} [P_{j,t} \cdot Y_{j,t} - w_t \cdot l_{j,t} - PAC_{j,t} - (\Phi_d + i_{t-1}^l) \cdot DEBT_{j,t-1}] f(\omega_{j,t}^Y) d\omega_{j,t}^Y \right] \quad (21)$$

The lower integration bound $\tilde{\omega}_{j,t}^Y$ is the endogenous default cutoff implied by the firm's cash-flow constraint. When idiosyncratic productivity falls below this threshold, revenues cannot cover debt obligations, the firm defaults, and equity returns drop to zero. Consequently, expected profits are computed only over the non-default region $(\tilde{\omega}_{j,t}^Y, \bar{\omega}^Y)$. Default risk influences expected profits through this cutoff, which is determined by the model rather than chosen by the firm.

6.2.2 Capital Goods Producing Firms

Capital-goods producers operate under perfect competition, converting final goods into new capital that is sold to intermediate-goods firms. Following [Christiano \(2005\)](#), investment I_t is measured in real units of final goods, with P_t denoting the aggregate price level and p_t^k the nominal price of installed capital.

The expected nominal profit function of these firms can be expressed as:

$$\max E_0 \sum_{t=0}^{\infty} \frac{\beta^t}{P_t} \{[\Pi_t^k = p_t^k [K_t - (1 - \delta) K_{t-1}] - P_t I_t]\} \quad (22)$$

Investment I_t and capital stocks K_t are expressed in real units of final goods, while P_t and p_t^k denote nominal prices. The firm maximizes real profits by deflating nominal revenues and costs by P_t .

Capital accumulation is subject to quadratic adjustment costs:

¹ All variables written in lowercase denote their real (price-deflated) counterparts

$$K_t = (1 - \delta) \cdot K_{t-1} + I_t - \frac{\kappa}{2} \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t \quad (23)$$

The parameter κ governs the magnitude of investment adjustment costs. Maximization of (22) subject to (23) yields the optimal pricing condition for installed capital:

$$\frac{1}{p_t^k} = \left[\left(1 - \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} \right) + E \cdot \beta \cdot \frac{p_{t+1}^k}{p_t^k} \cdot \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t} \right)^2 \right] \quad (24)$$

This formulation corresponds exactly to the capital goods sector in [Christiano et al. \(2005\)](#).

The detailed derivation of Equation (24) is provided in Appendix D.

6.3 Banks

Banks are passive with respect to default realization and reserve provision, but actively choose loan issuance and deposit composition to maximize profits. Firm default is determined solely by the realization of the production-side cash-flow shock ω_t^Y and occurs automatically whenever firms are unable to meet their contractual debt obligations.

In the event of firm survival, banks receive the full contractual repayment, including interest. In default states, contractual repayments are not made; instead, banks seize the firm's residual cash flow and the depreciated capital stock ex post as collateral. Capital does not constitute an independent source of default risk but serves purely as a recovery asset following default. Capital therefore affects bank profits only through the recovery term in default states and does not enter the default threshold itself.

Accordingly, the bank's nominal profit equals the expected value of repayments in survival states plus the recovery value in default states, net of interest payments on deposits.

$$\Pi_t^b = \int_{\tilde{\omega}_t^Y} \bar{\omega}_t^Y i_{t-1}^l \cdot DEBT_{t-1} f(\omega_t^Y) d\omega_t^Y + \int_{\tilde{\omega}_t^Y} [(1 - \delta) \cdot p_t^k \cdot K_{t-1} + P_t \cdot Y_t - PAC_t - W_t \cdot L_t - DEBT_{t-1}] f(\omega_t^Y) d\omega_t^Y - i_{t-1}^d \cdot D_{t-1} \quad (25)$$

The first integral represents contractual loan repayments in survival states. The second integral captures the bank's recovery value in default states, where no contractual repayment occurs and the bank seizes residual cash flows and collateral.

The model abstracts entirely from loan rescheduling and forbearance. Default leads to immediate liquidation and collateral seizure.

In this equation, Π_t^b represents the bank's nominal profit. The interest rates i_{t-1}^l , i_{t-1}^d , and correspond to loans, investment deposits, respectively. Banks aim to maximize profits while adhering to a balance sheet constraint.

$$D_t + BT_t + BD_t = R_t + DEBT_t \quad (26)$$

Equation (26) represents the bank's balance-sheet identity, where liabilities—term deposits D_t , Demand deposits BT_t , and borrowing from the

central bank BD_t —equal assets, consisting of reserves held at the central bank R_t and outstanding loans to firms $DEBT_t$.

One of the assumptions of this method is that, after creating liquidity through double-entry accounting and following the endogenous money creation model, banks analyze their available reserves and required reserves. They then borrow the equivalent of the difference between these two from the central bank, based on the following relationship:

$$BD_t = rr_b \cdot BT_t + rr_d \cdot D_t - [R_{t-1} - BD_{t-1} \cdot (1 + i_{t-1}^{bd})] \quad (27)$$

Equation (27) does not represent an optimality condition. Instead, it serves as a balance-sheet closure rule consistent with the endogenous money creation framework. Banks first create deposits through lending via double-entry accounting. Given the resulting level of demand and term deposits, they then compare required reserves with actual reserves carried over from the previous period. Central-bank borrowing BD_t adjusts passively and ex post to cover any reserve shortfall.

Therefore, BD_t is not a control variable chosen by banks but an accounting outcome implied by reserve requirements and previous-period reserves.

The term inside the parentheses in Equation (27) represents the reserves available prior to the banks borrowing from the central bank. According to this, the reserves of banks at the beginning of period t are equal to R_{t-1} , which have been carried over from the previous period to the current one. Banks allocate $BD_{t-1} \cdot (1 + i_{t-1}^{bd})$ to repay their previous debts to the central bank. Based on the endogenous money creation model, a portion of the monetary base will be created ex post.

Before deriving the optimality conditions, it is useful to clarify the timing, control variables, and default mechanism in the banking sector. Banks maximize expected profits with respect to loan issuance ($DEBT_t$) and deposit composition, including term deposits (D_t) and long-term deposits (BT_t), subject to the balance-sheet constraint (26).

Accordingly, the probability of default faced by banks is defined as $\Phi_t^Y = \int_{\omega_t^Y}^{\bar{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y$. This object captures the mass of firms that default due to insufficient cash flows. The complementary probability, $(1 - \Phi_t^Y)$, represents the likelihood that firms remain solvent and fully repay their contractual debt obligations.

Central bank borrowing (BD_t) is not a choice variable for banks. Instead, it is determined ex post by the reserve-requirement closure rule (27), which ensures balance-sheet consistency after endogenous liquidity creation. Consequently, BD_t does not belong to the bank's set of control variables, and no first-order condition is derived with respect to central bank borrowing.

Only the variables actively controlled by the bank — $DEBT_t$, D_t , and BT_t — are differentiated, since others such as R_t and BD_t are passive and exogenous, not bank decisions.

Given the objective function (25) and constraints (26) and (27), the Lagrangian of the bank's

problem—defined over $debt_t$, d_t and bt_t —is written as:

$$L = \max E_t \left[\sum_{t=0}^{\infty} \beta^t \left(\int_{\tilde{\omega}_t^Y}^{\bar{\omega}_t^Y} \frac{i_{t-1}^l}{(1+\pi_t).(1+n)} \cdot debt_{t-1} f(\omega_t^Y) d\omega_t^Y + \int_{\tilde{\omega}_t^Y}^{\bar{\omega}_t^Y} \left[\frac{(1-\delta)}{(1+\pi_t).(1+n)} \cdot p_t^k \cdot K_{t-1} + Y_t - pac_t - w_t \cdot l_t - debt_{t-1} \right] f(\omega_t^Y) d\omega_t^Y - \frac{i_{t-1}^d}{(1+\pi_t).(1+n)} \cdot d_{t-1} - \frac{i_{t-1}^{bd}}{(1+\pi_t).(1+n)} \cdot bd_{t-1} \right) + E_t \cdot \lambda_t \cdot \beta^t \left[d_t + bt_t + bd_t - \frac{R_t}{P_t} - debt_t \right] + E_t \cdot \mu_t \cdot \beta^t \left[rr_b \cdot bt_t + rr_d \cdot d_t - \left[\frac{R_{t-1}}{P_t} - \frac{bd_{t-1} \cdot (1+i_{t-1}^{bd})}{(1+\pi_t).(1+n)} \right] - bd_t \right] \right] \quad (28)$$

This real-form Lagrangian formulation allows inflation expectations to explicitly enter intertemporal discounting, without altering the accounting identity or the reserve-requirement closure rule. All nominal magnitudes—such as deposits and loans—remain defined in nominal units, while optimization operates over deflated (real) variables.

The first-order conditions with respect to loan issuance ($DEBT_t$), time deposits (D_t), and demand deposits (BT_t) are given as follows.

$$\lambda_t = \frac{\beta}{(1+\pi_{t+1}).(1+n)} \cdot [(1 - \Phi_{t+1}^Y) \cdot i_t^l - \Phi_{t+1}^Y] \quad (29)$$

Equation (29) shows that the shadow value of bank lending depends on the expected repayment probability Φ_{t+1}^Y , while the default cutoff ω_{t+1}^Y is entirely determined at the firm level and is not chosen by banks.

The first-order condition with respect to time deposits implies that the marginal value of funds for the bank (λ_t) and the shadow value of the reserve constraint (μ_t) jointly determine the equilibrium deposit rate:

$$\lambda_t + \mu_t \cdot rr_d = \frac{\beta \cdot i_t^d}{(1+\pi_{t+1}).(1+n)} \quad (30)$$

Solving for μ_t yields:

$$\mu_t = \frac{\frac{\beta \cdot i_t^d}{(1+\pi_{t+1}).(1+n)} - \lambda_t}{rr_d} \quad (31)$$

This expression shows that the shadow cost of the reserve requirement is proportional to the gap between the discounted return paid to depositors and the internal shadow value of bank funds. When the required-reserve ratio rr_d increases, the constraint becomes more binding (a higher absolute value of μ_t , reflecting a larger opportunity cost of holding reserves rather than extending loans).

