Journal of Money and Economy
Vol. 21, No. 3, Summer 2026
pp. 447-510

Original Research Article

Restructuring Non-Performing Loans and Liquidity Distribution

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Received: 18 Jan 2026 Approved: 01 Jun 2026

The distribution of bank deposits is an increasingly important factor in financial and economic stability. Given recent developments in monetary policy and challenges arising from the repayment of non-performing loans, this issue has gained even greater significance. This study examines the effect of the repayment of NPLs on the distribution of deposits in the Iranian economy using a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. The findings indicate that a technological shock reduces macroeconomic production and income of firms. In this regard, the repayment of firm debt to banks decreases, and banks offer implicit extensions, resulting in an increase in bank debt and endogenous liquidity creation. This process disrupts the distribution of liquidity across heterogeneous household groups and leads to an imbalanced distribution of liquidity in various sectors of the economy. This research, by presenting a DSGE model focused on banks and incorporating institutional features of the Iranian banking system, including administered lending, and taking into account the mechanisms of non-performing loan repayment, provides a more detailed analysis of these effects. The results indicate that the concentration of liquidity in the hands of households, due to a negative technology shock, can lead to increased financial risk and a reduction in investment in the productive sectors.

Keywords: Liquidity Distribution, Endogenous Liquidity Creation, Dynamic Stochastic General Equilibrium (DSGE) Model
JEL Classification*:* E44, C63, E51

1 Introduction

Monetary supply creation is fundamental to the economy and profoundly impacts banking system stability (Rothbard, 2008). Consequently, a comprehensive and transparent monetary and financial framework is essential

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for defining banking operations, optimizing resource allocation, and ensuring economic stability. This framework must be grounded in a deep understanding of money creation mechanisms and their associated challenges (McLeay et al., 2014; Disyatat, 2011).

Two main perspectives exist on the role of banks in the economy. The first views banks as financial intermediaries that merely allocate existing savings, while the second argues that banks can create liquidity independently of prior savings through lending. Although some regard liquidity creation as a driver of economic growth, critics link it to asset price bubbles, financial instability, and rising inequality (Werner, 2014; Mazzucato & Wray, 2015).

Understanding bank liquidity distribution requires examining liquidity creation processes. Banks generate liquidity not just through lending, but also via other mechanisms. A key factor in this context is loan default and its management. When borrowers default, this can disrupt the flow of liquidity within the economy (Disyatat, 2011).

When banks face non-performing loans, they typically have two options: set aside reserves for potential losses or extend loan terms. However, due to regulatory weaknesses and incentives for concealment, banks often opt to extend loan maturities through cosmetic restructuring. This practice distorts money distribution and expands the money supply (Homar et al., 2015).

To understand the complex relationship between liquidity and inflation in the Iranian economy, a comprehensive analysis of multiple factors and their long-term impact on economic stability is essential. This study addresses this issue through a rigorous and policy-relevant analysis.

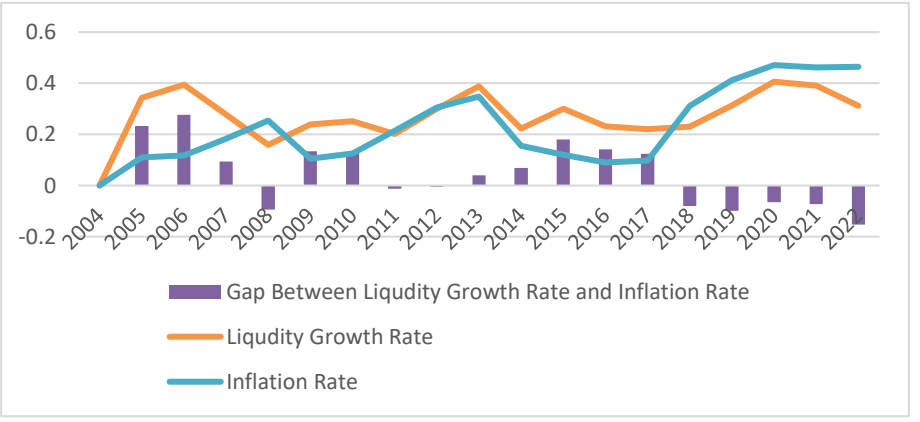

Figure 1. Trends in Inflation and Liquidity Variables

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Source: Central Bank of the Islamic Republic of Iran, n.d

As shown in Figure (1), the growth rate of liquidity has exhibited a downward trend in recent years, declining over the period 2020–2022. Moreover, since 2018, the inflation rate has surpassed the growth rate of liquidity. Particularly since 2018, the negative gap between the two rates has widened markedly, reaching its maximum divergence in 2022. In fact, despite the control of liquidity growth in recent years, inflation has not declined.

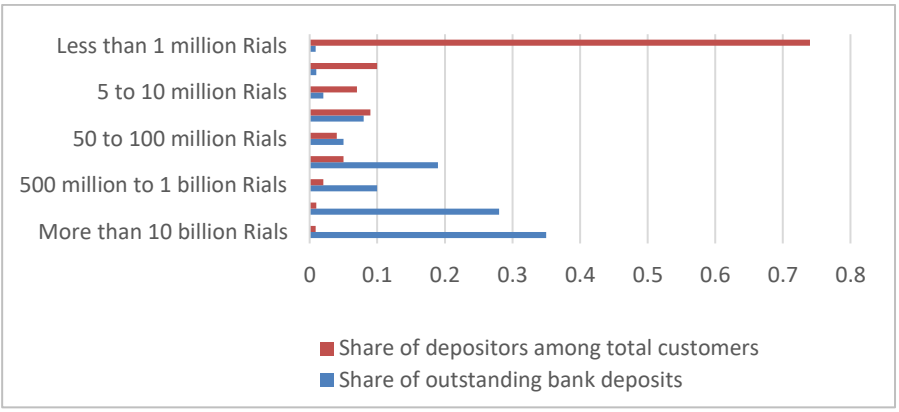

Figure 2. Concentration of Liquidity among Bank Depositors
Source: Islamic Parliament Research Center, 2018

Despite efforts to restrain liquidity growth, persistently high inflation in Iran suggests that liquidity concentration within the banking system plays a crucial role in the country's economic dynamics. Recent data reveal a significant concentration in deposit holdings within the Iranian banking system, where a small fraction of depositors—predominantly large-scale entities and wealthy households—controls a disproportionately large share of total funds (Islamic Parliament Research Center, 2018). This high degree of concentration raises concerns regarding asset market volatility and inflationary pressures, suggesting that understanding macroeconomic instability requires looking beyond aggregate liquidity growth to examine its distribution across the depositor base.

Building on the previous analysis of deposit concentration in the Iranian banking system, this study utilizes a bank-centered DSGE framework to investigate the impact of bank-driven liquidity shocks on deposit distribution and social welfare. Unlike conventional DSGE models treating default as

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exogenous, this research incorporates endogenous forbearance of non-performing loans as a key institutional mechanism in bank-based economies. It examines how these shocks, operating through cosmetic restructuring of NPLs, affect the dynamic interplay between deposit distribution, default probability, and overall social welfare in Iran, evaluating the quantitative significance of these responses.

The main problem of the article is: Considering the combined efforts of declining business income, adjustments to bank reserves, and potential write-offs of non-performing loans, what significant shifts are observed in household deposit allocation patterns within the banking system?

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature, specifically focusing on endogenous liquidity distribution under loan forbearance, while Section 3 provides the research background regarding the Iranian banking system. Section 4 develops the bank-centered New Keynesian DSGE model, detailing the interactions between households, various types of firms, banks, and the government. Section 5 presents the model solution and calibration, followed by Section 6, which evaluates the model's fit through moment matching with Iranian empirical data. Finally, Section 7 analyzes the simulation results, discussing the distributional and welfare implications as well as policy implications, and concludes the study.

2 Literature Review

The present study explicitly departs from the intermediation and money-multiplier views of banking and adopts the bank credit creation perspective as its theoretical foundation for modeling liquidity dynamics and deposit distribution. Within this framework, banks are not passive intermediaries of existing savings but active creators of money through lending, with loans and deposits being generated simultaneously on bank balance sheets (Jakab & Kumhof, 2015; McLeay et al., 2014).

The post-2007 financial crisis played a decisive role in re-establishing this view as the dominant paradigm in monetary economics. A growing body of theoretical and institutional research has shown that money creation is an endogenous process driven by bank lending decisions and balance-sheet dynamics, rather than by exogenous reserve constraints or prior deposits (Disyatat, 2011; Jakab & Kumhof, 2015).

Crucially, while the bank credit creation literature provides a coherent explanation of how liquidity is created endogenously, it remains largely silent on how newly created deposits are distributed across economic agents. Most existing DSGE models with banking sectors focus on aggregate liquidity,

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credit volumes, or financial stability (e.g., Bernanke et al., 1999; Gerali et al., 2010), abstracting from the distributional consequences of bank balance sheet decisions—particularly in environments characterized by loan defaults and non-performing loan forbearance.

This omission becomes especially important in economies where banks systematically engage in forbearance policies, delaying loss recognition and restructuring non-performing loans rather than writing them off. In such settings, liquidity creation is not merely the outcome of new lending but also arises from banks' treatment of defaulted loans. When loans become non-performing, banks may either recognize losses—leading to balance-sheet contraction—or restructure and extend debt, allowing these assets to remain on their balance sheets. The latter mechanism sustains and potentially expands both bank assets and liabilities, generating liquidity endogenously over time (Homar et al., 2015).

Despite its macroeconomic relevance, this channel has received limited attention in DSGE frameworks. While recent studies have established the link between NPL forbearance and endogenous liquidity creation (Amirali et al., 2023), existing DSGE models rarely connect these dynamics to the distribution of deposits across households and sectors. Specifically, how liquidity generated through bank payments, interest flows, and profit distribution affects heterogeneous deposit holdings and the subsequent propagation of monetary shocks remains an underexplored dimension.

The present paper contributes to this literature by integrating non-performing loan forbearance into a DSGE model with endogenous money creation and heterogeneous deposit flows. Within this framework, forbearance is modeled not as a purely accounting adjustment, but as a macroeconomic mechanism that simultaneously affects liquidity creation, bank balance sheets, and the distribution of deposits. This structure provides the theoretical foundation for the model developed in Section 4 and underpins the empirical and simulation results presented in Sections 6 and 7.

2.1 Endogenous Liquidity Distribution under Loan Forbearance

Uneven distribution of liquidity in bank deposits is a key issue in bank-based economies, including Iran. Empirical evidence (e.g., Islamic Parliament Research Center, 2018) indicates that a small fraction of depositors—less than 1 percent—holds nearly 70 percent of total bank liquidity. Such a high degree of concentration not only influences asset prices and raises inflationary concerns, but also restricts credit access for marginal depositors, distorts

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investment toward non-productive assets such as housing, and exacerbates inequality by limiting access to financial resources (Mohammadi et al., 2026).

However, a focus on empirical concentration alone cannot explain the structural drivers of this phenomenon. As discussed in the preceding section, the bank credit creation framework emphasizes that liquidity is generated endogenously through banks' balance-sheet operations. The central mechanism emphasized in this study is banks' decision to forbear on non-performing loans—that is, to restructure and extend overdue debt rather than recognize default and liquidate the borrower. When firms experience repayment difficulties but the value of their assets (including collateral) still exceeds liabilities, banks may optimally defer repayment and continue to treat loans as performing for accounting purposes. This practice leads to an accumulation of overdue debt on bank balance sheets and, in order to preserve the accounting identity between assets and liabilities, mechanically necessitates the creation of new deposits (Homar et al., 2015).

The transmission of this process to liquidity distribution operates through an asymmetric profit-distribution channel across households**.** In the two-household structure of the model, the active household (L) earns labor income and holds deposits primarily for transactional purposes, while the passive household (H) receives profit distributions from firms and banks and holds wealth in time deposits. Under loan forbearance, accrued interest on non-performing loans is recognized as accounting profit, despite the absence of corresponding cash inflows. These notional profits—together with profits generated by firms benefiting from forbearance—are fully distributed to Household H, assumed to be the ultimate shareholder of banks and firms, and are subsequently reinvested in time deposits. As a result, liquidity created through forbearance accumulates disproportionately in the deposits of Household H, generating persistent concentration consistent with observed patterns in Iranian banking data.

The evergreening and rollover of non-performing loans channel liquidity toward unproductive sectors, impairing monetary policy transmission and crowding out financing for the real economy (Mohammadi et al., 2026). This institutional mechanism—modeled explicitly as cosmetic forbearance in Section 4—also functions as a key driver of liquidity hoarding, leading to a structural impairment in liquidity circulation among active economic agents. The resulting transmission channel, from loan forbearance to endogenous deposit concentration, is quantitatively assessed in Section 4 using a liquidity distribution index that captures the evolving share of aggregate time deposits

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held by the passive household. Detailed balance-sheet mechanics and numerical illustrations are provided in Appendix A.

3 Research Background

Contemporary economic scholarship has shifted its focus towards the endogenous generation of liquidity through banking balance sheet operations, moving away from the conventional view that liquidity is merely a result of passive savings. This 'credit creation' framework underscores that banks function as active agents in deposit formation by making lending decisions, rather than functioning solely as conduits for reallocating existing financial resources. Evidence supporting this phenomenon within the Iranian economy has been documented by Bagherpour and Shakeri (2021), who establish that domestic banks have the capability to initiate liquidity creation without relying on external funding. Furthermore, research by Nasiri et al. (2023) corroborates this by showing that critical macroeconomic variables—specifically interest rates, oil prices, and exchange rates—significantly influence deposit levels and liquidity, thereby positioning credit expansion as a primary driver of this dynamic.

Despite recognizing the endogenous nature of money creation, much of the existing literature abstracts from the micro-level balance sheet mechanisms governing loan repayment, default, and restructuring. In many macroeconomic models, non-performing loans (NPLs) are either treated exogenously or represented through highly stylized default processes. In contrast, the banking and finance literature provides compelling evidence that, when faced with borrower distress—particularly in environments characterized by weak regulatory enforcement—banks frequently resort to cosmetic forbearance or loan evergreening rather than immediate default recognition (Peek & Rosengren, 2005). These practices allow banks to record accrual-based profits without corresponding cash inflows**,** thereby expanding balance sheets while masking underlying fragilities. Nevertheless, these insights remain restricted to partial equilibrium or institutional studies, lacking the necessary systematic integration into DSGE frameworks.

Within the domestic theoretical landscape, Amirali et al. (2023) have pioneered a crucial advancement by integrating the cosmetic forbearance of non-performing loans into a DSGE structure. Their study examines the effects of debt restructuring on bank balance sheets and overall liquidity generation; yet, a significant gap persists. Their model does not fully address how the liquidity resulting from these balance sheet practices is distributed among

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diverse economic agents, nor does it analyze the subsequent impact on deposit concentration and systemic liquidity inequality.

Separate research streams have analyzed the welfare and distributional implications of liquidity concentration. Specifically, Mohammadi et al. (2026) demonstrate that liquidity hoarding coupled with deposit concentration in fractional reserve banking can lead to notable welfare declines. Data from the Islamic Parliament Research Center (2018) illustrates that Iran mirrors this pattern, with a marginal group of depositors commanding the bulk of total deposits. Despite this, contemporary DSGE models with endogenous money often restrict their analysis to aggregate liquidity variables, failing to account for household-level deposit distribution or the specific institutional pathways driving this concentration.

Crucially, existing studies have not integrated these two dimensions—cosmetic forbearance of non-performing loans and the endogenous distribution of bank-created liquidity—within a unified macroeconomic framework. In particular, the role of accrual-based (non-cash) bank profits arising from loan forbearance has not been formalized as a transmission channel linking balance-sheet expansion to asymmetric deposit accumulation in DSGE models. Consequently, the systemic feedback loops connecting debt restructuring, liquidity provision, and deposit concentration remain largely understudied.