The optimality conditions associated with the bank's problem clarify the link between the shadow value of funds, the reserve requirement, and the determination of the deposit rate.

By combining this relation with the optimality condition with respect to demand deposits, which is expressed as $\mu_t = -\frac{\lambda_t}{rr_b}$, yields the system

$$\frac{\beta \cdot i_t^d}{(1+\pi_{t+1}) \cdot (1+n)} - \lambda_t = -\frac{\lambda_t}{rr_b} \quad (32)$$

Substituting for $\lambda_t = \frac{\beta}{(1+\pi_{t+1}) \cdot (1+n)} \cdot [(1 - \phi_{t+1}^Y) \cdot i_t^l - \phi_{t+1}^Y]$ gives

$$\frac{\beta \cdot i_t^d}{(1+\pi_{t+1}) \cdot (1+n)} - \frac{\beta \cdot [(1 - \phi_{t+1}^Y) \cdot i_t^l - \phi_{t+1}^Y]}{(1+\pi_{t+1}) \cdot (1+n)} = \frac{-\beta}{(1+\pi_{t+1}) \cdot (1+n)} \cdot [(1 - \phi_{t+1}^Y) \cdot i_t^l - \phi_{t+1}^Y] \quad (33)$$

Simplifying results in the closed-form solution for deposit rate determination:

$$i_t^d = [(1 - \phi_{t+1}^Y) \cdot i_t^l - \phi_{t+1}^Y] \cdot \frac{rr_b - rr_d}{(rr_b)} \quad (34)$$

This expression shows that the deposit rate depends positively on the net expected return from lending and negatively on the reserve-requirement gap $rr_b - rr_d$. In equilibrium, i_t^d is not a discretionary choice of the bank but a rate implicitly determined by households through the reserve constraint and the intermediation margin.

It is important to emphasize that the model does not include a Taylor rule or any active monetary policy rule.

Accordingly, the loan rate i_t^l and the deposit rate i_t^d are bank-determined contractual rates, while the central bank operates exclusively through balance-sheet channels and reserve accommodation.

The expression for i_t^d derives from the deposit contract structure and not from a monetary-policy rule. It reflects the intertemporal pricing of investment deposits rather than a policy-driven benchmark rate.

$$\ln(i_t^l) = \rho \ln(i_{t-1}^l) + (1 - \rho) \ln(\bar{i}_l) + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2) \quad (35)$$

Credit conditions in the banking sector are subject to exogenous disturbances reflecting changes in bank funding costs, regulatory pressures, risk perceptions, and liquidity conditions. These disturbances affect the effective lending rate i_t^l , which represents the contractual return on bank credit. Importantly, this rate does not correspond to a policy interest rate set by the central bank. Instead, it captures variations in bank credit conditions within the financial system.

The AR(1) process for i_t^l captures shocks to bank credit conditions (funding costs, liquidity stress, regulatory pressures) and should not be interpreted as a monetary-policy shock. No policy rule exists in the model.

6.3. Liquidity Distribution Based on Bank Performance

The banking sub-model characterizes how liquidity, once created, is allocated across different components of the balance sheet. At the beginning of each period, the representative bank carries forward its opening balance-sheet positions, consisting of loans extended to firms and reserves held at the central bank on the asset side, and various deposit instruments and central-bank borrowing on the liability side. These positions determine the initial distribution of liquidity within the banking system.

Table 1. Bank Balance Sheet at the Beginning of Period t

Liabilities and Equity		Assets
D_t		$DEBT_t$
BT_t		R_t
BD_t		

Source: Research Findings

The initial-stage balance sheet records the bank's assets—loans ($DEBT_t$) and reserves (R_t)—and its liabilities, which consist of demand deposits (D_t), term deposits (BT_t), and borrowing from the central bank (BD_t). The balance-sheet identity is:

$$D_t + BT_t + BD_t = R_t + DEBT_t \quad (36)$$

In a representative-agent DSGE framework, the model does not track heterogeneity across individual households or depositors. Therefore, liquidity distribution cannot be defined in terms of the dispersion of deposits across agents. Instead, liquidity distribution is captured through the allocation of bank-created liquidity between the real sector and the banking system's financial buffers.

Table 4 thus provides the initial conditions for tracing how liquidity circulates through the banking sector in subsequent periods. In the empirical section, cross-country differences in this balance-sheet allocation will help explain variations in the observed LDI levels for Iran, Armenia, and Azerbaijan.

To quantify this mechanism, we construct a fully model-consistent Liquidity Distribution Index (LDI) that measures the share of created liquidity (deposits) that is effectively channelled to the real economy through lending:

$$LDI_t = \frac{(DEBT_t)}{(D_t + BT_t)} \quad (37)$$

The denominator ($D_t + BT_t$) represents total deposits created by the banking sector, i.e., the stock of liquidity supplied to households. The numerator $DEBT_{t-1}$ captures the volume of liquidity allocated to the real sector via loans to firms. A higher value of the index indicates that a larger fraction of bank-created liquidity is transmitted to productive activity, whereas a lower value suggests that liquidity remains within the banking system—primarily in the form of reserves—rather than supporting real-sector activity.

Deposits in the DSGE framework function as bank-created liabilities supplied to households, consistent with the endogenous money creation block.

This definition of liquidity distribution is fully grounded in the structural DSGE model and directly linked to the bank's optimization problem and balance-sheet dynamics. It provides a coherent metric for comparing how different economies allocate created liquidity across financial and real-sector uses.

6.4 Government

The government's budget constraint is as follows:

$$g_t = T_t + gd_t - \frac{gd_{t-1}}{1+\pi_t} \quad (38)$$

According to this, the government's revenues include the collected tax revenue T_t and borrowing from the central bank gd_t , which are allocated to government expenditures. It is assumed that the government's tax revenue depends on the level of production.

$$T_t = t.Y_t \quad (39)$$

6.5 Market Clearing Conditions

The market clearing conditions in the goods and assets markets are systematically defined as follows:

$$Y_t = C_t + I_t + G_t + pac_t \quad (40)$$

All financial flows (interest payments, recovery values, and bank profits) are internal transfers within the private sector and thus net to zero in the aggregate resource constraint.

6.6 Selection of Comparative Countries Based on the Liquidity Creation Intensity Indicator

In this study, the selection of comparative countries is based on a structural banking variable referred to as the Liquidity Creation Intensity Indicator (LCI). The purpose of this indicator is to measure the extent to which banking sector liquidity expansion relies on central bank funding relative to deposit-based funding.

Conceptually, commercial banks primarily finance their lending activities through customer deposits. However, when deposit resources are insufficient to support credit expansion, banks may resort to borrowing from the central bank. A higher reliance on central bank funding reflects greater pressure on liquidity conditions and a stronger role of monetary base expansion in sustaining credit

creation. Therefore, the ratio of central bank borrowing to total bank deposits provides a scale-free and internationally comparable measure of liquidity creation intensity within the banking system.

Formally, the Liquidity Creation Intensity Indicator is defined as:

$$LCI_{i,t} = \frac{(BD_{i,t})}{Deposits_{i,t}} \quad (41)$$

where:

- $BD_{i,t}$ denotes borrowing of commercial banks from the central bank in country i at time t ,
- $Deposits_{i,t}$ represents total bank deposits.

6-6-1 Data Construction

For Iran, total bank deposits are obtained directly from the Central Bank of Iran (CBI) database. Total deposits are calculated as the sum of demand deposits and time deposits reported in the monetary statistics. Central bank borrowing of commercial banks is also obtained from the CBI monetary accounts.

For Armenia and Azerbaijan, consistent time-series data on total bank deposits are not fully available in the World Bank database. Therefore, total bank deposits are approximated using the World Development Indicator: Deposit money banks' assets to GDP (%)

This variable is defined as:

$$\frac{Bank\ Assets_{i,t}}{GDP_{i,t}} \times 100 \quad (42)$$

To recover total bank assets, the following transformation is applied:

$$Bank\ Assets_{i,t} = \frac{Deposit\ Money\ Banks'\ Assets\ to\ GDP\ (\%)}{100} \times GDP_{i,t} \quad (43)$$

In standard banking balance sheet identity:

$$Assets = Liabilities + Equity\ Assets$$

For commercial banks in emerging economies, deposits constitute the dominant component of liabilities and represent the primary funding source of bank assets. Since equity and non-deposit liabilities account for a relatively small share compared to total deposits, total bank assets provide a close approximation to total deposits for macro-level comparative analysis.

Accordingly, total bank assets are used as a proxy for total bank deposits for Armenia and Azerbaijan.

Central bank borrowing data for these countries are obtained from IMF monetary statistics.

Table 5 summarizes the Liquidity Creation Intensity (LCI) for Iran, Armenia, and Azerbaijan. This table is essential for identifying countries with comparable structural banking conditions, specifically in terms of their reliance on central-bank-funded liquidity. Presenting these values allows us to justify the selection of the comparative sample for the DSGE model.

Table 2. Liquidity Dependence Indicator (LCI) for Selected Countries

Country Liquidity Dependence Indicator (LCI) Value	
Armenia	0.0821 51409
Iran	0.082943969
Azerbaijan	0.0834 67465

Source: Research Findings

As shown in Table 2, the LCI values for Iran, Armenia, and Azerbaijan are nearly identical, lying in the narrow range of 0.082–0.083. This similarity indicates comparable reliance on central bank funding across the three banking systems, ensuring that cross-country differences in the DSGE results reflect underlying macro-financial dynamics rather than structural differences in liquidity dependence.

After constructing the Liquidity Creation Intensity Indicator for the period 2005–2021, the computed values for Iran, Armenia, and Azerbaijan are found to be very close to one another. The estimated ratios lie within the narrow range of 0.082–0.083.

This close proximity indicates that the three banking systems exhibit similar degrees of reliance on central bank liquidity relative to their deposit bases. Importantly, the indicator is scale-independent; it does not measure the absolute size of the banking sector but rather the intensity of central-bank-supported liquidity within each system.

Therefore, selecting Iran, Armenia, and Azerbaijan ensures that the sample reflects a broad range of banking structures and liquidity conditions.

Based on this structural banking criterion, these three countries are selected as the comparative set for the DSGE analysis.

6.7 Calibration and Estimation Procedures

The model parameters are estimated through a structured calibration strategy combining three sources of information. First, a set of steady-state ratios is computed from long-run averages of key macroeconomic variables relative to output (Tables 3–4). Second, several structural parameters are calibrated based on findings from earlier studies (Table 5). Third, country-specific values for money

growth, output growth, and inflation are obtained from the World Bank database and reported in Table 6.

The calibration does not impose structural similarity across the three economies. Each country's steady state and parameter values are obtained independently from its own macroeconomic data. Annual data covering 2005–2024 are used for all variables. To mitigate distortions arising from the COVID-19 pandemic, sanctions, oil-price volatility, and episodes of high inflation, the sample is split into a pre-COVID period (2005–2019) and a post-COVID period (2020–2024). This separation allows us to capture potential shifts in long-run ratios driven by structural breaks.

Key macroeconomic variables used to determine steady-state ratios include real GDP, consumption, and the capital stock. Table 6 reports the consumption-to-output ratio for each subperiod, while Table 7 provides the capital-output ratio. All data are taken from the World Bank database.

Table 3. Calibrated steady-state ratios ($\frac{c}{y}$) for pre- and post-COVID periods, based on previous studies and authors' calculation

Country	Iran	Azerbaijan	Armenia
Parameter	$\frac{c}{y}$	$\frac{c}{y}$	$\frac{c}{y}$
Value:	0.45	0.45	0.81
Pre-COVID			
Value:	0.43	0.53	0.69
Post-COVID			

Source: Research Findings

The relatively high $\frac{c}{y}$ ratio in Armenia reflects the structural characteristics of a small open economy with a low domestic savings rate and a higher reliance on imported capital goods, consistent with national accounts data.

Table 4. Calibrated steady-state ratios ($\frac{k}{y}$) for pre- and post-COVID periods, based on previous studies and authors' calculation

Country	Iran	Azerbaijan	Armenia
Parameter	$\frac{k}{y}$	$\frac{k}{y}$	$\frac{k}{y}$
Value:	0.28	0.24	0.28
Pre-COVID			
Value:	0.26	0.17	0.20
Post-COVID			

Source: The authors

As shown in Table 4, the capital–output ratio declines in the post-COVID period across all three countries, reflecting reduced investment activity and delays in capital accumulation following the pandemic shock.

Table 5 summarizes the structural parameters used for calibration. These values draw on previous empirical and DSGE studies for Iran, Armenia, and Azerbaijan.

Table 5. Calibrated parameter values Iran, Azerbaijan, Armenia

	Country Iran	Azerbaijan	Armenia
β (discountfactor)	0.99 Rahmani and Fallahi (2019)	0.99 Ahmadov (2010)	0.99 Igityan (2021)
δ (rate of depreciation)	0.042 Ghafar et al (2019)	0.015 Ahmadov (2010)	0.025 Igityan (2021)
α (share of capital in output, intermediate goods)	0.4 Rafat et al (2020)	0.35 Huseynov et al (2014)	0.57 Igityan (2021)
σ (Relative Risk Aversion Coefficient)	1.2 Rafat et al (2020)	0.54 Huseynov and Ahmadov (2014)	1.1 Asoyan et al (2020)
$\theta\theta$ Price Adjustment Cost	4.26 Parvin and colleagues (2014)	0.19 Huseynov and Ahmadov (2014)	0.91 Igityan (2021)

Source: Research Findings

These parameters determine key behavioral features of the DSGE model, including household intertemporal preferences, capital accumulation, and price adjustment dynamics.

To assess the robustness of the calibrated structural parameters, Appendix E provides a supplementary Bayesian analysis showing that the posterior distributions for all three countries are centered around the calibrated values.

The relatively low coefficient of relative risk aversion for Azerbaijan ($\sigma = 0.54$) reflects the structural characteristics of its oil-based economy. High dependence on volatile hydrocarbon revenues leads to more pronounced income fluctuations and stronger intertemporal consumption substitutions, resulting in a higher intertemporal elasticity of substitution ($IES = \frac{1}{\sigma}$) and thus a lower σ .

To assess the robustness of these calibrated values, Appendix E presents a supplementary Bayesian exercise showing that the posterior means for all three countries are centered around the calibrated parameters.

Table 6 presents the parameters calibrated using World Bank macroeconomic data. These include the money-growth rate (θ), output-growth rate (n), and the inflation rate (π) for the pre- and post-COVID periods. The division of the sample enables the analysis to track changes in steady-state values and examine the stability of the calibration across alternative subsamples.

Table 6. Calibrated parameter values

Country	Iran			Azerbaijan			Armenia		
Parameter Rates	θ	n	π	θ	n	π	θ	n	π
Pre-COVID	0.22	0.04	0.18	0.24	0.13	0.07	0.16	0.07	0.03
Rates	0.47	0.07	0.38	0.10	0.09	0.06	0.13	0.20	0.04
Post-COVID									

Source: Research Findings

In the model, θ represents the observed average liquidity growth rate, used only for steady-state scaling—not as a policy rule.

For Armenia and Azerbaijan, annual effective lending rates (series code FR.INR.LEND) for 2005–2024 are obtained directly from the World Bank. For Iran, lending-rate data are constructed using official statistics from the Central Bank of Iran. Specifically, information on outstanding loans across Islamic contract categories is used to generate a representative lending-rate series. Because lending rates in Iran are administratively regulated, observed fluctuations may reflect policy decisions rather than market forces.

Depending on data availability, lending-rate observations across loan categories (exports, trade and services, housing, industry, and agriculture) are aggregated using either a simple or weighted average. These data are used solely for steady-state scaling and for estimating the persistence of credit-condition shocks. They do not represent monetary policy instruments.

Prior to trend–cycle decomposition, all lending-rate series are transformed into natural logarithms to ensure scale consistency. The log series are filtered using the Hodrick–Prescott (HP) filter, and the cyclical components serve as the empirical proxy for the credit-condition shock. Stationarity is assessed using Augmented Dickey–Fuller (ADF) tests.

The shock persistence parameter ρ is estimated using a Box–Jenkins framework implemented in EViews. Model identification and validation rely on the autocorrelation function (ACF), partial autocorrelation function (PACF), and the Ljung–Box Q-statistic. These diagnostics support an AR(1) specification for the effective lending-rate process. The estimated AR(1) coefficients are reported in Table 7 and are subsequently used as the dynamic parameter governing the credit-condition shock in the DSGE model. Full estimation results appear in Supplementary Appendix A.

Table 7. Estimated AR(1) Coefficient for the Effective Lending Rate

Country	ρ	Armenia
Armenia	0.90	0.1359
Azerbaijan	0.89	0.10155
Iran	0.79	0.1642

Source: Research Findings

The high values of ρ indicate strong persistence in lending rates, suggesting that shocks to bank credit conditions tend to propagate over time rather than dissipating quickly.

The AR(1) process is interpreted as a shock to bank credit conditions rather than a monetary-policy shock. The effective lending-rate data used for estimation represent market-based credit costs, not policy rates.

7. Evaluation of Model Fit and Performance

The model's quantitative performance is evaluated by comparing unconditional moments (means and standard deviations) generated from stochastic simulations with their empirical counterparts. Empirical moments are constructed using annual macroeconomic data for Iran, Armenia and Azerbaijan over the period 2005–2024.

All variables are expressed in real aggregate terms and transformed into logarithms prior to moment calculation. To measure business-cycle volatility, each series is expressed as a deviation from its sample mean and filtered using the Hodrick–Prescott filter to extract the cyclical component. The standard deviation of this component is used as the empirical measure of volatility.

Model-implied moments are obtained from stochastic simulations of the DSGE model solved in Dynare around its deterministic steady state. Standard deviations therefore capture cyclical fluctuations rather than steady-state levels.

The comparison of empirical and model-generated moments provides an assessment of the model's ability to replicate observed macroeconomic volatility. As reported in Table 8–10, the model broadly reproduces the magnitude of cyclical fluctuations in output and consumption.

Table 8. Comparison of Empirical and Model-Implied Unconditional Moments: Iran

				S.D Average	Variable
Model	Data	Model	Data		
0.0002	0.0059	0.2201	0.2676		GDP-pre
0.0001	0.0059	0.0990	0.1202		Consumptin-pre
0.0000	0.0072	0.1198	0.0749		Capital-pre
0.0002	0.0036	0.2095	0.2672		GDP-post
0.0001	0.0028	0.0901	0.1148		Consumption-post
0.0000	0.0031	0.1059	0.0694		Capital-post

Source: Research Findings

Table 9. Comparison of Empirical and Model-Implied Unconditional Moments: Armenia

				S.D Average	Variable
Model	Data	Model	Data		
0.0002	0.0060	0.1148	0.2301		GDP-pre
0.0002	0.0060	0.0930	0.1863		Consumption-pre
0.0000	0.0112	0.0518	0.0644		Capital-pre
0.0001	0.0029	0.0735	0.2363		GDP-post
0.0001	0.0024	0.0507	0.1630		Consumption-post
0.0000	0.0030	0.0237	0.0472		Capital-post

Source: Research Findings

Table 10. Comparison of Empirical and Model-Implied Unconditional Moments: Azerbaijan

		S.D Average		Variable
Model	Data	Model	Data	
0.0006	0.0103	0.2256	0.2451	GDP-pre
0.0002	0.0079	0.1015	0.1102	Consumption-pre
0.0000	0.0096	0.1113	0.0588	Capital-pre
0.0002	0.0054	0.1874	0.2486	GDP-post
0.0001	0.0012	0.0993	0.1317	Consumption-post
0.0000	0.0040	0.0655	0.0422	Capital-post

Source: Research Findings

Although the model reproduces the relative ordering of volatility across variables, the simulated standard deviations are smaller than those observed in the data. This pattern is common in DSGE models calibrated around a deterministic steady state, particularly in frameworks with financial frictions and bank balance-sheet rigidities, where endogenous adjustment mechanisms dampen short-run volatility.