To overcome these research limitations, we propose a bank-centric DSGE model where the renegotiation of non-performing loans operates as an endogenous institutional mechanism on bank balance sheets. Through the explicit accounting of accrual-based profits and the incorporation of their heterogeneous distribution among households, this model provides a coherent, dynamic framework for analyzing both liquidity generation and allocation. Consequently, this approach facilitates the integrated examination of real and financial disturbances, deposit concentration, financial risk, and welfare impacts, offering a structural lens to explain the liquidity hoarding phenomena evident in Iran.

4 Model Structure

This section presents a Dynamic Stochastic General Equilibrium (DSGE) model with an explicit banking sector designed to analyze how endogenous loan forbearance affects both liquidity creation and its distribution across households. The economy consists of four types of agents: households, firms, commercial banks, and a monetary authority. Households are divided into two groups—liquidity-constrained workers (Household L) and passive

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profit-receiving households (Household H)—while firms operate in intermediate- and final-goods sectors. All agents are forward-looking and behave subject to their respective constraints.

The model combines a standard New Keynesian DSGE core with a bank-centered balance-sheet framework. In particular, household preferences, labor supply, price setting by firms, and monetary policy follow the conventional New Keynesian structure, as in Tavakolian et al. (2023)**.** These components serve as the baseline macroeconomic environment and are not the source of the paper's main contribution.

Building on this core, the modeling of firm default risk and repayment behavior adopts a balance-sheet-based threshold approach following Hristov and Hülsewig (2017)**,** in which firms' asset values and cash-flow conditions jointly determine their ability to service debt. This framework allows default risk to arise endogenously in response to real and financial shocks.

The bank's treatment of non-performing loans follows a threshold-type forbearance rule inspired by Hristov and Hülsewig (2017)**.** Specifically, as long as the value of a firm's assets exceeds its outstanding liabilities, banks optimally roll over non-performing loans instead of recognizing default and liquidating the firm. This rule captures the institutional practice of cosmetic loan restructuring observed in weakly regulated banking systems (Homar et al.,2015).

In the Iranian banking system, this forbearance behavior is further reinforced by the presence of administered or government-directed lending programs (Tashilat Taklifi), which account for a non-negligible share of total bank credit (Alahyari-Fard, 2025). Such loans are typically associated with weaker repayment enforcement and institutional pressure to delay default recognition. As a result, the effective forbearance threshold faced by banks is systematically relaxed relative to a purely market-based lending environment.

The main contribution of this paper lies in embedding this forbearance mechanism directly into banks' balance sheets within a DSGE framework. By keeping impaired loans on the asset side, loan forbearance requires a simultaneous expansion of bank liabilities to preserve balance-sheet consistency, thereby generating endogenous liquidity through deposit creation. Unlike existing DSGE models, the framework explicitly distinguishes between cash-based and accrual-based bank profits, allowing accounting profits generated under forbearance to affect balance-sheet dynamics even in the absence of cash inflows.

The newly created liquidity enters the economy through income and profit channels. Working households (type L) receive labor income and use deposits

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for transaction purposes, while passive households (type H) receive profit distributions from firms and banks and accumulate time deposits. Since cosmetic loan restructuring sustains bank profitability at the accounting level, a disproportionate share of bank-created liquidity is transferred to profit-receiving households, generating an endogenous concentration of liquidity on the liability side of banks' balance sheets.

To quantify this mechanism, the model introduces a liquidity distribution index measuring the share of total time deposits held by passive households. The evolution of this index reflects banks' forbearance decisions and associated profit flows, providing a structural measure of how real and financial shocks propagate through bank balance sheets to affect liquidity distribution.

Although the model is general in structure, several key assumptions are deliberately chosen to reflect institutional characteristics of the Iranian economy. First, the explicit modeling of cosmetic loan forbearance captures the widespread rollover of non-performing loans under weak supervisory enforcement and limited balance-sheet transparency, while simultaneously incorporating the balance-sheet implications of administered lending (Tashilat Taklifi)**,** which mainly materialize through delayed default recognition and persistent loan rollover rather than immediate credit expansion. Second, the distinction between transaction-constrained households (L) and passive profit-receiving deposit holders (H) reflects the highly concentrated structure of bank deposits**.** Third, the passive treatment of fiscal policy is consistent with the dominant role of bank balance-sheet mechanisms, rather than fiscal channels, in shaping liquidity dynamics in Iran. Finally, the focus on accrual-based bank profits under loan restructuring captures an environment in which accounting profits may persist despite weak cash flows, allowing liquidity to accumulate without a corresponding expansion in real activity. Together, these features ensure a structurally meaningful representation of liquidity creation and distribution in the Iranian banking system.

The remainder of this section details the behavior of individual agents and the equilibrium structure of the model within a standard New Keynesian DSGE environment.

4.1 Households

The household sector follows a standard New Keynesian DSGE structure with capital accumulation, investment adjustment costs, and a cash-in-advance constraint, as in Tavakolian et al. (2023).

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In contrast to representative-household DSGE models—where bank profits and newly created deposits are immediately absorbed by consumption and investment decisions and therefore generate no persistent distributional effects—the model introduces a two-household structure to capture endogenous liquidity distribution.

Households are divided into transaction-constrained workers (Household L) and passive profit-receiving deposit holders (Household H). Household L participates in goods and labor markets, supplies labor, makes consumption and investment decisions, and is subject to a cash-in-advance constraint. Household H does not participate in goods or labor markets and does not solve an intertemporal optimization problem; instead, it passively receives profit distributions from firms and banks and accumulates these income flows in bank deposits according to accounting identities.

This separation allows bank profits generated through loan restructuring and balance-sheet expansion to be transformed into non-transactional deposits, rather than being immediately recycled into spending. As a result, the model can generate persistent deposit accumulation and endogenous liquidity concentration while preserving the aggregate properties of the baseline DSGE framework. Aggregate household variables are defined as the sum of the corresponding variables across the two household types.

4.1.1 Household L (Workers and Cash Users)

Household L has an infinite lifetime and maximizes expected utility derived from consumption C_t, labor supply L_t, and real money balances $\frac{M_t}{P_t}$. Preferences exhibit external habit formation in consumption. The utility function is given by:

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

Equation (1) defines the consumer's objective function, maximizing utility based on current and future consumer preferences.

$$Y_t = C_t + I_t \quad (2)$$

Equation (2) represents the resource constraint, stating that total output is allocated to consumption and investment.

$$I_t = K_t - (1 - \delta) K_{t-1} \quad (3)$$

Equation (3) specifies how capital is updated over time.

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$$Y_t = \frac{Z_t f(K_t.L_t)}{L_t} = \frac{Z_t K_t^{\alpha} L_t^{1-\alpha}}{L_t} = Z_t K_t^{\alpha} L_t^{-\alpha} = \frac{ZK^{\alpha}{}_t}{L^{\alpha}{}_t} = Zk_t^{\alpha} \quad (4)$$

Equation (4) represents the productivity of factors of production.

$$k_t = Zk_t^{\alpha} + (1-\delta)k_{t-1} - c_t \quad (5)$$

Equation (5) shows how household capital changes over time.

Total factor productivity evolves as:

$$\ln(Z_t) = \rho \ln(Z_{t-1}) + \varepsilon_t \quad (6)$$

4.1.2 Household L Budget Constraint

In the presence of capital accumulation and capital utilization, the real budget constraint of Household L is given by

$$c^L{}_t + m^L{}_t + b^L{}_t + i_t = w_t L_t + \frac{m^l{}_{t-1}}{(1+\pi_t)} + (1 + \mathrm{i}i_{t-1}) \frac{b^L{}_{t-1}}{(1+\pi_t)} + (\frac{r_t^k k_{t-1} A_t}{(1+\pi_t)} - \frac{\psi(A_t) k_{t-1}}{(1+\pi_t)}) \quad (7)$$

where $c^L{}_t$ denotes consumption of Household L, $m^L{}_t$ represents real money balances, $b^L{}_t$ denotes real demand deposits held at commercial banks, and I_t is investment. w_t is the real wage rate and $L_t$denotes labor supply. Π_t represents gross inflation and n is production growth rate. i_{t-1} is the nominal interest rate on deposits. k_{t-1} denotes the capital stock inherited from the previous period, r_t^k is the rental rate of capital, and A_t represents the capital utilization rate. The function $\psi(A_t)$ captures the cost of capital utilization.

Capital accumulation follows

$$k_t = (1-\delta)k_{t-1} + I_t \left[1 - s\left(\frac{I_t}{I_{t-1}}\right)\right] \quad (8)$$

where δ is the depreciation rate and s(·) represents investment adjustment costs.

Equation (9) implies that Household L must use liquid balances to purchase goods, with no credit or borrowing allowed. Cash holdings are financed by carryover deposits, labor income, and withdrawals from time deposits at commercial banks.

Based on this condition, the cash-in-advance constraint for Household L is written as

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$$P_t {C^L}_t = {B^L}_{t-1} + W_t L_t + {M^L}_t - T_t \quad (9)$$

where P_t denotes the price level, ${C^L}_t$ is consumption of Household L, ${B^L}_{t-1}$ represents demand deposits carried over from the previous period, W_t is the nominal wage rate, L_t denotes labor supply, ${M^L}_t$ indicates withdrawals from time deposits used to finance consumption expenditures, and T_t denotes lump-sum taxes.

The cash-in-advance constraint in equation (9), together with the associated deposit dynamics in equations (10)–(12), follows Fernandez-Corugedo et al. (2011).

4.1.3 Deposit Dynamics

Investment (time) deposits of Household L evolve as:

$${D^L}_t = {D^L}_{t-1}\left(1 + i^d_{t-1}\right) - {M^L}_t \quad (10)$$

Time deposits held by Household L function purely as a liquidity buffer under the cash-in-advance constraint. Interest income is offset by consumption-related withdrawals, so Household L does not accumulate interest-bearing wealth, and persistent deposit accumulation is structurally attributed to Household H.

In this equation, ${B^L}_{t-1}$ and $W_t L_t$ denote, respectively, the demand deposits carried over from period t−1 and the labor income of Household L, earned from supplying labor to intermediate-goods-producing firms. Household L then withdraws an amount ${M^L}_t$ from its time deposit account and transfers it into its demand deposit account in order to finance consumption expenditures. In this expression, P_t denotes the consumer price index (CPI), W_t is the nominal wage rate, and T_t represents the labor income tax per unit of labor supplied by Household L, which is treated as part of this household's expenditures.

$${B^L}_t = {B^L}_{t-1} + W_t L_t + {M^L}_t - T_t - P_t {C^L}_t \quad (11)$$

Combining the above constraints yields:

$$P_t {C^L}_t \le W_t L_t + {D^L}_{t-1}\left(1 + i^d_{t-1}\right) + {D^L}_t - T_t \quad (12)$$

Household L can hold time deposits, but these are solely for liquidity management under the cash-in-advance constraint. L does not accumulate interest-bearing wealth. Persistent bank deposit accumulation is attributed exclusively to Household H, introduced to model endogenous liquidity

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concentration. The corresponding first-order conditions are reported in Appendix E.

4.1.4 Household H (Profit Receivers and Savers)

Household H is modeled as a passive residual claimant that receives profit distributions from banks and firms. It does not participate in goods or labor markets and is therefore not subject to the cash-in-advance constraint.

Its income consists of:

- bank profits Π_t^b,
- a fraction ϑ of intermediate-goods firms' profits Π_t^f
- capital-goods firms' profits Π_t^k.

All received profits are fully and directly accumulated in interest-bearing time (investment) deposits.

Rather than solving an intertemporal optimization problem, Household H's behavior is governed by accounting identities that track the evolution of its deposit holdings. This specification ensures that the specific streams of profits allocated to this household—namely all banking profits, all capital goods profits, and the designated fraction of intermediate goods profits—are endogenously absorbed into time deposits. This mechanism maintains consistency between the sectoral income flows and the balance sheet structure of the economy, ensuring that the profit distributions characteristic of a bank-centric system is systematically reflected in the deposit structure."

The fundamental role of Household H is to absorb income flows generated by the banking sector's balance-sheet operations, particularly those stemming from loan restructuring and accrual-based profit recognition under forbearance. When banks roll over non-performing loans, accounting profits emerge without corresponding cash inflows. These profits cannot be absorbed by transaction-constrained households (L) without impairing the liquidity distribution channel. Therefore, Household H is introduced as a passive agent to ensure bank-generated income is efficiently transformed into time deposits, allowing the observed concentration of liquidity to arise endogenously rather than mechanically.

$$D^H{}_t = D^H{}_{t-1}\left(1 + i^d_{t-1}\right) + \Pi_t^b + \vartheta\Pi_t^f + \Pi_t^k \tag{13}$$

The accounting-based deposit accumulation rule in equation (13) follows Fernandez-Corugedo et al. (2011).

$D^H{}_t$ represents Household H's time deposits at time t. It is purely accounting-based, not participating in consumption, labor, investment or transaction deposits. Its role is to ensure consistency between aggregate

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income and the balance sheet, allowing deposit distribution to evolve endogenously.

In empirical terms, Household H represents large-scale depositors and institutional owners (e.g., holding companies and pension funds) whose income primarily consists of financial returns. These agents recycle profits directly into time deposits and do not participate in goods or labor markets. Modeling Household H passively enables the DSGE framework to isolate the liquidity concentration mechanism observed in Iran, where a small fraction of wealthy depositors holds a disproportionately large share of total time deposits.

4.1.5 Aggregation and Liquidity Distribution

Aggregate deposits in the banking system consist of demand (transaction) deposits and time deposits. Given the household structure described above, aggregate time deposits are defined as:

$$D_t = D_t^L + D_t^H \tag{14}$$

while aggregate demand deposits are given by:

$$B_t = B_t^L \tag{15}$$

since Household H does not participate in goods-market transactions and therefore does not hold transaction deposits.

To quantify the endogenous distribution of bank-created liquidity across deposit holders, we define the following liquidity distribution index:

$$\omega_t{}^H = \frac{D_t^H}{D_t^H + D_t^L} \tag{16}$$

This household structure ensures that changes in the distribution of bank deposits are driven by banking-sector balance-sheet dynamics, rather than by exogenous heterogeneity in preferences or endowments. Loan forbearance and accrual-based profit recognition expand bank liabilities in the form of time deposits, which are endogenously absorbed by Household H. At the same time, transaction-constrained households use deposits purely for liquidity purposes and do not accumulate interest-bearing wealth.

As a result, movements in the liquidity distribution index $\omega_t{}^H$ directly reflect the interaction between bank behavior, profit flows, and deposit accumulation, providing a structural and model-consistent measure of liquidity concentration. This index captures the extent to which bank-created liquidity is concentrated in non-transactional deposits, consistent with the

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liquidity-hoarding mechanism emphasized in the endogenous money literature.

Here, D_t^H denotes time deposits held by Household H, while D_t^L represents time deposits held by optimizing households subject to liquidity needs. An increase in ${\omega_t}^H$ indicates a higher concentration of bank-created liquidity among passive, high-income deposit holders and a corresponding impairment in liquidity circulation.

This modeling approach is consistent with empirical evidence for Iran, where a small fraction of depositors holds a disproportionately large share of bank deposits. Household H is interpreted as a representative large-scale depositor whose deposit share evolves endogenously in response to shocks and loan forbearance mechanisms. Quantitatively, the impulse response functions of ${\omega_t}^H$ are used to assess the impact of these forces on liquidity distribution and, ultimately, social welfare.

4.2 Final-Goods-Producing Firm

There exists a representative firm that purchases intermediate goods indexed by j and produces the final good using a Dixit–Stiglitz (1977) aggregator, as follows:

$$Y_t = \left[\int_0^1 \omega_j^Y Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}}\, dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{17}$$

In this expression, $Y_t(j)$ denotes intermediate good j, ε is the constant elasticity of substitution among intermediate goods, and ω_j^Y represents the weight of differentiated goods in the production of the final good Y. The weight ω_j^Y represents a firm-specific efficiency or quality component in the aggregation of intermediate goods into final output, capturing heterogeneity in the effective contribution of differentiated goods to production due to persistent differences in productivity or input quality. The weight ω_j^Y follows the weighted Dixit–Stiglitz formulation in Hristov and Hülsewig (2017).