8. Solution Methodology (Fully Nonlinear Numerical Solution)

To solve the model, I follow a fully nonlinear numerical approach consisting of two steps: (i) computation of the deterministic steady state, and (ii) simulation of the nonlinear transition dynamics following a structural shock.

Step 1 — Steady-State Computation

All equilibrium conditions—including households' first-order conditions, firms' optimality conditions, banks' profit-maximization conditions, market-clearing constraints, and the default threshold equation—are first simplified symbolically in Maple. Given the calibrated parameter values, the full nonlinear system is solved for the deterministic steady state with Maple's built-in nonlinear algebraic solver. This symbolic-numerical procedure allows the nested equilibrium conditions to be reduced and substituted into one another so that the steady-state vector is obtained in closed numerical form.

Importantly, the nonlinear system consistently converges to the same steady-state vector under different initial guesses, providing numerical evidence of local uniqueness.

Step 2 — Nonlinear Model Solution and IRFs

After the steady state is obtained, the full nonlinear model is implemented in Dynare (MATLAB). The equilibrium system is entered in levels (not in log-linear or log-deviation form). Dynare's nonlinear equation solver computes the transition path of all endogenous variables after a structural innovation. Since the model is solved in its nonlinear form rather than through log-linearization, the standard Blanchard-Kahn conditions for linear rational expectations models are not applied. Impulse-response functions are therefore generated from the nonlinear transition dynamics of the model rather than from a log-linear

approximation. A one-percent negative innovation to the effective lending rate is used as the baseline shock.

Overall, the DSGE model is solved entirely in nonlinear form: the steady state is computed numerically in Maple, and all dynamic simulations—including impulse-response functions—are generated through Dynare’s nonlinear solution routine without any log-linearization.

9. Equilibrium Conditions

For the calibration process, the model’s steady-state equations were extracted and a system of steady-state relationships was constructed. Key parameters and variables were calculated using economic data for Iran, Armenia, and the Republic of Azerbaijan over the period 2005–2024. The data were obtained from the World Bank’s World Development Indicators (WDI) database. Some parameter values were adopted from previous studies, while others were obtained by solving the steady-state system using MAPLE software. This process aligns the model with empirical data and ensures theoretical consistency, thereby providing a robust foundation for analyzing and interpreting the economic dynamics of the three countries.

The following equations characterize the steady-state relationships of the model.

$$\pi = \frac{(\theta - n)}{1 + n} - 1 \quad (44)$$

$$i = \frac{(1 + \pi - \beta)}{\beta} \quad (45)$$

$$r^k = \frac{(i - \pi)}{1 + \pi} \quad (46)$$

These steady-state interest-rate expressions do not represent monetary-policy rules or policy instruments. They arise purely from the model’s intertemporal accounting identities and bank-balance-sheet consistency conditions, not from an active policy block.

$$l = 0.33 \quad (47)$$

$$I = \delta \cdot K \quad (48)$$

$$w = \frac{(l^\eta \cdot \chi)}{(c - H)^{-\sigma}} \quad (49)$$

$$m = (c - H)^{\frac{\sigma}{b}} \cdot \left(\frac{(1 + \pi - \beta)}{1 + \pi} \right)^{-\frac{1}{b}} \quad (50)$$

$$b = \left(\left(w \cdot l - \frac{m}{(1 + \pi)} \right) + \frac{((-c - m - I))}{(1 + (1 + i) \cdot (k \cdot r^k \cdot z - \psi(A) \cdot k))} \right) \cdot (1 + \pi) \quad (51)$$

$$c + m + l + b = w.l - \frac{m}{(1+\pi).(1+n)} - \frac{(1+i)}{(1+\pi).(1+n)}.b.(k.r.Z - \psi(A_t).k) \quad (52)$$

$$SS = 0 \quad (53)$$

$$S = 0 \quad (54)$$

$$(c - H)^{-\sigma} \cdot \left(S + \frac{l.SS}{l} \right) = \beta \cdot (c - H)^{-\sigma} \cdot SS \cdot \left(\frac{l}{l} \right)^2 \quad (55)$$

$$DEBT = loan \quad (56)$$

$$loan = w.l + r.k \quad (57)$$

$$\Pi^f = P.y - w.l - pac.P - (\Phi_d + i^l).DEBT \quad (58)$$

$$i^d = \frac{(1+\pi)}{\beta} - 1 \quad (59)$$

$$i^{bd} = \frac{i^d}{(1-rr_d)} \quad (60)$$

$$gd = \left(\frac{(G-T)(1+\pi)}{\pi} \right) \quad (61)$$

$$G = \left(T + gd - \frac{gd}{1+\pi} \right) \quad (62)$$

$$BD = R + DEBT - D - BT \quad (63)$$

$$\Pi^k = p_k \cdot ((k - (1 - \delta).k) - P.I) \quad (64)$$

$$w_y = \frac{(w.l + pac + (1+i^l).DEBT)}{P.y} \quad (65)$$

$$R + DEBT = D + BT + BD \quad (66)$$

$$\psi(A) = r + 1 - \delta - \frac{1}{\beta} \quad (67)$$

$$BT = P.c - w.l - M \quad (68)$$

All nominal variables are expressed in real terms after dividing by the aggregate price level. Therefore, steady-state inflation enters only through the Fisher relation and does not change the real structure of the model.

Figures 1–2 present the impulse response functions (IRFs) to a negative credit-condition shock, modeled as a temporary decline in the effective lending rate, for Iran, Armenia, and the Republic of Azerbaijan. The IRFs are generated within a bank-centric DSGE framework and illustrate how weaker lending conditions propagate through these bank-dependent economies. The analysis highlights the key transmission channels—bank balance-sheet adjustments, lending profitability, and credit availability—focusing on qualitative propagation mechanisms rather than precise quantitative magnitudes. Overall, the figures provide a visual foundation for the subsequent comparative assessment of cross-country differences in credit-shock transmission.

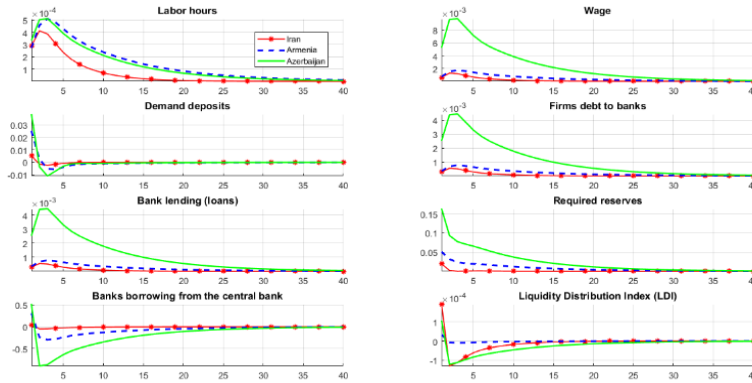


Figure 1. IRF Responses to a -1% Shock to the Bank Effective Lending Rate: Comparison Across Iran, Armenia, and Azerbaijan (Pre-COVID Period)
Source: Research Findings

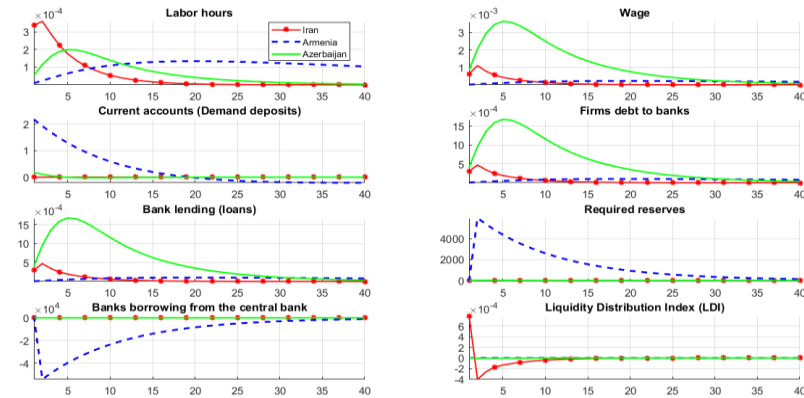


Figure 2. IRF Responses to a -1% Shock to the Bank Effective Lending Rate: Comparison Across Iran, Armenia, and Azerbaijan (Post-COVID Period)
Source: Research Findings

Figures 1 and 2 illustrate the dynamic responses of key macroeconomic and banking variables following a one percent negative shock to the effective lending rate. In the model, a decline in the lending rate reduces the cost of borrowing for firms and increases credit demand, which in turn encourages banks to expand lending and adjust their balance sheet positions. As bank lending expands, deposits, reserves, and other liquidity variables respond endogenously through the banking sector balance sheet constraint. In all three countries, most variables

gradually return to their steady state levels, indicating that credit condition shocks propagate through bank balance sheets but dissipate over time.

Table 11. Response of a Negative Credit-Condition Shock (i_t^l) to Macroeconomic Variables (Pre-COVID Period)

Countries	Hours Worked (l)%	Wage (w)%	Bank Currnt Deposits (BT)	Firm's Debt to Bank (DEBT)%	Loan%	Required Reserves (R)%	Bank's Debt to Central Bank(BD)	Liquidty Distribution Index (LDI)%
Armenia	+0.03	+0.06	+0.025	+0.04	+0.04	+5	+0.3	+0.0032
Azerbaijan	+0.035	+0.5	+0.04	+0.25	+0.25	+15	+0.5	+0.01
Iran	+0.03	+0.06	+0.0005	+0.03	+0.03	+2	+0.05	+0.02

Source: Research Findings

Table 11 reports the main directional responses of macroeconomic and banking variables to a negative credit-condition shock in the pre-COVID period. The shock, modeled as a decline in the effective lending rate, stimulates credit supply and generates positive but heterogeneous effects across countries.

In Armenia, the responses are moderate. Hours worked and wages increase slightly, accompanied by small expansions in deposits, firm debt, and bank lending. The relatively contained reaction of bank debt and liquidity indicators suggests that the adjustment primarily occurs through gradual credit expansion rather than aggressive balance-sheet leverage.

Azerbaijan exhibits comparatively stronger responses, particularly in wages, lending, and required reserves. The larger increase in bank debt to the central bank and liquidity variables indicates a more active balance-sheet adjustment mechanism, allowing banks to expand credit more rapidly following the easing in lending conditions.

Iran shows positive but relatively subdued real-sector effects. Credit variables increase modestly, and the adjustment is reflected mainly in reserve balances and liquidity allocation. The comparatively smaller movements in deposits and firm debt indicate that the transmission of credit-condition shocks is more constrained and occurs primarily within existing banking structures.

Overall, the results suggest that differences in financial sector depth, liquidity management practices, and bank balance sheet structures play a key role in shaping how negative credit condition shocks are transmitted to the real economy. In particular, economies with more flexible banking balance sheets exhibit stronger lending responses, whereas more constrained systems show smaller adjustments in credit aggregates and liquidity allocation.

Table 12. Response of a Negative Credit-Condition Shock (i_t^l) to Macroeconomic Variables (Post-COVID Period)

Countries	Hours Worked (l)%	Wage (w)%	Bank Current Deposits (BT)	Firm's Debt To Bank (DEBT)%	Loan%	Required Reserves (R)%	Bank's Debt to Central Bank(BD)	Liquidity Distribution Index (LDI)%
Armenia	+1	+1	+2	+0.01	+0.01	+0.01	+0.0001	+0.000001
Azerbaijan	+0.05	+0.1	+0.2	+0.05	+0.05	+0.2	+0.1	+0.0003
Iran	+0.035	+0.06	+0.001	+0.03	+0.03	+0.01	+1.2	+0.08

Source: Research Findings

Table 12 summarizes the responses of macroeconomic and banking variables to a negative credit-condition shock in the post-COVID period. Compared with the pre-COVID phase, the magnitude and direction of adjustments reflect notable changes in labor-market dynamics, credit elasticities, and balance-sheet behavior across countries.

In Armenia, the responses shift toward stronger movements in labor variables, while banking-sector indicators display very small changes. The substantial increase in hours worked and wages, combined with minimal adjustments in deposits, firm debt, and lending, suggests that the post-COVID environment is characterized by higher reliance on real-sector adjustment and a weaker amplification of credit shocks through banking variables.

Azerbaijan exhibits moderate and balanced reactions across both real and financial indicators. Deposits, lending, and required reserves increase somewhat more than in the real-sector variables, indicating that the transmission of the shock continues to operate through liquidity and balance-sheet channels, though with lower intensity than in the pre-COVID period. This pattern points to a more stable credit environment with less sensitivity to lending-rate disturbances.

Iran shows slightly larger adjustments in labor and liquidity indicators relative to the pre-COVID phase. The increase in bank debt to the central bank reflects a stronger balance-sheet response to changes in credit conditions, while movements in deposits, firm debt, and lending remain contained. These patterns indicate that the shock is primarily absorbed through liquidity management mechanisms within the banking system rather than through strong spillovers to broader macroeconomic variables.

Overall, the post COVID results indicate a weaker transmission of credit condition shocks through the banking system. Within the model framework, this outcome reflects changes in the relative responsiveness of credit demand and bank balance sheet adjustments. When lending and deposit responses become less elastic, a larger share of liquidity remains within banks' balance sheet buffers rather than being transmitted to firm borrowing. As a result, the macroeconomic impact of credit shocks becomes more limited.

10. Conclusion

This study examines the transmission of a negative credit condition shock across three bank-centered emerging economies—Iran, Armenia, and Azerbaijan—and compares the responses of macroeconomic and banking balance sheet variables before and after COVID-19.

The results prior to COVID-19 indicate that the intensity of response among the three countries varies. Azerbaijan exhibits the strongest reaction in variables such as bank lending and firm debt, with larger relative changes compared to the other two countries. Conversely, in Iran, direct changes in lending and firm debt are more limited; however, the Liquidity Distribution Index (LDI) suggests that the internal allocation of resources within banks was sensitive to the credit shock. Armenia shows an intermediate response, with relatively moderate variations in banking and macroeconomic indicators.

Post-COVID, the reaction pattern shifts somewhat. In Armenia and Azerbaijan, the responses of variables like lending and firm debt to the credit shock are noticeably subdued compared to the pre-COVID period, indicating a more muted transmission. In Iran, although the changes in lending and firm debt are not significantly different from the pre-COVID period, the increase in the central bank's debt and the rise in the LDI reflect structural adjustments in the banking system's resources and liabilities in response to the shock.

Overall, the findings suggest that the transmission of credit shocks varies across these economies and is influenced by each country's banking structure and economic conditions. These differences highlight that the impact of credit shocks on banking and macroeconomic variables can follow distinct pathways depending on the structural features of each financial system.

Although the time span for the main variables in this study covers the period from 2005 to 2024, the Liquidity Creation Index (LCI) was calculated only for the years 2005 to 2021. This limitation stems from the restricted availability of reliable data on central bank borrowing for all countries under consideration during the subsequent period. Consequently, the comparative analysis of countries based on the LCI is confined to the available data up to 2021, which constitutes a significant data limitation for this research.

Author Contributions:

Conceptualization, all authors; methodology, the first and second authors; formal analysis, the first author; writing—original draft preparation, the first author; writing—review and editing, all authors; supervision, the third author. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest:

The authors declare no conflict of interest.

Data Availability Statement:

The data used in this study were obtained from publicly available sources, including the Central Bank of Iran (CBI), the World Bank World Development Indicators, and IMF monetary statistics. Some variables were constructed by the authors based on these sources, as described in the Data Construction section. The data are available from the corresponding author upon reasonable request.

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Appendix A

The household's optimization problem is solved by constructing a Lagrangian that augments the utility function with the relevant constraints. Taking derivatives with respect to $c_t, l_t, m_t, b_t, I_t, k_t, A_t$ and d_t yields the corresponding first-order conditions. The associated multipliers λ_t, μ_t , and V_t represent the shadow values of the settlement constraint, the capital accumulation constraint, and the deposit accumulation constraint, respectively.

$$\frac{\partial L}{\partial c_t} = 0 \quad (c_t - H_t)^{-\sigma} = [\lambda_t + V_t] \quad (B-1)$$

$$\frac{\partial L}{\partial l_t} = 0, -E_t \beta^t \chi \frac{(1+\eta)}{(1+\eta)} l_t^\eta + E_t \beta^t \lambda_t w_t + E_t V_t \beta^t w_t = 0 \quad (B-2)$$

$$\frac{\partial L}{\partial m_t} = 0, E_t \beta^t \frac{(1-b)}{(1-b)} m_t^{-b} - E_t \beta^t \lambda_t + \frac{E_{t+1} \lambda_{t+1} \beta^{t+1}}{\Pi_{t+1}(1+n)} + V_{t+1} \frac{E_{t+1} \beta^{t+1}}{\Pi_{t+1}(1+n)} = 0 \quad (B-3)$$

$$\frac{\partial L}{\partial A_t} = 0, E_t \lambda_t \beta^t (r_t^k k_{t-1} - \psi(A_t) k_{t-1}) = 0 \quad (B-4)$$

$$\frac{\partial L}{\partial K_t} = 0, -E_t \mu_t \beta^t + E_{t+1} \lambda_{t+1} \beta^{t+1} [r_{t+1}^k Z_{t+1} - \psi(A_{t+1})] + \mu_{t+1} \beta^{t+1} E_{t+1} (1 - \delta) = 0 \quad (B-5)$$

$$\frac{\partial L}{\partial I_t} = 0, -\lambda_t + \mu_t - \mu_t \cdot S \left(\left(\frac{\varepsilon_t^I I_t}{I_{t-1}} \right) \right) - \mu_t I_t \dot{S} \left(\frac{\varepsilon_t^I I_t}{I_{t-1}} \right) \left(\frac{\varepsilon_t^I}{I_{t-1}} \right) + \beta \mu_{t+1} \cdot \dot{S} \left(\frac{\varepsilon_{t+1}^I I_{t+1}}{I_t} \right) \varepsilon_{t+1}^I \left(\frac{I_{t+1}}{I_t} \right)^2 = 0 \quad (B-6)$$

$$\frac{\partial L}{\partial d_t} = 0, -E_t V_t \beta^t - E_t \beta^{t+1} V_{t+1} \frac{(1+i_t^d)}{(1+\pi_t)} = 0 \quad (B-7)$$

Appendix B

The equation for the representative household's current deposits at the end of period t is defined as follows:

$$B_t = B_{t-1} + W_t L_t + M_t - T_t - P_t C_t + \Pi_t^b + \vartheta \Pi_t^f + \Pi_t^k \quad (C-1)$$

In this equation, Π_t^f , Π_t^k and Π_t^b are the nominal profits transferred by intermediate goods producers, capital goods producers, and banks to the household's account. The parameter ϑ shows the share of profits from intermediate goods producers given to households.

By combining equations (4), (5), and (C-1), the following relationships can be derived:

$$B_{t-1} = P_t C_t - W_t L_t - M_t + T_t \quad (C-2)$$

$$B_t = P_t C_t - W_t L_t - M_t + T_t + W_t L_t + M_t - T_t - P_t C_t + \Pi_t^b + \vartheta \Pi_t^f + \Pi_t^k \quad (C-3)$$

$$B_t = \Pi_t^b + \vartheta \Pi_t^f + \Pi_t^k \text{ (C-3)}$$

$$B_{t-1} = \Pi_{t-1}^b + \vartheta \Pi_{t-1}^f + \Pi_{t-1}^k \text{ (C-4)}$$

$$P_t C_t \leq \vartheta \Pi_{t-1}^f + \Pi_{t-1}^b + \Pi_{t-1}^k + W_t L_t + D_{t-1}(1 + i_{t-1}^d) - D_t - T_t \text{ (C-5)}$$

Household deposits (B_t , D_t) evolve according to bank-provided returns and liquidity transfers rather than monetary policy operations.