The objective of the final-goods-producing firm is to choose the quantities of intermediate goods so as to maximize its profit. Accordingly, the firm's optimization problem can be written as follows:

The representative final goods firm operates under perfect competition and chooses the quantities of intermediate goods $Y_t(j)$ so as to minimize total production cost subject to the aggregation technology in equation (17), the demand function (18) follows.

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$$Y_t(j) = \omega_j^Y \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} Y_t \tag{18}$$

Equation (18) indicates that the demand for each intermediate good depends negatively on its relative price and positively on aggregate output. The condition ε>1 also has its usual interpretation in this setting: ε>1 implies that monopolistically competitive firms operate on the elastic portion of the demand curve.

The demand for intermediate good j is a function of its relative price, $P_t(j)$ —that is, its price relative to the price of the final good—as well as final-goods output and technological productivity. Imposing the zero-profit condition for the final-goods-producing firm, the price index of the final good is given by:

$$P_t = \left[\int_0^1 \omega_j^Y P_t(j)^{1-\varepsilon}\, d_j\ \right]^{\frac{1}{1-\varepsilon}} \tag{19}$$

Under zero profits in the perfectly competitive final goods sector, the price index P_t corresponds to the minimum unit cost of producing one unit of final output.

weight ω_j^Y is time-invariant and captures cross-sectional heterogeneity across intermediate goods producers. While ω_j^Y itself exhibits no intrinsic dynamics, it conditions the distribution of firms' cash flows and debt-servicing capacity, thereby interacting with banking frictions to endogenously determine default and loan forbearance thresholds over the business cycle.

4.3 Intermediate-Goods-Producing Firms

4.3.1 Production Function

A continuum of intermediate-goods-producing firms with infinite lifetimes operates under monopolistic competition. The production technology of firm j is given by:

$$Y_{j,t} = Z_{j,t} K^{\alpha}{}_{j,t-1} L_{j,t-1}^{1-\alpha} \tag{20}$$

To produce output $Y_{j,t}$, firms hire labor input from households and purchase capital input $K_{j,t-1}$ from capital-goods-producing firms. Firm- level productivity $Z_{j,t}$ is decomposed into an aggregate component and an idiosyncratic component, as follows:

$$Z_{j,t} = \omega_j^Y Z_t \tag{21}$$

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Aggregate productivity Z_t follows a first-order autoregressive process:

$$lnZ_t = \rho\ lnZ_{t-1} + \varepsilon_t \qquad \varepsilon \sim (0, \partial_Z^2) \tag{22}$$

where ε_t denotes an exogenous aggregate technology shock and ρ governs the persistence of productivity over time.

The idiosyncratic productivity term ω_j^Y is time-invariant and captures cross-sectional heterogeneity across firms. It is drawn from a continuous uniform distribution defined over the interval $\left[\underset{\sim}{\omega^Y}, \overline{\omega^Y}\right]$, (Agénor et al., 2014) with unit mean:

$$\omega_j^Y \sim uniform\left[\underset{\sim}{\omega^Y}, \overline{\omega^Y}\right] \qquad E\left[\omega_j^Y\right] = 1 \tag{23}$$

This specification preserves the standard production structure commonly used in DSGE models. Aggregate technology shocks affect all firms exclusively through Z_t, while ω_j^Y governs how these shocks translate into heterogeneous output realizations, profitability, and cash-flow positions across firms.

Importantly, ω_j^Y does not constitute an independent source of shocks and does not exhibit intrinsic dynamics. Instead, it conditions the cross-sectional distribution of firms' debt-servicing capacity under aggregate disturbances. As a result, ω_j^Y plays a crucial role in determining default and loan-forbearance cutoffs in the bank–firm debt contract derived below, without altering firms' underlying production technology.

A negative aggregate technology shock reduces firms' productive capacity and operating profits, thereby weakening their ability to meet scheduled debt-service obligations.

Default risk therefore rises endogenously, prompting banks to decide between default recognition and cosmetic loan forbearance, as formalized in the subsequent sections.

4.3.2 The Bank–Debt Contract

The debt contract is a modified Costly State Verification (CSV) framework (Townsend, 1979), which incorporates two central institutional features: installment-based debt repayment and non-performing loan (NPL) restructuring via loan forbearance.

Established at t-1 under accrual accounting, interest income is recognized when accrued, irrespective of cash payment realization. At time t, if a firm

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fails its scheduled installment, the bank faces a discrete institutional choice: enforce default (asset seizure) or grant forbearance (reschedule NPLs).

Forbearance permits the contractual relationship to continue even without contemporaneous cash repayments. Consequently, outstanding debt is rolled over and remains on the balance sheet, with interest income continuing to accrue. This institutional feature is key, as it causes accounting profits to diverge from realized cash flows.

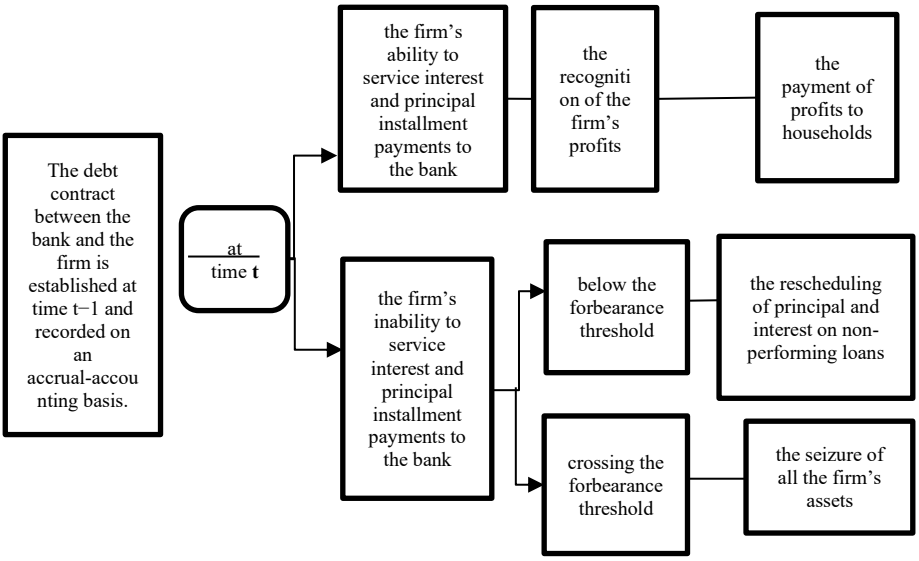

Figure 3. The Bank–Firm Contract
Source: Amirali (2023)

Figure 3 illustrates the timing and structure of the bank–firm contract, highlighting the distinction between installment default and loan forbearance. The figure serves as an institutional prerequisite for the mechanisms analyzed in subsequent sections, rather than a description of liquidity distribution itself.

4.3.3 Determination of the Default Cutoff for Debt Service Installments

Default on the firm's scheduled principal and interest installments occurs when, at time t, the revenues generated from production are insufficient to meet the firm's contractual debt service obligations after accounting for wage payments and price adjustment costs. This condition is defined as follows:

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$$P_t Z_{j,t} K^{\alpha}{}_{j,t-1} L_{j,t-1}^{1-\alpha} - W_t L_{j,t} - PAC_{j,t} < \left(\Phi_d + i_{t-1}^{l}\right) DEBT_{j,t-1} \tag{24}$$

$DEBT_{j,t-1}$, $\Phi_d \epsilon (0,1)$, i_{t-1}^{l}, $PAC_{j,t}$ denote, respectively, the firm's total outstanding debt to the bank, the fraction of debt installments that are due relative to total debt, the loan interest rate, and the price adjustment cost. The parameter Φ_d captures the contractual installment structure of corporate debt and determines the fraction of outstanding principal that becomes due in each period.

Accordingly, the term $\left(\Phi_d + i_{t-1}^{l}\right) DEBT_{j,t-1}$ represents total debt service (principal installment plus accrued interest) that must be repaid in period t.

Following Ireland (2007), prices are assumed to be indexed to long-run inflation and lagged inflation. Accordingly, the price adjustment cost is defined as follows:

$$PAC_{j,t} = \frac{\theta}{2}\left(\frac{P_{j,t}}{P_{j,t-1}\left(\Pi_{t-1}^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{1-\mu}} - 1\right)^2 P_t Y_t \tag{25}$$

In this equation, θ, Π, $x \in [0,1]$, $\mu \in [0,1]$ denote, respectively, the degree of price stickiness, the gross inflation rate, the degree of price indexation, and the weight of indexation to past inflation.

Accordingly, the cutoff point between default and non-default is determined as a function of the idiosyncratic shock, as follows:

$$\widetilde{\omega}_t^{Y} = \frac{W_t L_t + PAC + \left(\Phi_d + i_{t-1}^{l}\right) DEBT_{t-1}}{P_t Z_t K^{\alpha}{}_{t-1} L_{t-1}^{1-\alpha}} \tag{26}$$

The probability of installment default (characterized by the cutoff $\widetilde{\omega}_t^{Y}$ rises when the firm's costs—including debt service, wages, and price adjustment costs—increase, or when production declines.

Crucially, this cutoff defines default solely from the firm's cash-flow perspective and is determined entirely by real production conditions and contractual debt obligations. The bank remains passive at this stage; $\widetilde{\omega}_t^{Y}$ serves merely as a sufficient statistic summarizing the financial distress faced by firms after real shocks.

The banking sector's active role begins only after installment default occurs, when banks make the subsequent institutional decision to either enforce default or grant loan forbearance. Thus, the default cutoff constitutes a necessary input into the bank's decision, but not a substitute for it.

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4.3.4 Determination of the Forbearance Cutoff for Non-Performing Loans

Following a firm's installment default due to insufficient cash flows (as defined in Section 4.3.3), banks decide whether to recognize default and liquidate assets or to grant forbearance. Crucially, this institutional decision is governed by a balance-sheet solvency criterion, not the firm's contemporaneous cash flow repayment capacity.

The bank applies a rule-based process: forbearance is granted only if the recoverable value of the firm's pledgeable assets exceeds the total contractual value of its outstanding liabilities recorded on an accrual basis.

To formally derive this solvency threshold, we introduce the idiosyncratic capital valuation factor ($\omega_{j,t}^{k}$). This factor captures *ex-post* uncertainty in collateral recovery upon liquidation—it is not a structural shock—and is used solely to determine the forbearance cutoff in a tractable manner.

The capital valuation factor is assumed to be independently and uniformly distributed over the interval

$$\omega_j^k \sim uniform\left[\underset{\smile}{\omega^k}, \overline{\omega^k}\right] \qquad E\left[\omega_j^k\right] = 1 \tag{27}$$

Accordingly, the condition for loan forbearance is given by:

$$P_t Y_{j,t} - W_t L_{j,t} - PAC_{j,t} + p_t^k(1-\delta)\omega_{j,t}^k k_{j,t-1} \geq \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1} \tag{28}$$

Condition (28) represents a solvency-based balance sheet constraint from the bank's perspective and should not be interpreted as a cash-flow repayment condition. While default on matured installments is triggered by insufficient operating cash flows in Section 4.3.3, banks evaluate loan rollover and restructuring decisions based on the total contractual value of outstanding debt recorded on an accrual basis.

When condition (28) is satisfied, the bank grants cosmetic forbearance, carries forward the non-maturing principal balance, and rolls over the matured installment into the total outstanding debt according to:

$$DEBT_{j,t} = (1-\Phi_d) DEBT_{j,t-1} + \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1} = (1 + i_{t-1}^l) DEBT_{j,t-1} \tag{28′}$$

If this condition is violated, the bank recognizes default and liquidates the firm's assets.

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The cutoff threshold for loan forbearance on non-performing loans—defined as the value of the capital valuation factor that renders condition (28′) binding—is given by:

$$\widetilde{\omega}_t^{k,BS} = \frac{W_t L_t + PAC + (\Phi_d + i_{t-1}^l) DEBT_{t-1} - P_t Y_t}{p_t^k (1-\delta) k_{t-1}} \tag{29}$$

While equation (29) characterizes the balance-sheet based forbearance cutoff that would arise under purely economic considerations, actual loan rollover decisions may be systematically biased in the presence of institutional constraints. In banking systems characterized by administered lending and government-directed credit programs—such as Iran—banks often face implicit or explicit pressure to delay loss recognition and continue rolling over non-performing loans, even when liquidation would be optimal from a purely balance-sheet perspective.

$$\widetilde{\omega}_t^k = \widetilde{\omega}_t^{k,BS} - x_\tau \tau_t \tag{30}$$

where $\widetilde{\omega}_t^{k,BS}$ is the economically optimal forbearance threshold implied by bank solvency, while $x_\tau \tau$ captures non-economic institutional pressure from administered lending (*Tashilat Taklifi*) that lowers the effective cutoff and increases the likelihood of cosmetic loan rollover.

If $\omega_{j,t}^k \geq \widetilde{\omega}_t^k$, the firm remains solvent on a balance-sheet basis and the bank grants loan forbearance. While higher outstanding debt or weaker real conditions increase the balance-sheet cutoff, the effective forbearance threshold applied by banks may be relaxed in the presence of administered lending. In particular, institutional pressure associated with directed credit programs lowers the solvency standard required for rollover, increasing the probability of cosmetic loan forbearance and delaying default recognition, even when liquidation would be optimal under purely economic considerations.

The probability of a firm's debt being forborne is derived analytically from the bank's forbearance cutoff under the assumed distribution, and is illustrated schematically in the following figure.

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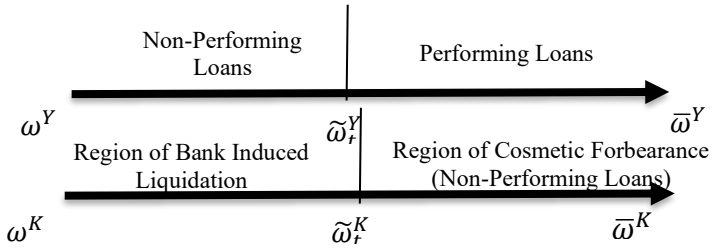

Figure 4. Schematic Representation of Firm Default and Bank Forbearance Cutoffs
Source: Research Findings

Based on Figure 4, firms are categorized into two broad groups according to their cash-flow condition $\widetilde{\omega}_t^Y$: those capable of meeting debt obligations (performing firms) and those unable to repay (non-performing firms). The probabilities associated with these states sum to one.

Furthermore, the bank's follow-up decision—whether to grant forbearance or proceed with liquidation—is governed by a separate collateral-based cutoff $\widetilde{\omega}_t^K$, reflecting the balance-sheet solvency criterion rather than short-term repayment capacity.

The density function $f(\omega_t^Y)$ denotes the probability density of the idiosyncratic firm-level productivity term, which is assumed to be continuously and uniformly distributed across firms. Following Hristov and Hülsewig (2017), the use of integrals reflects the continuum of heterogeneous firms in the economy and allows the computation of the probability mass associated with repayment and default regions defined by the cutoff $\widetilde{\omega}_t^Y$. Since the support of the distribution is fully exhausted by these regions, their associated probabilities jointly sum to unity.

$$\int_{\underline{\omega}^Y}^{\widetilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y + \int_{\widetilde{\omega}_t^Y}^{\overline{\omega}^Y} f(\omega_t^Y) d\omega_t^Y = 1 \tag{31}$$

$$\int_{\underline{\omega}^Y}^{\widetilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y = \int_{\underline{\omega}^k}^{\widetilde{\omega}_t^K} f\left(\omega_t^k\right) d\omega_t^k + \int_{\widetilde{\omega}_t^K}^{\overline{\omega_t}^k} f\left(\omega_t^k\right) d\omega_t^k \tag{32}$$

Combining Equations (31) and (32) yields Equation (33). Equation (33) confirms that the performing, liquidation, and forbearance regions jointly exhaust the entire state space of firms, thereby providing a complete and non-overlapping partition under the assumed continuous distributions.

For firms that default on their scheduled debt-service payments in the first stage, the bank's subsequent decision between cosmetic forbearance and asset seizure depends on the relationship between the firm's total asset value and its

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debt obligation. If the firm's total asset value exceeds its debt obligation, that is,

$$P_t Y_{j,t} - W_t L_{j,t} - PAC_{j,t} + p_t^k(1-\delta)\omega_{j,t}^k k_{j,t-1} > \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1}$$

the firm is economically solvent despite its inability to meet the scheduled payment, and the bank applies cosmetic forbearance by rolling over the unpaid installment and interest and maintaining the debt relationship. In contrast, if the firm's total asset value is less than or equal to its debt obligation, that is,

$$P_t Y_{j,t} - W_t L_{j,t} - PAC_{j,t} + p_t^k(1-\delta)\omega_{j,t}^k k_{j,t-1} \leq \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1}$$

the firm is insolvent, and the bank seizes the firm's assets and terminates the debt relationship. Therefore, cosmetic forbearance and asset seizure are mutually exclusive resolution decisions that apply only to firms that have already defaulted on their scheduled debt-service payments.

$$\int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y} f(\omega_t^Y) d\omega_t^Y + \int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^K} f\left(\omega_t^k\right) d\omega_t^k + \int_{\tilde{\omega}_t^K}^{\overline{\omega_t}^k} f\left(\omega_t^k\right) d\omega_t^k = 1 \tag{33}$$

$$\Phi_t^F = 1 - \int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y} f(\omega_t^Y) d\omega_t^Y - \int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^K} f\left(\omega_t^k\right) d\omega_t^k \tag{34}$$

Equation (34) defines Φ_t^F as the share of bank claims that are neither repaid nor liquidated but instead rolled over through cosmetic forbearance, corresponding to non-performing yet solvent firms.

Generally, a firm's debt to the bank is divided into four categories:

1) Firms that are capable of repaying their debt installments and interest are obligated to settle the remaining installments of their debt, which were determined at time t−1. This debt is structured as follows:

$$\int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y} \left[(1-\Phi_d) DEBT_{j,t-1}\right] f\left(\omega_{j,t}^Y\right) d\omega_{j,t}^Y \tag{35}$$

The integral range encompasses firms that possess the capacity to repay their debt installments and interest to the bank. These firms remit an amount equal to $\Phi_d . DEBT_{j,t-1}$ of their total installments to the bank. Subsequently, an outstanding balance of $(1-\Phi_d) DEBT_{j,t-1}$ remains with the bank, to be settled in future installments.

2) Firms that are unable to repay their debt to the bank, yet their total assets exceed their liabilities. In this scenario, the bank considers implementing

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forbearance on the principal and interest of non-performing loans, which is equivalent to:

$$\left[DEBT_{j,t-1}\left(1-\int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y} f(\omega_t^Y)d\omega_t^Y-\int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^K} f(\omega_t^k)d\omega_t^k\right)\right](1+i_{t-1}^l) \quad (36)$$

3) Firms whose total liabilities exceed their assets, leading to the termination of the relationship between the bank and the firm.
4) Loans obtained in period t, for which new liquidity has been deposited into the firm's account.

4.3.4.1 Debt Accumulation and Liquidity Creation Channel

The activation of the bank's forbearance rule implies that maturing firm debts are not settled but instead rolled over to future periods. As a result, firms' outstanding debt gradually accumulates on banks' balance sheets. Since banks must maintain balance-sheet consistency between assets and liabilities, persistent forbearance and the associated increase in outstanding loans require corresponding adjustments on the liability side of the bank.

Within the model's framework, these adjustments occur endogenously through liability creation, in the form of deposit expansion and/or increased borrowing from the central bank. In this sense, liquidity creation emerges as a mechanical consequence of balance-sheet adjustment rather than an exogenous policy action.

Conditional on the activation of the forbearance rule (28'), maturing debts are not repaid and are instead rolled over to subsequent periods. Firm-level debt therefore evolves endogenously according to:

$$DEBT_{j,t}=Loan_{j,t}+\int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y}\left[(1-\Phi_d)DEBT_{j,t-1}\right]f(\omega_{j,t}^Y)d\omega_{j,t}^Y+$$
$$\left[DEBT_{j,t-1}\left(1-\int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y} f(\omega_t^Y)d\omega_t^Y-\int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^K} f(\omega_t^k)d\omega_t^k\right)\right](1+i_{t-1}^l) \quad (37)$$

Crucially, equation (37) tracks the remaining stock of outstanding debt on the bank's balance sheet rather than the flow of debt repayment. This stock accumulates at a compounded interest rate, and since the firm's default threshold ($\tilde{\omega}_t^Y$) is an increasing function of its outstanding liabilities, this mechanism amplifies the probability of default in subsequent periods.

At the aggregate level, the commercial banking sector's balance-sheet identity is given by:

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$$D_t + BT_t + BD_t = R_t + DEBT_t \quad (38)$$

where D_t denotes aggregate time deposits, BT_t transaction (demand) deposits held by firms and households, BD_t borrowing from the central bank, R_t required and excess reserves, and $DEBT_t$ the total stock of outstanding firm loans.

While equation (38) establishes the static accounting balance, the transmission of loan expansion into deposit creation is governed by behavioral decisions within the model rather than a purely mechanical identity. Specifically, the endogenous link between $DEBT_t$ and deposit creation operates through two distinct channels:

1. New Loan Origination: Following the post-Keynesian credit-creation mechanism, newly originated working capital loans ($Loan_{j,t}$) are directly credited to firms' transaction accounts (BT_t). As firms disburse these funds for wage payments ($W_t L_t$) and investment outlays, the liquidity flows into the household sector and is dynamically allocated between transaction balances (BT_t) and interest-bearing time deposits (D_t) based on household optimal portfolio decisions and liquidity constraints.
2. Debt Forbearance and Balance-Sheet Closure: When distressed debts are rolled over under cosmetic forbearance (equation 37), the stock of assets compounds. Since previously created deposits are not extinguished through loan repayment, and banks are obligated to service existing interest on time deposits, the bank closes its balance sheet endogenously. The split between deposit growth and central bank borrowing is determined by the bank's first-order optimality conditions regarding deposit rate setting, the cost of central bank standing facilities, and the reserve requirement ratio.

The expansion of deposits is subsequently transmitted to households through their budget constraints. Transaction deposits accrue exclusively to optimizing households (Household L), while newly created time deposits are allocated between Household L and the passive profit-receiving household (Household H), the latter primarily through bank and firm profit distributions. In this way, bank forbearance affects not only aggregate liquidity but also its distribution across deposit holders.

4.3.4.2 Liquidity Creation Transmission Channel to Deposit Distribution

Newly created deposits in the household sector are transmitted to the rest of the economy through households' budget constraints. For Household H (the passive, profit-receiving agent), deposit accumulation is driven exclusively by

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distributed profits and interest earned on time deposits, consistent with its non-participation in labor markets. These profits include bank profits (Π_t^b), capital-goods firms' profits (Π_t^k), and a fraction (ϑ) of intermediate-goods firms' profits ($\vartheta\Pi_t^f$). The model assumes that bank-created liquidity is distributed among heterogeneous households. Specifically, newly created liquidity is channeled into the deposits of Household HHH, in accordance with the accounting identity (39), which is identical to equation (13):

$$D^H{}_t = D^H{}_{t-1}\left(1 + i_{t-1}^d\right) + \Pi_t^b + \vartheta\Pi_t^f + \Pi_t^k \tag{39}$$

This mechanism transmits liquidity changes through payments and withdrawals, affecting the distribution of deposits. The occurrence of a negative productivity shock ($\downarrow\omega_t^Y$) leads to a decline in firms' productivity. This shock reduces firms' cash flow and endogenously leads to an increase in loan forbearance (as defined by Φ_t^F). This sustained forbearance, in turn, expands bank balance sheets (the stock of $DEBT_{j,t}$ increases) and alters the asymmetry of income and profit flows. Consequently, the newly created liquidity is distributed unevenly among deposit holders, primarily accumulating in the accounts of Household H.

Figure 5 illustrates this transmission mechanism for a negative productivity shock. A fall in productivity reduces firms' cash flow and increases loan forbearance. The resulting accumulation of debt expands bank balance sheets and leads to the creation of new liquidity. Although the households may share identical parameters regarding, they differ fundamentally in their decision-making processes: Household L is an optimizing agent, while Household H is a passive holder of deposits.

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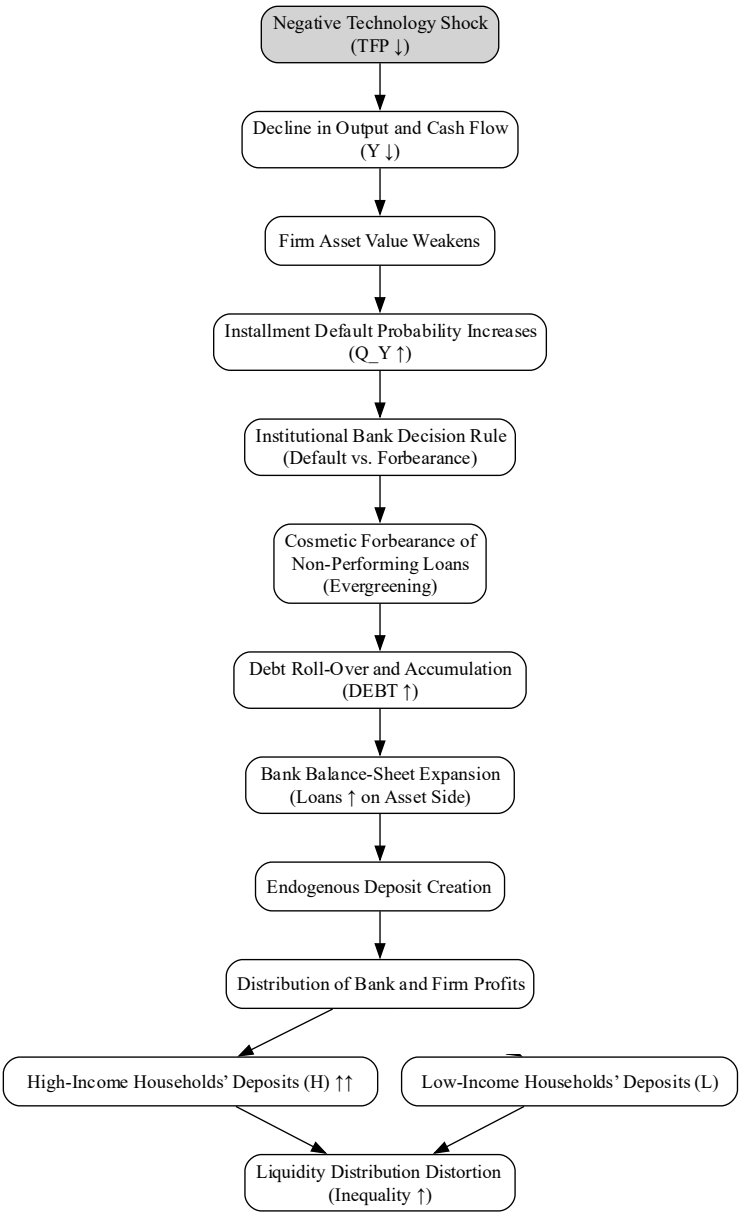

Figure 5. Transmission Mechanism of Productivity Shock to Liquidity Distribution in the Model
Source: Research Findings

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A negative productivity shock reduces firms' output and cash flows, which increases the probability of installment default. Based on an institutional decision rule, banks optimally choose cosmetic forbearance over default recognition as long as firm asset values remain sufficient to cover outstanding liabilities. This policy leads to the rollover and accumulation of non-performing debt, balance-sheet expansion, and endogenous deposit creation. Due to asymmetric profit distribution across banks and firms, newly created liquidity accrues disproportionately to high-income households, resulting in a distortion of deposit distribution and increased liquidity inequality.

4.4 Intermediate-Goods Firms: Profit Function and Optimization

Intermediate-goods firms, indexed by j, are infinitely lived agents operating in a monopolistically competitive environment. Their production decisions are constrained by technological factors (Equations (20) – (23)) and, crucially, by the presence of a debt contract subject to default and forbearance rules (Hristov & Hülsewig, 2017).

A. Conditional Nominal Profit (Equation 40)

The nominal profit of firm j in period t, $\Pi_{j,t}^{f}$, is defined as a piecewise cash flow identity, contingent on the firm's ability to meet its scheduled debt service obligations:

$$\Pi_{j,t}^{f} = \begin{cases} \left[P_{j,t}Y_{j,t} - w_t l_{j,t} - PAC_{j,t} - (\Phi_d + i_{t-1}^{l})DEBT_{j,t-1}\right] & \text{Non} - \text{default} \\ 0 & \text{default} \end{cases} \quad (40)$$

- Non-default State: Cash profit is calculated after deducting operational costs (labor cost $w_t l_{j,t}$ and price adjustment costs $PAC_{j,t}$) and the total debt service obligation (principal installment $\Phi_d + DEBT_{j,t-1}$ plus interest $i_{t-1}^{l}.DEBT_{j,t-1}$).

Default State: In line with the Costly State Verification (CSV) framework, if the firm's cash flow is insufficient, default occurs. The entire cash flow is seized by the bank, and the firm's equity holders receive zero profit ($\Pi_{j,t}^{f}$=0).

B. Intertemporal Profit Maximization (Equation 41)

The firm is forward-looking and maximizes the expected present discounted value of its future profits by optimally choosing its price, capital, and debt level. Since positive profit is only realized in the non-default state, the maximization problem is conditional on the firm's survival, as captured by the integration over the non-default region of the idiosyncratic shock ($\omega_{j,t}^{Y}$):

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$$maxE_0\left[\sum_{t=0}^{\infty}\beta^t\int_{\widetilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^Y}\left[P_{j,t}Y_{j,t}-w_t l_{j,t}-PAC_{j,t}-\left(\Phi_d+i_{t-1}^{l}\right)DEBT_{j,t-1}\right]f\left(\omega_{j,t}^{Y}\right)d\omega_{j,t}^{Y}\right] \quad (41)$$

Integral Bounds: The integration is performed over the range $\int_{\widetilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^Y}\left[\Pi_{j,t}^{f}\right]$, where $\widetilde{\omega}_{j,t}^{Y}$ is the endogenous default cutoff (as defined in Equation (26)). This explicitly incorporates the probability of default into the firm's objective function.

The firm's Cash-in-Advance (CIA) constraint for capital purchases is defined as follows:

$$P_t^k k_{j,t}-(1-\delta)P_t^k k_{j,t-1}+\int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^K}\left[(1-\delta)P_t^k k_{j,t-1}\right]f\left(\omega_{j,t}^{k}\right)d\omega_{j,t}^{k}\leq \left(P_{j,t}Y_{j,t}-w_t l_{j,t}\right)\left[1-\int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^K}f\left(\omega_{j,t}^{k}\right)d\omega_{j,t}^{k}\right]-\int_{\widetilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^Y}\left[\left(\Phi_d+i_{t-1}^{l}\right)DEBT_{j,t-1}\right]f\left(\omega_{j,t}^{Y}\right)d\omega_{j,t}^{Y}-\vartheta\Pi_{j,t}^{f}+Loan_{j,t} \quad (42)$$

The firm's cash-in-advance constraint for capital purchases arises from the timing of cash flows and the structure of the bank–firm debt contract. Since investment decisions must be financed before revenues are realized, firms can only use liquid resources available at the beginning of the period, including surviving operational cash flows and newly created bank credit. Upon liquidation, the bank seizes the firm's assets to satisfy its outstanding debt obligations. The resulting liquidation proceeds are channeled through the banking system, acting as a liquidity source that facilitates the reallocation of capital to productive intermediary firms. Thus, while the distressed firm does not directly utilize these proceeds for its own reinvestment, the process ensures that the economy's capital stock is maintained through the credit channel. This constraint ensures consistency between endogenous loan forbearance, balance-sheet liquidity creation, and firms' capital accumulation decisions.