Appendix C. Optimal Pricing of Capital Goods

This appendix derives the optimal pricing condition for installed capital goods. The capital-goods producer operates under perfect competition and takes all prices as given. The firm chooses the investment path I_t to maximize the expected present value of real profits, subject to the capital accumulation constraint with quadratic adjustment costs.

Accordingly, the shadow value λ_t represents the marginal value of installed capital at time t .

To solve the firm's dynamic optimization problem, we form the Lagrangian by incorporating the capital accumulation constraint using a time-varying Lagrange multiplier λ_t .

$$L = E_t \cdot \frac{\beta^t}{P_t} [p_t^k \cdot [K_t - (1 - \delta) \cdot K_{t-1}] - P_t \cdot I_t] - E_t \cdot \lambda_t \cdot \frac{\beta^t}{P_t} \left[K_t - (1 - \delta) \cdot K_{t-1} - I_t + \frac{\kappa}{2} \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \cdot I_t \right] \text{ (D-1)}$$

$$L = E_{t+1} \cdot \frac{\beta^{t+1}}{P_{t+1}} \cdot [p_{t+1}^k \cdot [K_{t+1} - (1 - \delta) \cdot K_t] - P_{t+1} \cdot I_{t+1}] - E_{t+1} \cdot \frac{\beta^{t+1}}{P_{t+1}} \cdot \lambda_{t+1} \left[K_{t+1} - (1 - \delta) \cdot K_t - I_{t+1} + \frac{\kappa}{2} \cdot \left(\frac{I_{t+1}}{I_t} - 1 \right)^2 \cdot I_{t+1} \right] \text{ (D-2)}$$

The first-order condition with respect to the capital stock K_t links the shadow value of capital to its market price.

$$\frac{\partial L}{\partial K_t} = 0 \quad E_t \cdot \frac{\beta^t}{P_t} \cdot p_t^k - E_t \cdot \lambda_t \cdot \frac{\beta^t}{P_t} - E_{t+1} \cdot \frac{\beta^{t+1}}{P_{t+1}} \cdot p_{t+1}^k \cdot (1 - \delta) + E_{t+1} \cdot \lambda_{t+1} \cdot \frac{\beta^{t+1}}{P_{t+1}} \cdot (1 - \delta) = 0 \text{ (D-3)}$$

$$\frac{\beta^t}{P_t} \cdot p_t^k = \frac{\beta^t \lambda_t}{P_t} + \frac{\beta^{t+1}}{(1+\pi) \cdot P_t} p_{t+1}^k \cdot (1 - \delta) - \frac{\beta^{t+1} \lambda_{t+1} \cdot (1 - \delta)}{(1+\pi) \cdot P_t} \text{ (D-4)}$$

$$\frac{\beta^t}{P_t} \cdot p_t^k = \frac{\beta^t}{P_t} \cdot \left(\lambda_t + \frac{\beta \cdot p_{t+1}^k \cdot (1 - \delta)}{(1+\pi)} - \frac{\beta \cdot \lambda_{t+1} \cdot (1 - \delta)}{(1+\pi)} \right) \text{ (D-5)}$$

$$p_t^k = \left(\lambda_t + \frac{\beta \cdot p_{t+1}^k \cdot (1 - \delta)}{(1+\pi)} - \frac{\beta \cdot \lambda_{t+1} \cdot (1 - \delta)}{(1+\pi)} \right) \text{ (D-6)}$$

$$p_t^k = \left(\lambda_t + \frac{\beta \cdot (1 - \delta)}{(1+\pi)} \cdot (p_{t+1}^k - \lambda_{t+1}) \right) \text{ (D-7)}$$

Steady state

$$\lambda_t = \lambda_{t+1} \quad (\text{D-8})$$

$$p_t^k = \left(\lambda_t + \left(\frac{\beta \cdot (1-\delta)}{(1+\pi)} \cdot p_t^k \right) - \lambda_t \cdot \frac{\beta \cdot (1-\delta)}{(1+\pi)} \right) \quad (\text{D-9})$$

$$p_t^k - \frac{\beta \cdot (1-\delta)}{(1+\pi)} \cdot p_t^k = \left(\lambda_t - \left(\lambda_t \cdot \frac{\beta \cdot (1-\delta)}{(1+\pi)} \right) \right) \quad (\text{D-10})$$

$$p_t^k \cdot \left(1 - \frac{\beta \cdot (1-\delta)}{(1+\pi)} \right) = \lambda_t \cdot \left(1 - \frac{\beta \cdot (1-\delta)}{(1+\pi)} \right) \quad (\text{D-11}) \quad p_t^k = \lambda_t \quad (\text{D-12})$$

$$p_{t+1}^k = \lambda_{t+1} \quad (\text{D-13})$$

Current investment affects profits through two channels: directly through its resource cost, and indirectly through adjustment costs, which depend on the investment growth rate. Moreover, changes in current investment influence future adjustment costs by altering the denominator of the investment growth term.

$$\frac{\partial L}{\partial I_t} = 0 - E_t \cdot \frac{\beta^t}{P_t} \cdot P_t + E_t \cdot \beta^t \cdot \lambda_t - E_t \cdot \beta^t \cdot \lambda_t \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} +$$

$$E_{t+1} \cdot \beta^{t+1} \cdot \lambda_t \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right) \cdot I_{t+1} \quad (\text{D-14})$$

$$- E_t \cdot \frac{\beta^t}{P_t} \cdot P_t + E_t \cdot \beta^t \cdot \lambda_t - E_t \cdot \beta^t \cdot \lambda_t \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} =$$

$$- E_{t+1} \cdot \beta^{t+1} \cdot \lambda_{t+1} \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right) \cdot I_{t+1} \quad (\text{D-15})$$

$$- E_t \cdot \beta^t \cdot \left[1 - \lambda_t + \lambda_t \cdot \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} \right] = - E_{t+1} \cdot \beta^{t+1} \cdot \lambda_{t+1} \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right) \cdot I_{t+1} \quad (\text{D-16})$$

$$\left[1 - \lambda_t + \lambda_t \cdot \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} \right] = E \cdot \beta \cdot \lambda_{t+1} \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right) \cdot I_{t+1} \quad (\text{D-17})$$

$$1 = \lambda_t - \lambda_t \cdot \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} + E \cdot \beta \cdot \lambda_{t+1} \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right) \cdot I_{t+1} \quad (\text{D-18})$$

$$1 = \left[\lambda_t \cdot \left(1 - \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} \right) + E \cdot \beta \cdot \lambda_{t+1} \cdot \frac{\kappa}{2} \cdot 2 \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right)^2 \right] \quad (\text{D-19})$$

$$\frac{1}{p_t^k} = \left[\left(1 - \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \frac{I_t}{I_{t-1}} \right) + E \cdot \beta \cdot \frac{p_{t+1}^k}{p_t^k} \cdot \kappa \cdot \left(\frac{I_t}{I_{t-1}} - 1 \right) \cdot \left(-\frac{I_{t+1}}{I_t^2} \right)^2 \right] \quad (\text{D-20})$$

Rearranging the first-order condition yields the optimal pricing equation for installed capital goods. In steady state, the price of capital equals its shadow value, consistent with the standard Tobin's q formulation.

Appendix D

Bayesian Estimation of the DSGE Model

To evaluate the robustness of the calibrated DSGE framework and address concerns regarding parameter sensitivity, a Bayesian estimation procedure is conducted for the key structural parameters of the model. The estimation is performed separately for Iran, Armenia, and Azerbaijan in order to account for country-specific macroeconomic characteristics.

The Bayesian approach combines prior information—drawn from standard DSGE literature and empirical studies on emerging economies—with the likelihood implied by the model and observed macroeconomic data. The

estimation is implemented using a Markov Chain Monte Carlo (MCMC) algorithm.

The focus is placed on a set of core structural parameters that govern preferences, production technology, and shock persistence, namely α , β , ρ , and σ . These parameters are central to the transmission mechanism of credit shocks and the dynamics of liquidity allocation within the banking sector.

The following subsections report the estimation results for each country.

D.1 Bayesian Estimation: Iran

The Bayesian estimation for Iran is conducted using macroeconomic time series consistent with the model structure. Prior distributions are selected based on commonly accepted ranges in the DSGE literature.

The posterior results indicate that the estimated parameters remain within economically plausible intervals. In particular, the posterior mean of σ confirms a moderate degree of intertemporal substitution, while ρ suggests a meaningful persistence of credit shocks. The posterior estimates of α and β are also consistent with standard values for emerging economies.

Importantly, when posterior means are used instead of baseline calibrated values, the impulse response functions and the qualitative behavior of key variables—such as bank lending, firms' debt, required reserves, and the Liquidity Distribution Index (LDI)—remain stable. This supports the robustness of the baseline calibration for Iran.