Differentiating the objective function (41) with respect to constraint (42) will systematically yield the following first-order conditions**:**

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$$\mu_{A,t} = \frac{-\int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} f\left(\omega_{j,t}^{Y}\right) d\omega_{j,t}^{Y}}{\left[\left[1-\int_{\underbrace{\omega^{k}}}^{\tilde{\omega}_{t}^{Y}} f\left(\omega_{j,t}^{k}\right) d\omega_{j,t}^{k}\right]+\left[\vartheta\left(\int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} f\left(\omega_{j,t}^{Y}\right) d\omega_{j,t}^{Y}\right)\right]\right]} \tag{43}$$

$$\mu_{C,t} = \beta \frac{1}{1+\pi_{t+1}}\left(\int_{\tilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}} f\left(\omega_{j,t+1}^{Y}\right) d\omega_{j,t+1}^{Y}\right).\left(\left(\phi_d + i_t^{l}\right)\left(1+\mu_{A,t+1}(1-\vartheta)\right) - \mu_{C,t+1}.(1-\phi_d)\right) - \frac{1}{1+\pi_{t+1}}\beta.\mu_{C,t+1}\left(1 - \int_{\tilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}} f\left(\omega_{j,t+1}^{Y}\right) d\omega_{j,t+1}^{Y} - \int_{\underbrace{\omega^{k}}}^{\tilde{\omega}_{t+1}^{k}} f\left(\omega_{j,t+1}^{k}\right) d\omega_{j,t+1}^{k}\left(1+i_t^{l}\right)\right)\right) \tag{44}$$

$$\int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}}\left(\left[\frac{\omega_{j,t}^{Y}}{P_t}.Y_t\left(\left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon}\right) - \varepsilon.Y_t\left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon-1}\frac{P_t(j)}{P_t}.\frac{\omega_{j,t}^{Y}}{P_t}\right] f\left(\omega_{j,t}^{Y}\right) d\omega_{j,t}^{Y}\right) - \int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} \frac{\theta}{P_t}\left(\frac{P_{j,t}}{P_{j,t-1}\left(\Pi_{t-1}^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{1-\mu}} - 1\right)^{1}\left(\frac{1}{P_{j,t-1}\left(\Pi_{t-1}^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{1-\mu}}\right) Y_t\, f\left(\omega_{j,t}^{Y}\right) d\omega_{j,t}^{Y} - \beta\int_{\tilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}} \theta\frac{\theta}{P_{t+1}}\left(\frac{P_{j,t+1}}{P_{j,t}\left(\Pi_t^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{1-\mu}} - 1\right)^{1}\left(\frac{P_{j,t+1}}{P_{j,t}{}^{2}\left(\Pi_t^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{2(1-\mu)}}\right).Y_{t+1}\, f\left(\omega_{j,t+1}^{Y}\right) d\omega_{j,t+1}^{Y}\left(1 - \mu_{A,t+1}\vartheta\right) = -\mu_{A,t}(1-\vartheta)\left(\left[\frac{\omega_{j,t}^{Y}}{P_t}.Y_t\left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} - \varepsilon.Y_t.\left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon-1}\frac{P_t(j)}{P_t}\frac{\omega_{j,t}^{Y}}{P_t}\right]\right)\int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} f\left(\omega_{j,t}^{Y}\right) d\omega_{j,t}^{Y} - \left(\int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} \frac{\theta}{P_t}\left(\frac{P_{j,t}}{P_{j,t-1}\left(\Pi_{t-1}^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{1-\mu}} - 1\right)^{1}\left(\frac{1}{P_{j,t-1}{}^{2}\left(\Pi_{t-1}^{fe}\right)^{\mu.2}(\bar{\Pi}.fe)^{2.(1-\mu)}}\right).Y_t\right).\int_{\tilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} f\left(\omega_{j,t}^{Y}\right) d\omega_{j,t}^{Y} \tag{45}$$

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$$E.\beta.\alpha.\int_{\widetilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}}\left[\left[\frac{P_{t+1}(j)}{P_{t+1}}\omega_{j,t+1}^{Y}\left(\frac{P_{t+1}(j)}{P_{t+1}}\right)\frac{Y_{t+1}}{k_{j,t}}^{-\varepsilon}\right]f(\omega_{j,t+1}^{Y})d\omega_{j,t+1}^{Y}\right].(1 \quad (46)$$

$$+\mu_{A,t+1}-\mu_{A,t+1}.\vartheta)$$

$$=\mu_{A,t}.p_t^k-E.\beta.\mu_{A,t+1}(1-\delta).p_{t+1}^k.(1$$

$$-\int_{\underset{\sim}{\omega}^{k}}^{\widetilde{\omega}_{t+1}^{k}}\left[\omega_{j,t+1}^{k}K_{j,t}\right]f(\omega_{j,t+1}^{k})d\omega_{j,t+1}^{k}$$

$$+\ E.\beta.\mu_{A,t+1}\alpha\int_{\widetilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}}\left[\left[\frac{\theta}{2.P_{t+1}}\left(\left(\frac{P_{j,t+1}}{P_{j,t}\left(\Pi_t^{fe}\right)^{\mu}(\bar{\Pi}.fe)^{1-\mu}}\right.\right.\right.\right.$$

$$\left.\left.\left.\left.-1\right)^{2}\right)\right]f(\omega_{j,t+1}^{Y})d\omega_{j,t+1}^{Y}\right]\ (\vartheta-1)$$

$$\mu_{A,t}=\frac{1}{(1-\vartheta)} \quad (47)$$

4.4.1 Derivation of Equations Based on the Properties of the Continuous Uniform Distribution

To clarify the modeling of default, liquidation, and loan forbearance, this section derives the key probability expressions implied by the assumed distributions of firm-specific parameters firm-specific parameters. As discussed in earlier sections, heterogeneity in firms' productivity realizations and capital valuations is central to determining repayment capacity and banks' forbearance decisions. These firm-specific variables are assumed to follow continuous uniform distributions with unit mean, defined over the supports $\left[\underset{\sim}{\omega^{Y}},\overline{\omega^{Y}}\right]$, $\left[\underset{\sim}{\omega^{k}},\overline{\omega^{k}}\right]$,, respectively.

Given that the mean and median of a continuous uniform distribution coincide, the supports can be equivalently expressed as $[1-q^{Y},1+q^{Y}]$, $[1-q^{K},1+q^{K}]$. This parametrization allows the model to derive closed-form expressions for default, non-default, liquidation, and cosmetic forbearance probabilities as probability masses associated with well-defined cutoff thresholds. These probabilities exhaust the entire support of the underlying distributions and enter directly into firms' cash-in-advance constraints, banks' balance-sheet identities, and the endogenous liquidity-creation mechanism analyzed in the preceding sections.

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The probability of default on due installments and debt interest, under the continuous uniform distribution with idiosyncratic productivity shock, is as follows:

$$\Phi_t^Y = \int_{\underbrace{\omega^Y}}^{\tilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y = \frac{\tilde{\omega}_t^Y - (1-q^Y)}{(1+q^Y)-(1-q^Y)} = \frac{\tilde{\omega}_t^Y - (1-q^Y)}{2q^Y} \tag{48}$$

Herein, Φ_t^Y corresponds to the probability of default on due installments and debt interest.

The probability of seizure of all the firm's assets, based on the properties of the continuous uniform distribution, is as follows:

$$\Phi_t^K = \int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^k} f\left(\omega_{j,t}^k\right) d\omega_{j,t}^k = \frac{\tilde{\omega}_t^K - (1-q^K)}{(1+q^K)-(1-q^K)} = \frac{\tilde{\omega}_t^K - (1-q^K)}{2q^K} \tag{49}$$

In this equation, Φ_t^K denotes the probability of asset seizure, conditional on the firm having entered the forbearance stage (installment default).

The probability of the firm's non-default on its total debt to the bank is as follows:

$$\Phi_t^N = \int_{\tilde{\omega}_t^Y}^{\overline{\omega^Y}} f(\omega_t^Y) d\omega_t^Y = \frac{-\tilde{\omega}_t^Y + 1 + q^Y}{2q^Y} \tag{50}$$

They are obtained directly from the firm's first-order conditions in equations (43)–(47) after substituting the definitions of the probability terms Φ_t^N, Φ_t^Y, and Φ_t^K derived under the continuous uniform distribution. This step yields closed-form expressions for the corresponding Lagrange multipliers and involves no additional assumptions.

$$\mu_{A,t} = \frac{-\Phi_t^N}{\left[[1-\Phi_t^K]+[\vartheta(\Phi_t^N)]\right]} \tag{51}$$

$$\mu_{A,t+1} = \frac{-\alpha.\beta.\left[\frac{P_{t+1}(j)}{P_{t+1}}\omega_{j,t+1}^Y\left(\frac{P_{t+1}(j)}{P_{t+1}}\right)\frac{Y_{t+1}}{k_{j,t}}^{-\varepsilon}\right].\Phi_{t+1}^N + \left(\mu_{A,t}.p_t^k\right)}{\beta.\alpha.\left[\frac{P_{t+1}(j)}{P_{t+1}}\omega_{j,t+1}^Y\left(\frac{P_{t+1}(j)}{P_{t+1}}\right)\frac{Y_{t+1}}{k_{j,t}}^{-\varepsilon}\right].\Phi_{t+1}^N(1-\vartheta) + (1-\delta).p_{t+1}^k.(1-\omega_{j,t+1}^k K_{j,t})\Phi_{t+1}^K\left[\left[\frac{\theta}{2.P_{t+1}}\left(\left(\frac{P_{j,t+1}}{P_{j,t}\left(\Pi_t^{fe}\right)^{\mu}(\Pi.fe)^{1-\mu}}-1\right)^2\right)\right]\Phi_{t+1}^N(\vartheta-1)\right]} \tag{52}$$

$$\mu_{A,t+1} = -\left(\frac{-\Phi_t^N}{\left[[1-\Phi_t^K]+[\vartheta(\Phi_t^N)]\right]}\right)\frac{p_t^k}{\beta(1-\vartheta)} \tag{53}$$

In this relation, the equation corresponding to cosmetic forbearance on non-performing loans is obtained as follows:

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$$\Phi_t^F = 1 - \Phi_t^N - \Phi_t^K \quad (54)$$
$$\Phi_t^K = 1 + \Phi_t^N \quad (55)$$
$$\Phi_t^F = 1 - \Phi_t^N - 1 - \Phi_t^N \quad (56)$$
$$\Phi_t^F = -2\Phi_t^N \quad (57)$$

Furthermore, Φ_t^N corresponds to the firms that are able to repay their debt to the bank.

Although equation (57) uses the firm-level cash flows obtained after substituting (48)–(50), it is not derived from the firm's optimization problem. It follows from the bank's balance-sheet identity under cosmetic forbearance.

4.5 Capital Goods Producing Firms

Operating within a competitive environment, capital goods producing firms acquire final goods to facilitate the production of new capital. These produced goods are then supplied to intermediate goods producers. The following expression defines the expected nominal profit function for these entities:

$$\max E_0 \sum_{t=0}^{\infty} \frac{\beta^t}{P_t} \{ [\Pi_t^k = p_t^k [K_t - (1-\delta)K_{t-1}] - P_t I_t] \} \quad (58)$$

According to Equation (58), capital goods-producing firms purchase $P_t I_t$ worth of final goods, which they transform into new capital goods after specific modifications. Subsequently, the sale of these capital goods to final goods-producing firms is equivalent to $p_t^k [K_t - (1-\delta)K_{t-1}]$. The capital formation constraint is defined as follows:

$$K_t = (1-\delta)K_{t-1} + I_t - \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t \quad (59)$$

Following Christiano et al. (2005), capital goods-producing firms are assumed to face quadratic adjustment costs in transforming final goods into capital goods, where κ denotes the adjustment cost parameter. By maximizing the profit function, consistent with the aforementioned constraint, the optimal price equation will be calculated as follows:

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$$\frac{1}{p_t^k} = [(1 - \mathrm{k}\left(\left(\frac{I_t}{I_{t-1}} - 1\right).\frac{I_t}{I_{t-1}} + \frac{k}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) + \mathrm{E}.\beta.\frac{p_{t+1}^k}{p_t^k}.\mathrm{k}.\left(\frac{I_t}{I_{t+1}} - 1\right).\left(\frac{I_{t+1}}{I_t}\right)^2] \quad (60)$$

4.6 Banks

Banks are homogeneous and competitive. Profit comes from lending, measured by the lending rate. When a firm defaults but remains asset-rich, cosmetic forbearance occurs: interest on the non-performing loan is added to profit as accrual-based income—no cash inflow, but recorded as continued loan activity. This reflects accounting, not actual cash flow.

Finally, for firms whose total assets are less than their liabilities, all assets are confiscated by the bank. In this case, an amount equivalent to the product of the respective interest rates and their corresponding deposit and borrowing balances is subtracted from the profit function. Their profit function will be defined as follows:

$$\Pi_t^b = \int_{\widetilde{\omega}_t^Y}^{\overline{\omega_t}^Y} i_{t-1}^l DEBT_{t-1} f(\omega_t^Y) d\omega_t^Y + i_{t-1}^l DEBT_{t-1}\left(1 - \int_{\widetilde{\omega}_t^Y}^{\overline{\omega_t}^Y} f(\omega_t^Y) d\omega_t^Y - \int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^k} f(\omega_t^k) d\omega_t^k\right) + \int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^k}[(1-\delta)p_t^k K_{t-1} + P_t Y_t - PAC_t - W_t L_t - DEBT_{t-1}] f(\omega_t^k) d\omega_t^k - i_{t-1}^d D_{t-1} - i_{t-1}^{bd} BD_{t-1} \quad (61)$$

It is important to note that mandatory lending policies do not enter the bank's profit function or balance-sheet constraint directly. Instead, they operate as an institutional wedge that relaxes banks' forbearance thresholds, as defined in equation (30). By lowering the effective liquidation cutoff, mandatory facilities increase the mass of loans subject to cosmetic forbearance, thereby amplifying accrual-based profits and the endogenous expansion of bank deposits captured in equation 61. Through this channel, mandatory lending affects liquidity creation and its distribution without altering the formal structure of banks' optimization problem.

Equation 61 clarifies how bank profits differ across repayment, forbearance, and liquidation regimes. Under cosmetic forbearance, interest on non-performing loans is recorded on an accrual basis without generating cash inflows. Combined with the balance-sheet identity in equation (38), this accounting profit mechanically requires an expansion of bank liabilities through deposit creation. These newly created deposits are then distributed to profit-receiving households (Household H), constituting the central

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transmission channel from loan forbearance to endogenous liquidity concentration.

In this equation, Π_t^b, BD_{t-1} respectively denote the bank's nominal profit and the bank's borrowing from the central bank. The variables i_{t-1}^l, i_{t-1}^d, i_{t-1}^{bd}, represent, respectively, the lending rate, the interest rate on investment deposits, and the interest rate on central bank borrowing.

The first term in the bank's profit function corresponds to interest income generated by firms that are able to fully repay both principal and interest on their debt to commercial banks. The second term reflects purely notional, accrual-based interest income recorded from the forbearance of non-performing loans. The third term captures the seizure of firms' assets by the bank, which leads to the termination of the debt relationship between the firm and the bank. Banks maximize profits subject to the balance-sheet constraint in equation (38).

A key assumption of this framework is that, after creating liquidity through double-entry bookkeeping and in line with the endogenous money creation paradigm, banks first assess their actual reserves and required reserves. They then borrow from the central bank an amount equal to the difference between the two, according to the following relationship.

$$BD_t = rr_b BT_t + rr_d D_t - \left[R_{t-1} - BD_{t-1}\left(1 + i_{t-1}^{bd}\right)\right] \tag{62}$$

Equation 62 determines the bank's borrowing from the central bank to meet its liquidity or reserve requirements, thereby ensuring the balance sheet identity holds.

Equation 62 models bank borrowing (BD_t) from the central bank to meet reserve requirements. Banks create liquidity through lending, and this liquidity is unevenly distributed among households via various income streams. The equation shows that the amount banks borrow depends on demand deposits, investment deposits, and previous period's reserves. This interaction is crucial for maintaining liquidity equilibrium in the banking system. Statutory reserve requirements (rr_b) are fixed, while actual reserves (R_t) fluctuate, necessitating borrowing from the central bank to maintain the required level.

Central bank reserves follow a first-order autoregressive process:

$$\ln(R_t) = (1 - \rho_R)\ln(\bar{R}) + \rho_R \ln(R_{t-1}) - \varepsilon_t^R \qquad \varepsilon_t^R \sim N(0, \sigma^2) \tag{63}$$

where ε_t^R denotes a negative liquidity shock imposed by the central bank. Accordingly, the variation in banks' borrowing from the central bank reflected

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in equation 62 is driven by a liquidity shock to reserves, R_t, rather than by changes in the statutory reserve requirement.

The term in parentheses in equation 62 represents banks' available reserves prior to borrowing from the central bank. Specifically, banks begin period t with reserves equal to R_{t-1}, carried over from the previous period, while an amount equal to $BD_{t-1}\left(1+i_{t-1}^{bd}\right)$ is used to repay outstanding debt to the central bank from the previous period. This mechanism is therefore captured in equation 62.

Consistent with endogenous money creation, a portion of the monetary base is generated ex post. Given the objective function 61 and constraints 62 and 38, the Lagrangian of the problem is formulated as follows:

$$L = \max E_t \Bigg[\sum_{t=0}^{\infty}\beta^t\Big(\int_{\widetilde{\omega}_t^Y}^{\overline{\omega_t}^Y} i_{t-1}^l \frac{debt_{t-1}}{(1+\pi_t)} f(\omega_t^Y)d\omega_t^Y + i_{t-1}^l \frac{debt_{t-1}}{(1+\pi_t)}\Big(1 - \int_{\widetilde{\omega}_t^Y}^{\overline{\omega_t}^Y} f(\omega_t^Y)d\omega_t^Y - \int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^k} f\left(\omega_t^k\right)d\omega_t^k\Big) + \int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^k}\Big[\frac{(1-\delta)}{(1+\pi_t)}p_t^k K_{t-1} + Y_t - pac_t - w_t L_t - \frac{debt_{t-1}}{(1+\pi_t)}\Big] f\left(\omega_t^k\right)d\omega_t^k - i_{t-1}^d \frac{d_{t-1}}{(1+\pi_t)} - i_{t-1}^{bd}\frac{bd_{t-1}}{(1+\pi_t)}\Big) + E_t\lambda_t\beta^t\Big[d_t + bt_t + bd_t - \frac{R_t}{P_t} - debt_t\Big] + E_t\mu_t\beta^t\Big[rr_b bt_t + rr_d d_t - \Big[\frac{R_{t-1}}{(1+\pi_t)} - \frac{bd_{t-1}}{(1+\pi_t)}\left(1 + i_{t-1}^{bd}\right)\Big] - bd_t\Big]\Bigg] \quad (64)$$

After taking derivatives, the first-order conditions with respect to debt, time deposits, banks' indebtedness to the central bank, and demand deposits, respectively, are given by:

$$\lambda_t = \frac{\beta i_t^l[Q_{t+1}^N + Q_t^F - Q_t^k]}{(1+\pi_{t+1})(1+n)} \quad (65)$$

$$i_t^d = \frac{(1+\pi_{t+1})}{\beta} \quad (66)$$

$$\mu_t = \frac{\frac{\beta i_t^d}{(1+\pi_{t+1})}\lambda_t}{rr_d} \quad (67)$$

$$i_t^d = \frac{(1+\pi_{t+1})(1+n)}{\beta} - 1 \quad (68)$$

The banking first-order conditions jointly determine lending and deposit rates and the shadow value of balance-sheet constraints. Combined with accrual-based profits from loan forbearance (Π_t^b), these mechanisms shape households' budget constraints and liquidity positions. Cosmetic forbearance expands bank liabilities through deposit creation that is asymmetrically

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allocated to profit-receiving households (Household H), thereby tightening the cash-in-advance constraint of active households (Household L). Through this liquidity-distribution channel, banking frictions affect consumption and labor supply, and social welfare is therefore evaluated using the utility of Household L.

4.7 Government

The government finances its expenditures through tax revenues and borrowing from the central bank. Its real budget constraint is given by:

$$g_t = T_t + gd_t - \frac{gd_{t-1}}{1+\pi_t} \tag{69}$$

where g_t denotes real government expenditures, T_t represents tax revenues, and gd_t is real government borrowing from the central bank. Inflation, π_t, erodes the real value of outstanding government debt carried over from the previous period.

Government revenues consist of proportional income taxes and central bank financing. Tax revenues are assumed to depend linearly on aggregate output:

$$T_t = t.Y_t \tag{70}$$

where t denotes a constant income tax rate and Y_t is aggregate output.

In this setup, fiscal policy is passive. Government borrowing from the central bank adjusts endogenously to satisfy the budget constraint and serves as a balance-sheet closure mechanism rather than an independent policy instrument.

4.8 Market Clearing Conditions

The goods market clearing condition is given by:

$$Y_t = C_t + I_t + G_t + pac_t \tag{71}$$

where C_t denotes aggregate consumption by liquidity-constrained households (Household L), I_t is aggregate investment, G_t represents government expenditures, and pac_t captures aggregate price adjustment costs incurred by intermediate-goods-producing firms.

Since passive households (Household H) do not participate in goods markets, bank-created deposits and profits distributed to them do not translate into contemporaneous goods demand. As a result, endogenous liquidity

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creation affects the economy through balance-sheet and liquidity-distribution channels rather than directly through aggregate demand.

5 Model Solution and Analysis of Results

5.1 Calibration

The model faces two exogenous shocks: a negative legal reserve (monetary/credit tightening) and a negative technology shock (lower productivity). Total factor productivity is exogenous; central bank reserves are a policy tool. Parameters are calibrated in three categories

1. Standard literature values
2. Iranian macroeconomic data (2005–2023) to match institutional features
3. Estimated stochastic processes for persistence and volatility

The calibration results for the model are presented in Tables 1 and 2.

Table 1

Key Variables of the Model in the Steady State

Source	Value	Symbol	Variable
Solving the steady-state	0.16	y	Output
The assumption of working one-third of a day	0.33	l	Working Hours
Central Bank of the Islamic Republic of Iran	0.35	$\frac{k}{y}$	The Ratio of Physical Capital to Output
Central Bank of the Islamic Republic of Iran	0.16	$\frac{G}{y}$	The Ratio of Government Expenditures to Output
Central Bank of the Islamic Republic of Iran	0.44	$\frac{c}{y}$	The Ratio of Private Consumption to Output
Solving the steady-state	0.29	i_{bd}	Interbank Market Interest Rate and Banks' Overdrafts from the Central Bank
Solving the steady-state	0	Π^f	Profits of intermediate-goods-producing firms
Solving the steady-state	0.26	i_d	Deposit Interest Rate
Authors' calculations based on official Majles Research Center and Central Bank of the Islamic Republic of Iran	0.146	τ	Share of Administered (Directed) Loans in Total Bank Credit
Solving the steady-state	0.5	Q_Y	Bank loan interest rate

Source: Research findings

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Table 2
Calibrated Parameters

Source	Value	symbol	Parameter
Rahmani and Fallahi (2019)	0.99	β	Time Discount Rate
Nakhli et al (2020)	0.4	α	Production Elasticity with Respect to Capital
Nasiri et al. (2023)	1.2	σ	Relative Risk Aversion Coefficient
Nasiri et al. (2023)	2.45	b	Inverse Interest Elasticity of Demand for Real Money Balances
Central Bank of the Islamic Republic of Iran (n.d.)	0.02	n	Production Growth Rate
Rahmani and Fallahi (2019)	0.1	rr_d	Reserve Requirement Ratio for Time Deposits
Optional	0.6	rr_b	Reserve Requirement Ratio for Demand Deposits
Amirali et al. (2023)	0.72	ρ_Z	Autoregressive Coefficient of the Productivity Process
Authors' empirical estimation	0.98	ρ_R	Autoregressive Coefficient of the Required Reserve Process
Parvin et al. (2014)	4.26	$\theta\theta$	Price Adjustment Cost
Amirali et al. (2023)	1	$\emptyset_d$	Percentage of Matured Installments from Total Debt in Each Period
Nakhli and Khodadadi (2025)	0.0103	δ	Capital Depreciation Rate
Calibrated (consistent with Vaziri et al. (2023) VAR evidence)	2.74	x_τ	Policy Wedge Intensity of Administered Lending
Central Bank of the Islamic Republic of Iran (n.d.)	0.25	π	Average Inflation Rate

Note. Compiled by the authors based on the sources reported in the table, including the studies listed in the References and Central Bank of the Islamic Republic of Iran.

The model uses parameters like risk aversion, real money demand elasticity, reserve requirements, price adjustment costs, and depreciation rates. These are based on existing literature Key steady-state parameters (output growth, money supply growth, consumption/capital/government expenditure ratios) are sourced from the Central Bank of Iran (2005-2023, constant 2016 prices) The autoregressive coefficient of banks' reserve holdings (ρ_R) is estimated using Box-Jenkins methodology, finding a stable AR(1) process with ρ_R= 0.98 The selected parameters are chosen for their credibility, recency, methodological consistency, and alignment with the study's objectives.

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6 Model Fit and Performance Evaluation

Model fit is evaluated via moment matching against Iranian data. Variables are min-max normalized. Table 3 shows close match for consumption, output, capital, and government spending—especially in relative variability. Discrepancies exist, notably in government expenditure. Since the goal is analyzing endogenous money creation and liquidity distribution, model fit is sufficient for policy and mechanism analysis**.**

Table 3

Comparison of Model Moments and Actual Iranian Economy Data

S.D		Average		Variable
Model	Data	Model	Data	
0.0015	0.0061	0.0721	0.0721	Consumption
0.0035	0.0028	0.1639	0.1639	GDP
0.0012	0.0071	0.0574	0.0573	Capital
0.0006	0.2828	0.0246	0.0262	Government Expenditures

Source: Research findings

7 Results Analysis

A negative productivity shock initially reduces output and consumption, causing inflation. Supply-side effects drive inflation, while reduced wages increase labor supply. From a monetary perspective, the shock reduces liquidity, worsening welfare due to lower economic activity and diminished purchasing power.

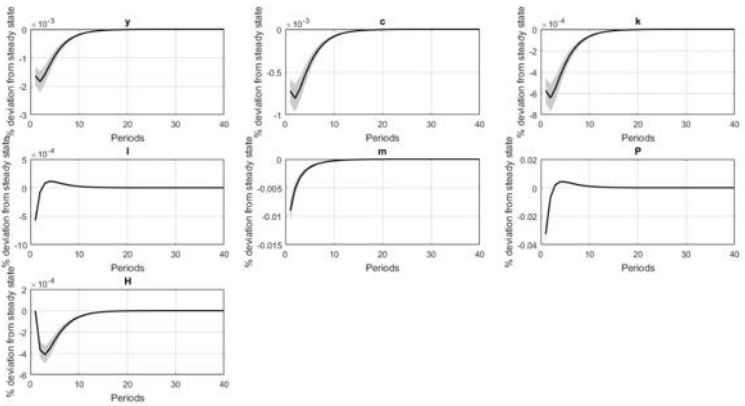

Figure 6. Impulse Response to Negative Productivity Shock

Source: Research Findings

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Figure 6 illustrates the impulse response functions of macroeconomic variables to a negative productivity shock in the bank balance-sheet model with heterogeneous households. A decrease in productivity, acting as a supply-side shock, triggers a simultaneous decline in output, consumption, and investment, which subsequently leads to a reduction in the physical capital stock. The decline in the marginal productivity of inputs weakens firms' demand for labor, thereby reducing real wages. Concurrently, the contraction in aggregate demand, driven by falling income and investment, leads to a decrease in the general price level. As a result, household current income falls, forcing households—particularly type L, which faces more severe liquidity constraints—to undergo more significant consumption adjustments. In the monetary sector, the slowdown in economic activity and the reduced incentive for transactions lower the demand for money and real money balances. However, due to habit formation, the consumption path does not adjust fully or instantaneously with output; rather, consumption declines more smoothly than output due to habit-induced stickiness. Overall, the impulse response patterns confirm that a negative productivity shock induces a real recession through falling income, wages, and prices, while simultaneously pressuring household consumption behavior, especially for constrained households, alongside a contraction in real money balances.

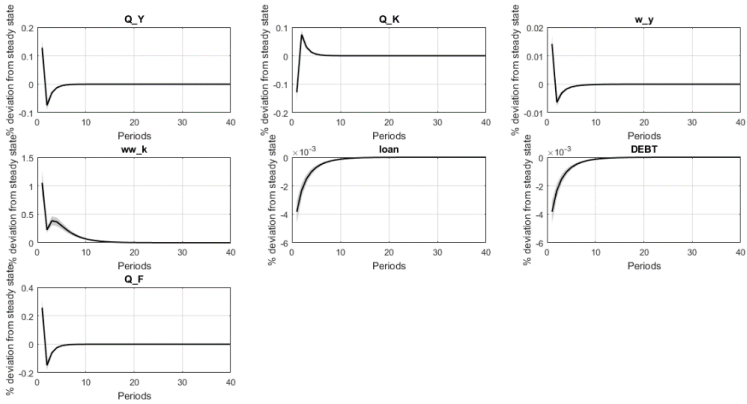

Figure 7. Impact of Negative Productivity Shock on Credit Risk and Lending
Source: Research Findings

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Figure 7 illustrates the transmission mechanism following a negative technology shock. Upon the occurrence of a negative technology shock, the productivity of production factors declines, thereby weakening firm profitability and the cash flows generated from productive activities. The reduction in economic returns diminishes the capacity of firms to meet their financial obligations to the banking system. Under these circumstances, credit risk in the economy rises, and the probability of firm default follows an upward trend, indicating that a larger share of firms faces the inability to repay their debts.

The escalation in credit risk, coupled with the declining returns on investment projects, reduces the expected value of loan repayments for banks. Consequently, the present value of receivables and, more broadly, the total value of bank assets decline. In response to these conditions, banks renegotiate their credit contracts to manage risk and prevent large-scale losses. A primary banking response in this context is an increase in the probability of loan forbearance; specifically, to avoid recording definitive defaults and further eroding asset values, banks prefer to restructure portions of firm debt or defer repayment maturities.

In line with this process, the default threshold rises, meaning the minimum level of performance or profitability required for a firm to satisfy its obligations increases. Simultaneously, the forbearance threshold also rises, as banks encompass a wider range of distressed firms within the debt restructuring zone to prevent them from transitioning into definitive default. These developments signify an intensification of credit constraints and increased financial fragility in the economy.