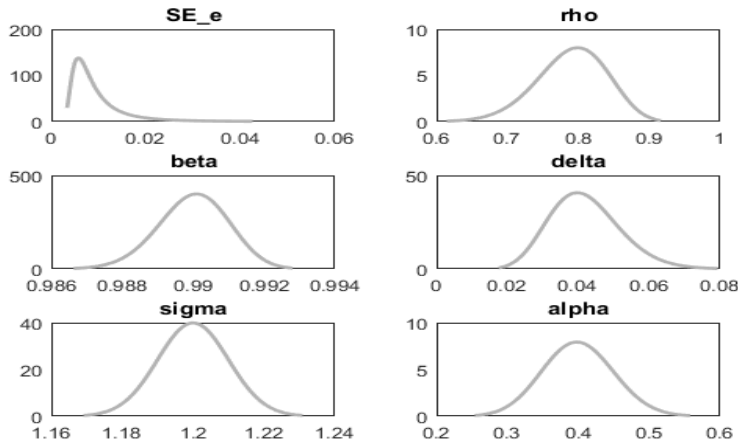


Figure D.1. Posterior Distributions of Structural Parameters (Iran)

Source: Research Findings

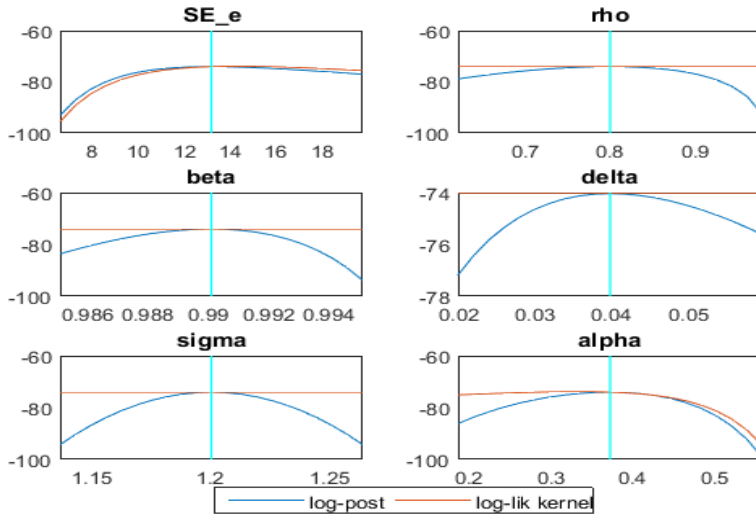


Figure D.2. Posterior Distributions of the Estimated Structural Parameters for Iran (SE_e , ρ , β , δ , σ , α)
Source: Research Findings

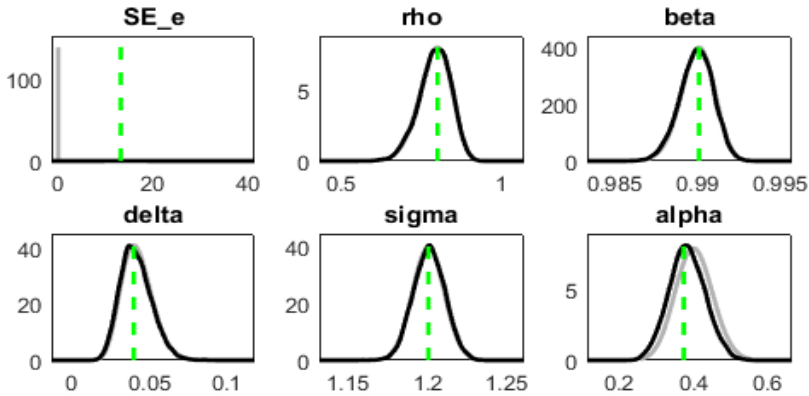


Figure D.3. MCMC Convergence Diagnostics for the Bayesian Estimation (Iran): Interval, M2, and M3 Statistics
Source: Research Findings

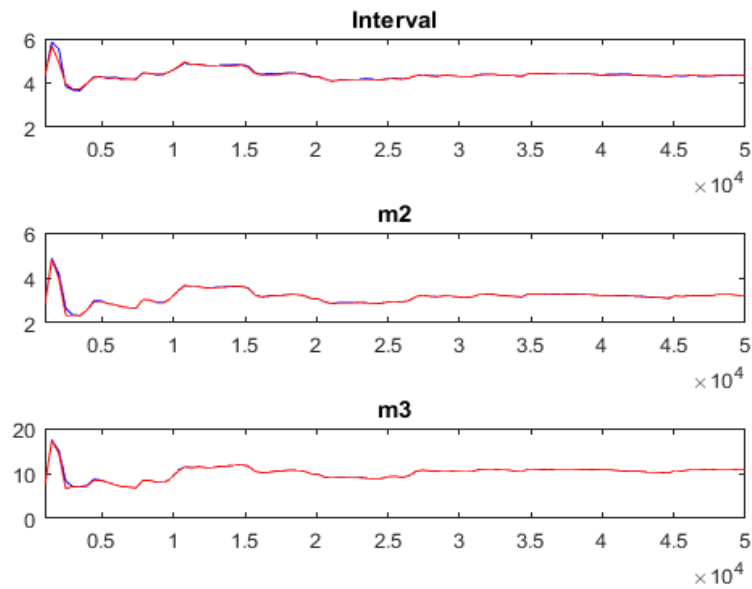


Figure D.4. Parameter-Specific MCMC Convergence Diagnostics for the Bayesian Estimation (Iran). Interval, M2, and M3 statistics for SE_e , ρ , and β across iterations.

Source: Research Findings

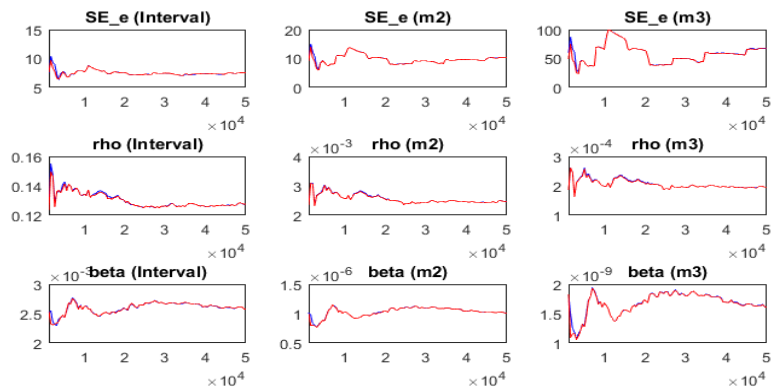


Table D.1. AR(1) Dynamic Parameter Estimation for the Log Effective Lending Rate – Iran (2005–2024)

parameters	prior mean	post. mean	90% HPD interval		prior	pstdev
rho	0.790	0.7897	0.7110	0.8735	beta	0.0500
beta	0.990	0.9899	0.9883	0.9916	beta	0.0010
delta	0.042	0.0411	0.0252	0.0574	beta	0.0100
sigma	1.200	1.2003	1.1841	1.2164	norm	0.0100
alpha	0.400	0.3805	0.3015	0.4631	beta	0.0500

Source: Research Findings

D.2 Bayesian Estimation: Azerbaijan

The Bayesian estimation for Azerbaijan reflects the structural characteristics of a resource-dependent economy with relatively higher income volatility. The posterior distributions of the estimated parameters confirm that the baseline calibration is broadly consistent with the data.

The estimated value of σ remains below unity, implying a relatively high intertemporal elasticity of substitution, which is economically consistent with stronger consumption adjustments in response to income fluctuations. The persistence parameter ρ also reflects the dynamic properties observed in the data.

Using posterior means instead of calibrated parameters does not materially alter the model's impulse responses. The dynamics of credit expansion, bank balance sheets, and the LDI remain stable, reinforcing the robustness of the results for Azerbaijan.

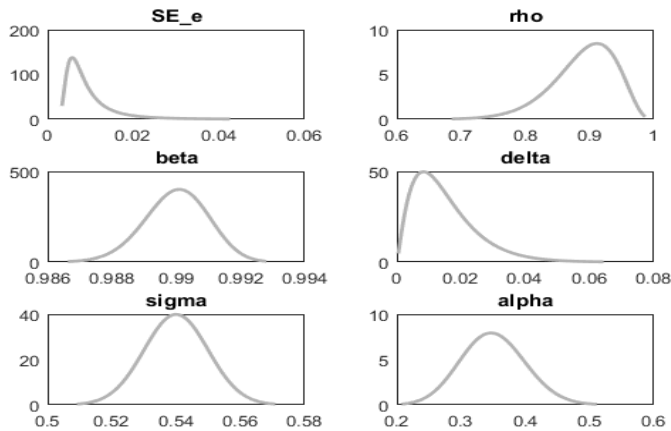


Figure D.5. Posterior Distributions of Structural Parameters (Azerbaijan)

Source: Research Findings

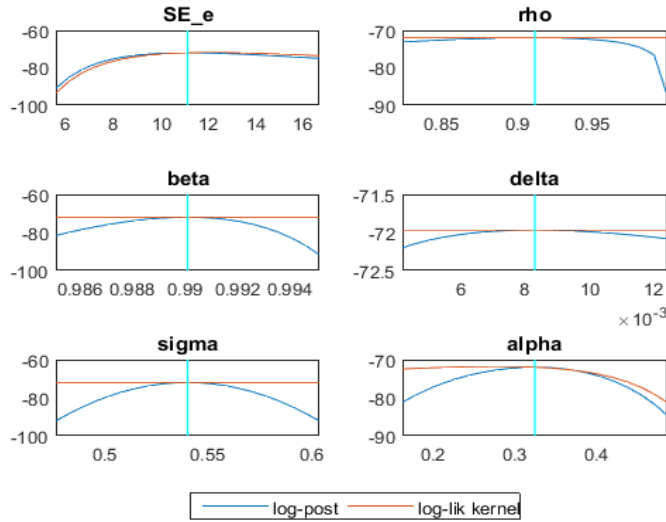


Figure D.6. Posterior Distributions of the Estimated Structural Parameters for Azerbaijan (SE_e , ρ , β , δ , σ , α)

Source: Research Findings

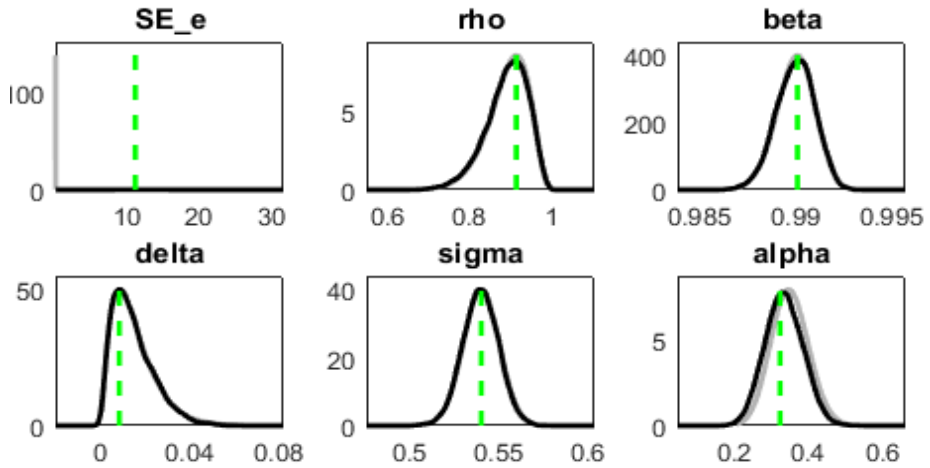


Figure D.7. Posterior Density Functions of the Estimated Structural Parameters for Azerbaijan (SE_e , ρ , β , δ , σ , α)