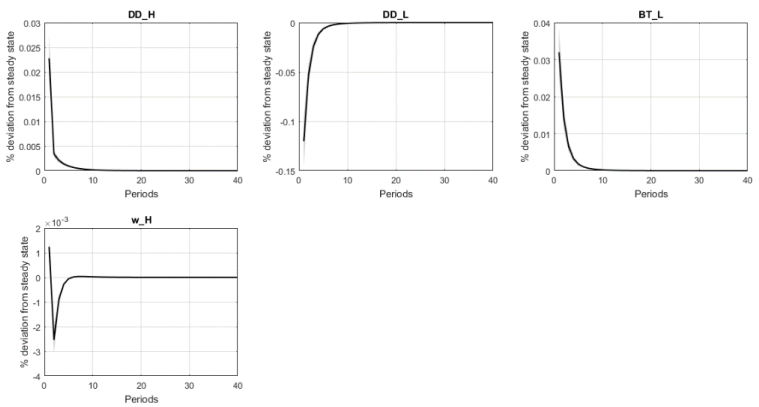

Figure 8. Demand for Bank Deposits and Loans in Response to Interest Rate Changes

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Source: Research Findings

Building upon the aforementioned mechanisms, the reaction patterns of deposits from the two household groups (H and L) and their subsequent impact on the liquidity distribution index provide a clear illustration of intensifying liquidity inequality within the banking system. Under conditions of rising credit risk and recession, H-type households—characterized by more stable incomes and more risk-averse preferences—tend to favor higher-yielding, long-term assets; consequently, their volume of time deposits increases.

In contrast, L-type households, which possess more volatile incomes and higher liquidity preferences, opt to hold their wealth in current accounts amidst growing uncertainty. The escalation of risk, diminished purchasing power, income volatility, and the heightened need for flexibility in daily expenditures drive these households to reduce their time deposits in favor of current accounts. As a result, L-type time deposits decline, with a significant portion of their resources shifting toward current deposits.

This structural shift in the deposit composition, coupled with the concentration of cash flows arising from loan forbearance, deferred repayments, and bank balance-sheet adjustments, leads to an increase in the liquidity distribution index (wHw_HwH). An increase in this index signifies a disruption in the equilibrium of liquidity distribution across different economic groups. Specifically, certain sectors and groups (such as H-type households and intermediary firms) capture a relatively larger share of liquidity, while groups with more unstable incomes (such as L-type households) see their liquidity structure shift toward low-yield, unstable current deposits. This transition reflects an intensification of financial fragility and increased liquidity heterogeneity within the banking system—a key consequence of recessionary and credit shocks in models of endogenous liquidity creation.

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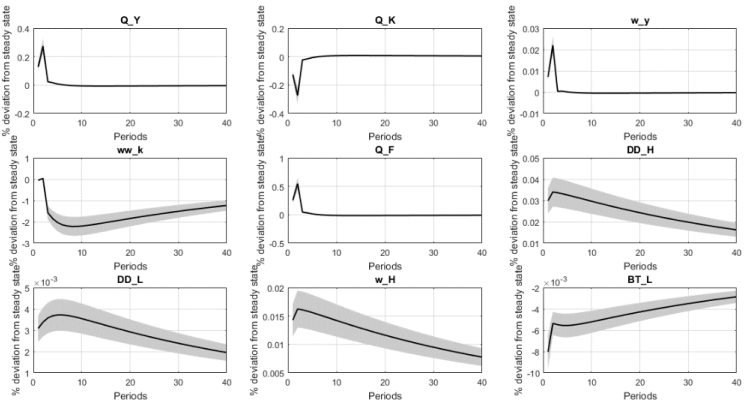

Figure 9. Impulse response functions of banking variables to a negative legal reserve shock
Source: Research Findings

Despite the improvement in real macroeconomic variables, the model results indicate that certain variables related to credit risk and the financial behavior of economic agents exhibit divergent responses. The expansion of lending and bank credit increases the aggregate level of corporate indebtedness to the banking system. Under these circumstances, although productive and investment activities expand, the growing scale of firms' financial obligations increases their exposure to credit risk, thereby driving up the probability of default. Simultaneously, the default threshold rises, implying that the critical level at which a firm becomes unable to meet its obligations shifts upward within credit contracts.

Conversely, given the relative improvement in economic conditions and the appreciation of asset values and firm income streams, the intensity of bank punitive actions in the event of default diminishes. Consequently, the probability of full seizure of collateralized assets decreases. Furthermore, to prevent firms' liquidity problems from escalating into definitive defaults, banks demonstrate a greater inclination toward renegotiating credit contracts. As a result, the forbearance threshold decreases while the probability of forbearance increases, meaning that in the event of repayment disruptions, banks are more likely to opt for debt extensions or restructuring.

In the deposit sector, divergent responses to changing economic conditions are observed across different household groups. High-income households, benefiting from higher income and wealth levels, allocate a substantial portion

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of their resources to time deposits in response to increased economic activity and enhanced yield opportunities within the banking system; thus, their time deposits show a significant increase. While time deposits of low-income households also increase, the magnitude of this rise is considerably smaller due to income constraints and a heightened need for liquidity to fund current consumption.

On the other hand, low-income households experience a contraction in current deposits due to increased consumption and a greater reliance on liquid resources to meet daily expenditures. This divergence in saving behavior between high-income and liquidity-constrained households causes a structural shift in the banking system's deposit composition in favor of high-income households' time deposits. Consequently, the distribution of liquidity across economic groups does not occur uniformly. The concentration of financial resources in the time deposits of more affluent households, coupled with the depletion of liquid resources among liquidity-constrained groups, leads to an increase in the liquidity distribution index. This rise signifies a disruption in the equilibrium of liquidity distribution, where liquidity becomes increasingly concentrated within specific economic segments, even when aggregate economic activity shows relative improvement.

7.1 Distributional and Welfare Implications of Banking Shocks

Banking shocks cause uneven liquidity shifts among different income groups. This affects bank balance sheets, with inflation adding complexity. A "cosmetic forbearance" mechanism (delaying loan liquidation) worsens deposit concentration by preventing funds from flowing to healthier assets. Ultimately, banking shocks create and amplify inequalities in liquidity and asset distribution.

7.2 Policy Implications and Quantitative Simulation Results

The simulation results highlight that shocks affecting bank reserves and liquidity creation propagate through the economy not only via aggregate quantities, but also through changes in the composition of bank balance sheets and the implied distribution of liquidity. Adjustments in household consumption, labor supply, and prices reflect the interaction between liquidity constraints, credit conditions, and nominal rigidities embedded in the model.

Reserve supply contractions tighten banks' balance-sheet constraints and lead to persistent reductions in real consumption and output, accompanied by heightened price volatility. These dynamics reflect disruptions in bank-based

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endogenous liquidity creation triggered by an exogenous reserve shock, rather than shifts in household preferences or direct interventions in the monetary aggregate.

In addition, liquidity shocks induce a recomposition of bank lending toward non-performing exposures through the cosmetic forbearance channel. Credit to productive activities contracts, while a larger share of bank assets remains allocated to rolled-over loans. This reallocation weakens the transmission of quantity-based monetary instruments by altering the composition, rather than the level, of credit.

These findings suggest that evaluations of monetary transmission mechanisms should account for banks' balance-sheet adjustments and liquidity allocation channels, particularly in environments characterized by persistent institutional incentives for forbearance.

7.3 Conclusion

This study aimed to investigate the effects of negative shocks to banking system reserves or technology, and their subsequent impact on the endogenous distribution of liquidity within the Iranian economy. The findings indicate that these shocks lead to reduced ability of enterprises to repay loans and increased liabilities of banks. Forced restructuring of non-performing loans, as a remedial measure, generates internal liquidity creation. However, the primary distinction of this research lies in its emphasis on the distribution of internal liquidity among households. The results of this study align with the findings of (Amirali et al., 2023), who demonstrated that negative shocks can lead to liquidity creation in the banking system. However, the key difference lies in the focus on liquidity distribution. While prior research has concentrated on liquidity creation and its effects on banking stability, this study emphasizes the consequences of endogenous liquidity distribution on households.

Endogenous liquidity distribution can lead to reduced investment, increased inequality, especially when the banking system faces liquidity challenges. The results also show that increases in non-performing loans generate liquidity shortages for banks, which leads to greater reliance on central bank funding. This process expands the central bank's balance sheet and ultimately contributes to inflationary pressures through the monetary channel.

This study, focusing on the impact of domestic liquidity distribution on the Iranian economy, represents a valuable contribution to the international literature. While prior research has primarily focused on liquidity creation within the banking system, this study offers a novel perspective by

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emphasizing the consequences of liquidity distribution on the macroeconomy and households. Considering the specific economic conditions of Iran and the importance of liquidity in economic development, the findings of this research can provide valuable policy guidance for other developing countries with similar banking systems.

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Appendix

Appendix A: How Loan Creation and Forbearance Affect Bank Balance Sheets

This appendix provides a stylized accounting illustration of the mechanics of endogenous money creation, the circulation of newly created deposits, and the initial impact of loan forbearance (cosmetic restructuring) on the bank's balance sheet. These mechanics form the structural foundation for the endogenous and asymmetrical liquidity creation modeled in Section 4 of the main text.

A.1 Loan Creation and Deposit Generation

In the bank credit creation paradigm, when a bank issues a loan, liquidity is created endogenously, simultaneously generating a corresponding deposit on the liability side. Table A.1 illustrates the stylized bank balance sheet immediately following the issuance of a 1000-unit loan to Individual A. The bank is assumed to hold 100 units as required reserves.

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Table A-1
Bank Balance Sheet at the Beginning of Period t−1

Liabilities and Capital		**Assets**		
1000		1000		
Deposit of Individual A		Loan		
100		100		Reserves
Borrowing from the Central Bank				
1100	Total	1100	Total	

Source: Research findings

Following this operation, the bank's assets (Loan) expand, requiring a corresponding expansion in liabilities (Deposit of A). A portion of the deposit is held as required reserves, while the remaining liquidity is concentrated in the borrower's account.

A.2 Deposit Transfer and Liquidity Circulation

The liquidity created by the loan often enters circulation when the borrower utilizes the funds for transactions. In the next step (Table A.2), we assume Individual A transfers the entire deposit to Individual B to purchase an asset. The overall bank balance sheet remains fixed, but the composition of depositors on the liability side changes:

Table A-2
Transactions Between Bank Depositors

Liabilities and Capital			**Assets**	
0	Current Deposit (Individual A)		1000	Loan
Time Deposits		0	100	Reserves
Borrowing from the Central Bank		100		
Current Deposit (Individual B)		1000		
1100		Total	1100	Total

Source: Research findings

A.3 The Accounting Mechanism and Macroeconomic Linkage of Cosmetic Forbearance

Normally, if the borrower (Individual A in this hypothetical example) were to repay the loan, the deposit would be destroyed, and the bank's balance sheet would contract.

However, the key assumption of our DSGE model is that if the firm is unable to repay, the bank may opt for cosmetic forbearance. This institutional decision means the existing debt is not settled but is instead rolled over to the next period.

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This forbearance action prevents the loan asset from being written off, mechanically preventing the bank's balance sheet from contracting**.**

Maintaining this loan on the balance sheet allows the bank to record accrual-based (notional) interest income. Although this accrual profit is not a real cash flow and is purely a notional income, it increases the bank's recorded profit.

As detailed in Section 4 of the main text, this notional profit is subsequently and asymmetrically channeled, due to the profit flow structure, to the passive Household H (Profit receivers and large depositors)**.** This asymmetrical transfer mechanism operates through the credit of accrued interest to the deposit accounts of certain households. Specifically, when the bank recognizes these notional earnings as actual interest payments, it increases the nominal balance of deposits held by the high-income group. This process, where accounting accruals are converted into liquid deposits through the bank's balance sheet adjustments, serves as the primary channel for the endogenous creation of liquidity and its subsequent unequal distribution. The continuous accumulation of non-performing debt, driven by the forbearance decision, compels the bank to maintain a corresponding and expanding liability base (deposits) to satisfy the balance-sheet identity (Assets=Liabilities + Capital).

Appendix B

The steady-state equilibrium conditions of the model are presented below.

$$\pi = \frac{(\theta - n)}{1+n} - 1 \tag{B-1}$$

$$i = \frac{(1+\pi-\beta)}{\beta} \tag{B-2}$$

$$r = \frac{(i-\pi)}{1+\pi} \tag{B-3}$$

$$l = 0.33 \tag{B-4}$$

$$k = \left(\frac{1}{a}\right)^{\frac{1}{a-1}} \tag{B-5}$$

$$I = \delta . K \tag{B-6}$$

$$w = \frac{(l^{\eta}.\chi)}{(c-H)^{-\sigma}} \tag{B-7}$$

$$m = (c-H)^{\frac{\sigma}{b}}.\left(\frac{(1+\pi-\beta)}{1+\pi}\right)^{-\frac{1}{b}} \tag{B-8}$$

$$bb = \left(\left(w.l - \frac{m}{1+\pi}\right) + \frac{\left((-c-m-II)\right)}{\frac{(1+(1+i)(k.r.Z-QZZ.k)}{(1+\pi)}}\right) \tag{B-9}$$

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$$c + m + I + bb = w.l - \frac{m}{1+\pi} - \frac{(1+i)}{1+\pi}.bb.(k.r.Z - QZZ.k) \quad \text{(B-10)}$$

$$SS = 0 \quad \text{(B-11)}$$

$$S = 0 \quad \text{(B-12)}$$

$$(c-H)^{-\sigma}.\left(S + \frac{II.SS.e_I}{II}\right) = \beta.(c-H)^{-\sigma}.SS.e_I.(\frac{II}{II})^2 \quad \text{(B-13)}$$

$$\Sigma = 1 + r + \Pi - \delta \quad \text{(B-14)}$$

$$mc = \frac{w.l.(1+r)}{y.(1-\alpha).(1+\pi)} \quad \text{(B-15)}$$

$$YF = \frac{(\chi.l^{\eta-1}(1+r))}{(1-\alpha).(c-H)^{-\sigma}.mc.(1+\pi)} \quad \text{(B-16)}$$

$$x = y - YF \quad \text{(B-17)}$$

$$PAC = \frac{\theta}{2}(\frac{P}{P.(\Pi^{fe})^{\mu}(\overline{\Pi}.fe)^{1-\mu}} - 1)^2 P.Y \quad \text{(B-18)}$$

$$DEBT = loan \quad \text{(B-19)}$$

$$loan = w.l + r.k \quad \text{(B-20)}$$

$$\Pi^f = P.y - w.l - pac.P - (\Phi_d + i_l).DEBT \quad \text{(B-21)}$$

$$w^{BS}{}_k = \frac{(l+pac+(1+i_l).DEBT-y)}{p_k(1-\delta).k} \quad \text{(B-22)}$$

$$i_d = \frac{(1+\pi)}{\beta} - 1 \quad \text{(B-23)}$$

$$i_{bd} = \frac{i_d}{(1-rr_d)} \quad \text{(B-24)}$$

$$gd = \left(\frac{(G-T)(1+\pi)}{\pi}\right) \quad \text{(B-25)}$$

$$G = \left(T + gd - \frac{gd}{1+\pi}\right) \quad \text{(B-26)}$$

$$BD = R + DEBT - DD - BT \quad \text{(B-27)}$$

$$\Pi^k = p_k.\left((k - (1-\delta).k) - P.II\right) \quad \text{(B-28)}$$

$$w_y = \frac{(w.l+pac+(1+i_l).DEBT)}{P.y} \quad \text{(B-29)}$$

$$H = h.c \quad \text{(B-30)}$$

$$T = t_t.y^{tt} \quad \text{(B-31)}$$

$$i_l = \frac{(p.y-w.l-pac.p)}{DEBT} - \Phi_d \quad \text{(B-32)}$$

$$QZZ = r + 1 - \delta - \frac{1}{\beta} \quad \text{(B-33)}$$

$$w_y = \frac{(w.l+pac+(1+i_l).DEBT}{P.y} \quad \text{(B-34)}$$

$$BT = P.c - w.l - M \quad \text{(B-35)}$$

$$R = rr_d.DD + rr_b.BT + i_{bd}BD \quad \text{(B-36)}$$

$$\Pi^b = -i_d DD^H - st.\Pi^f - \Pi^k \quad \text{(B-37)}$$

$$w_k = \frac{((1+i_l).DEBT-y+l+pac)}{p_k(1-\delta).k} \quad \text{(B-38)}$$

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$$Q^Y = \frac{(-w_y+(1+q^Y))}{2.q^Y} \quad \text{(B-39)}$$

$$Q^k = \frac{(w_K-(1-q^K))}{2.q^K} \quad \text{(B-40)}$$

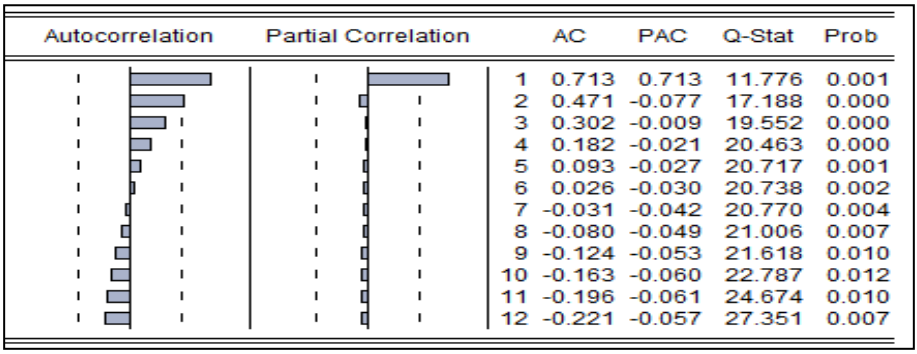
$$Q^N = \frac{(w_y-1+q^Y)}{2.q^Y} \quad \text{(B-41)}$$

$$Q^N + Q^Y = 1 \quad \text{(B-42)}$$

$$Q^N = \frac{(-p_k+(1-\delta).p_k.k-\vartheta.\pi^f+loan+P.Y-w.l)}{((Q_d+\mathrm{i}^l).DEBT+Q_F.(P.Y-w.l+P.Y+1)} \quad \text{(B-43)}$$

$$DD = \frac{((1-rr_b)BT+BD-DEBT-\mathrm{i}^{bd}BD)}{(rr_d-1)} \quad \text{(B-44)}$$