Source: Research Findings

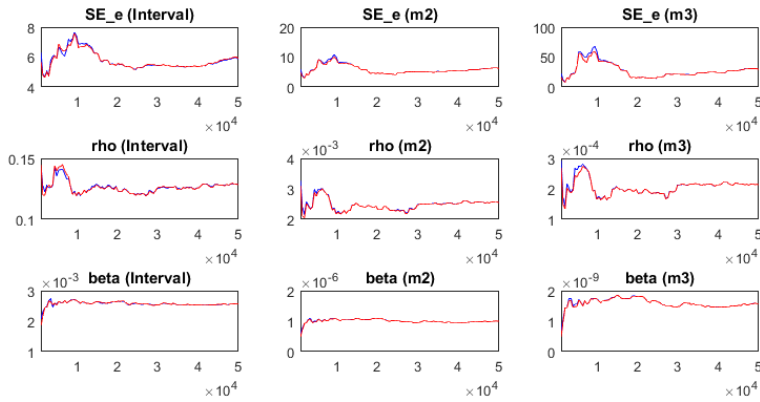


Figure D.8. Parameter-Specific MCMC Convergence Diagnostics for the Bayesian Estimation (Azerbaijan). Interval, M2, and M3 statistics for SE_e , ρ , and β across iterations

Source: Research Findings

Table D.2. Bayesian Estimation Results for the DSGE Model (Azerbaijan)

parameters	prior mean	post. mean	90% HPD interval		prior	pstdev
rho	0.890	0.8876	0.8100	0.9680	beta	0.0500
beta	0.990	0.9900	0.9884	0.9917	beta	0.0010
delta	0.015	0.0145	0.0011	0.0278	beta	0.0100
sigma	0.540	0.5395	0.5235	0.5556	norm	0.0100
alpha	0.350	0.3337	0.2511	0.4165	beta	0.0500

Source: Research Findings

D.3 Bayesian Estimation: Armenia

For Armenia, the Bayesian estimation accounts for country-specific structural features reflected in the macroeconomic data. The same set of structural parameters is estimated using consistent priors to ensure cross-country comparability.

The posterior results confirm that the parameter values lie within empirically reasonable bounds. In particular, the estimated σ aligns with values commonly reported in the literature, resolving concerns regarding excessively high risk-aversion values in earlier specifications.

The model's dynamic responses to credit condition shocks remain qualitatively unchanged under posterior estimates, indicating that the main findings for Armenia are robust to alternative parameter realizations.

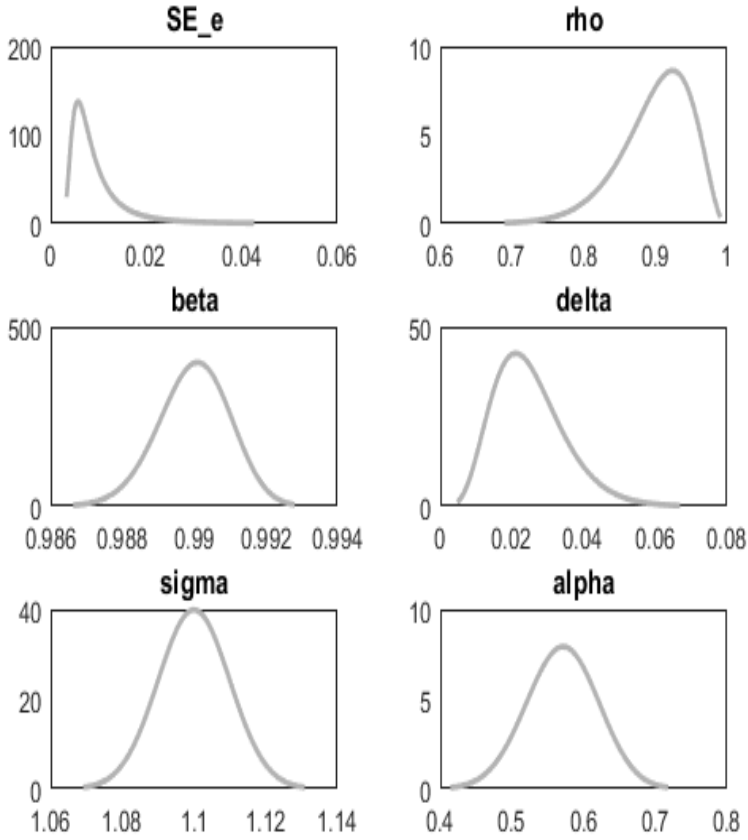


Figure D.9. Posterior Distributions of Structural Parameters (Armenia)

Source: Research Findings

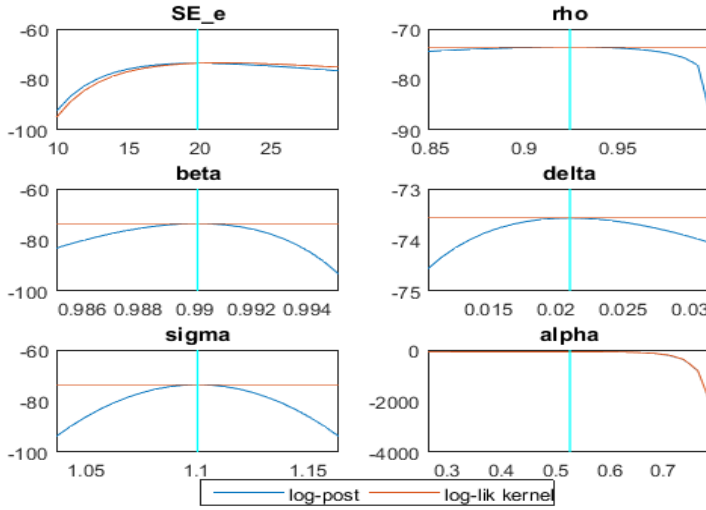


Figure D.10 Posterior Distributions of the Estimated Structural Parameters for Armenia (SE_e , ρ , β , δ , σ , α)

Source: Research Findings

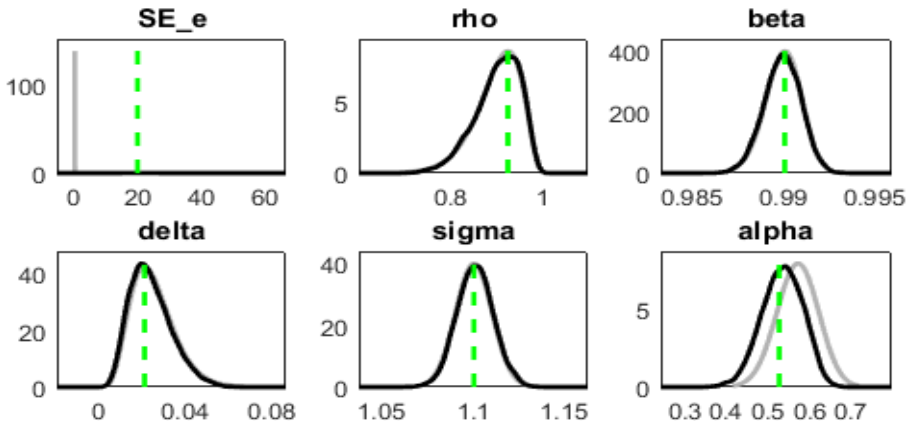


Figure D.11 Posterior Density Functions of the Estimated Structural Parameters for Armenia (SE_e , ρ , β , δ , σ , α)

Source: Research Findings

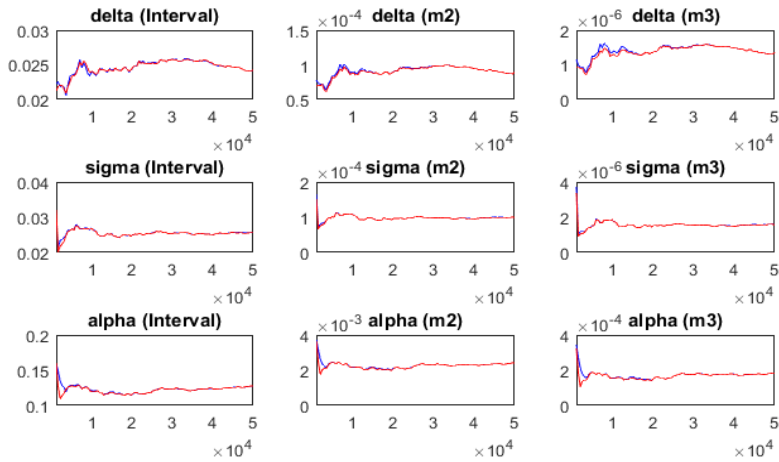


Figure D.12 Parameter-Specific MCMC Convergence Diagnostics for the Bayesian Estimation (Armenia). Interval, M2, and M3 statistics for SE_e , ρ , and β across iterations

Source: Research Findings

Table D.3. Bayesian Estimation Results for the DSGE Model (Armenia)

parameters	prior mean	post. mean	90% HPD interval		prior	pstdev
rho	0.900	0.9010	0.8245	0.9743	beta	0.0500
beta	0.990	0.9899	0.9883	0.9916	beta	0.0010
delta	0.025	0.0238	0.0087	0.0385	beta	0.0100
sigma	1.100	1.1006	1.0846	1.1173	norm	0.0100
alpha	0.570	0.5329	0.4524	0.6122	beta	0.0500

Source: Research Findings