Appendix C



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.713	0.713	11.776	0.001
		2	0.471	-0.077	17.188	0.000
		3	0.302	-0.009	19.552	0.000
		4	0.182	-0.021	20.463	0.000
		5	0.093	-0.027	20.717	0.001
		6	0.026	-0.030	20.738	0.002
		7	-0.031	-0.042	20.770	0.004
		8	-0.080	-0.049	21.006	0.007
		9	-0.124	-0.053	21.618	0.010
		10	-0.163	-0.060	22.787	0.012
		11	-0.196	-0.061	24.674	0.010
		12	-0.221	-0.057	27.351	0.007

Figure C-1. Autocorrelation and Partial Autocorrelation Analysis of Banks' Reserve Holdings at the Central Bank
Source: Research Findings

Appendix D

D.1 Bayesian Sensitivity Analysis of Model Parameters

This section presents a Bayesian sensitivity analysis of key model parameters (e.g., discount factor, capital share, depreciation, risk aversion, etc.) using prior distributions. By varying their means and standard deviations within plausible ranges, alternative scenarios are simulated and compared to the baseline. The goal is to identify which parameters cause disproportionately large changes in model outcomes, assessing the model's reliability and dependence on prior assumptions.

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To obtain the structural parameters of the model, we employ a Bayesian estimation approach. This method allows for the incorporation of prior information into the likelihood function, ensuring that the estimated parameters remain consistent with both empirical data and theoretical expectations. The summary of the posterior distributions, including the mean values and standard deviations for the identified parameters, is provided below:

Table D-1
Summary of Posterior Parameter Distributions

parameters

	prior mean	post. mean	90% HPD interval		prior	pstdev
rho_z	0.720	0.8978	0.8572	0.9447	beta	0.0500
alpha	0.400	0.4719	0.3806	0.5561	beta	0.0500
beta	0.990	0.9900	0.9884	0.9917	beta	0.0010
delta	0.010	0.0130	0.0000	0.0266	beta	0.0100
sigma	1.200	1.1999	1.1836	1.2171	norm	0.0100
b	2.450	2.4495	2.4319	2.4658	norm	0.0100
h	0.510	0.5103	0.4930	0.5269	beta	0.0100
tota	4.260	4.2598	4.2432	4.2761	norm	0.0100

Source: Research Findings

The convergence of the Markov Chain Monte Carlo (MCMC) algorithm was verified to ensure the reliability of the estimation process.

Furthermore, to evaluate the robustness of our findings and ensure that the results are driven primarily by the data rather than the initial prior specifications, a prior sensitivity analysis was conducted. In this procedure, the standard deviations of the priors for the key parameters were increased to allow for a broader range of possibilities. The impulse response functions for the core economic variables, which illustrate the model's transmission mechanisms, are presented as follows:

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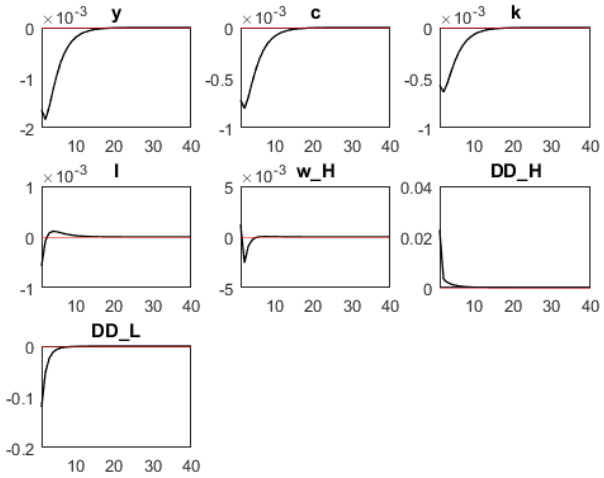

Figure D-1. Baseline Impulse Response Functions
Source: Research Findings

The comparison between the baseline estimations and the alternative estimations under relaxed priors demonstrates that the qualitative dynamics and the direction of the responses remain stable. This confirms that the model's outputs are robust and that the empirical evidence from the data plays a decisive role in shaping the estimated structural relationships.

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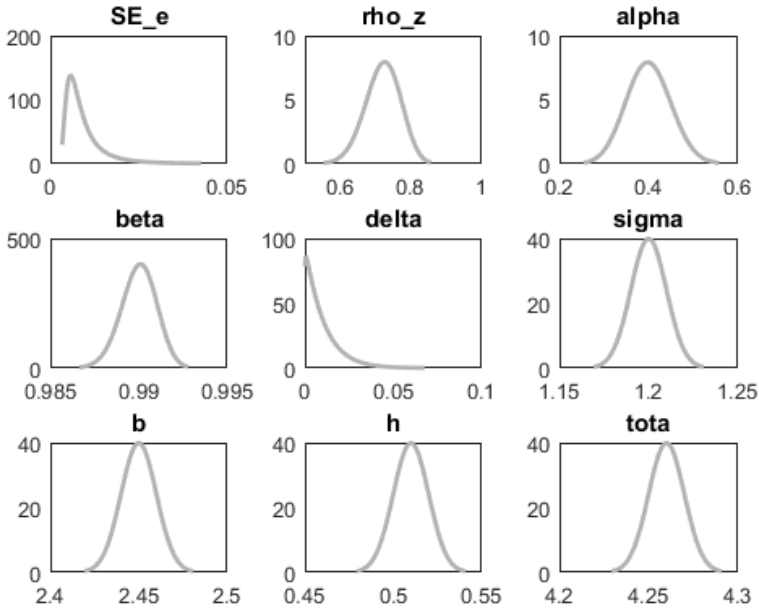

Figure D-2. Estimated Posterior Distributions of Key DSGE Model Parameters under Bayesian Inference
Source: Research Findings

Fig D-2 shows posterior distributions for key DSGE model parameters, estimated using MCMC with annual data (2005–2023). Peaks represent modal values, and spread reflects uncertainty. Comparing them to calibrated benchmark values assesses model robustness and sensitivity to prior assumptions.

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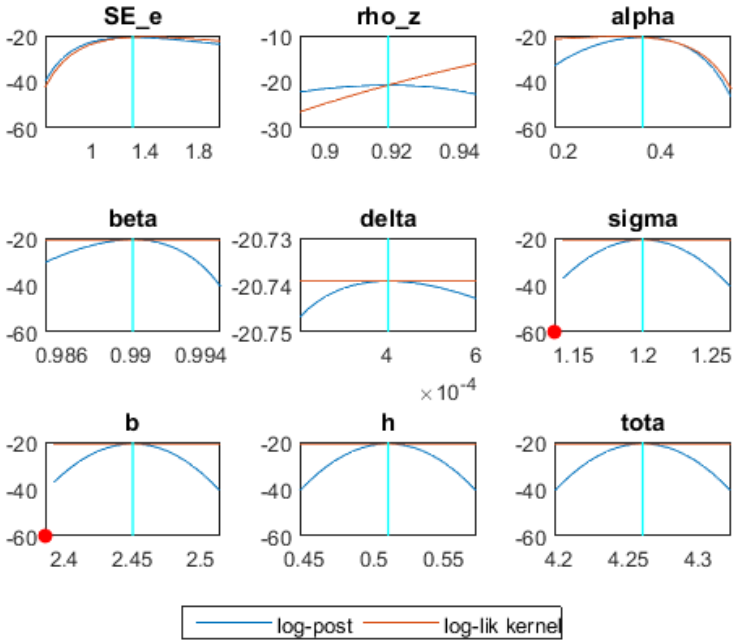

Figure D-3. Log-Likelihood Profiles of Key DSGE Model Coefficients under Bayesian Estimation
Source: Research Findings

The figure D-3 depicts the estimated log posterior (log likelihood) profiles for the key DSGE model quantities. In each panel, the horizontal axis represents the admissible range over which the coefficient is varied, while the vertical axis reports the corresponding value of the log posterior function. The vertical blue line indicates the location of the Bayesian likelihood maximum, corresponding to the value that yields the best fit of the model to the data, whereas the red markers denote the initial values or the boundaries of the search domain. Examining these profiles provides a valuable diagnostic tool for assessing the stability of the estimation, evaluating the convergence properties of the MCMC algorithm, and identifying regions of the parameter space with the highest posterior probability mass.

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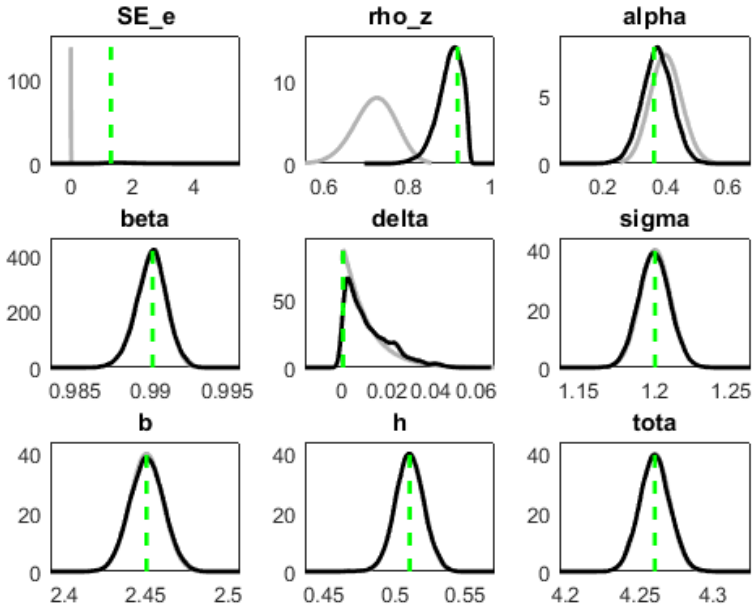

Figure D-4. Bayesian Estimation Analysis and Calibration Consistency in the DSGE Framework
Source: Research Findings

The Bayesian estimation results using MCMC show that most model parameters (β, b, h, θ) are consistent with the data, validating the initial assumptions. However, parameters such as SEε and ρ_Z exhibit significant adjustments, indicating a need for more careful prior specification. Posterior dispersion reflects estimation uncertainty: narrow profiles suggest well-identified variables, while wide ones indicate higher uncertainty. Overall, the calibration is internally consistent and yields acceptable precision, but further sensitivity and identification analysis is recommended for sensitive parameters.

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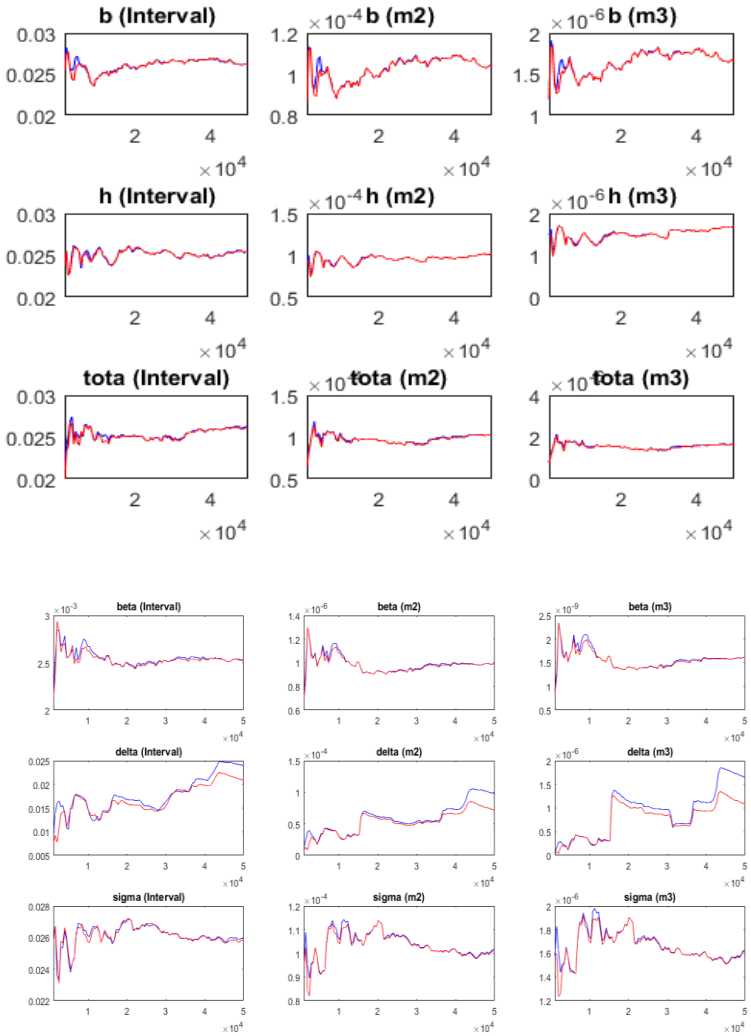

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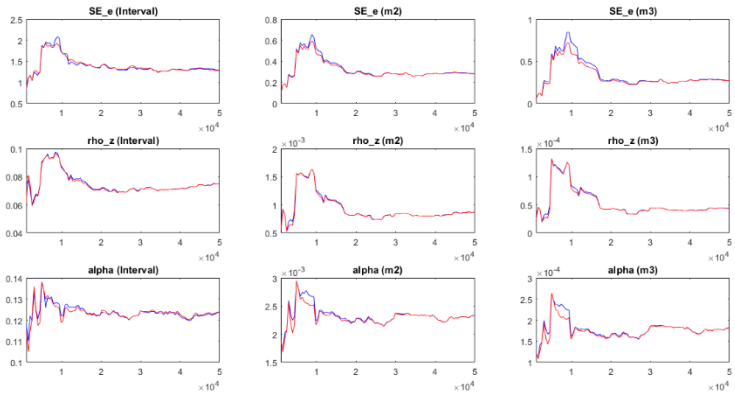

Figure D-5. Bayesian Estimation and MCMC Convergence Diagnostics in the DSGE Model
Source: Research Findings

This figure displays the MCMC convergence diagnostics for the estimated parameters. The red and blue lines represent the two different MCMC chains (or sub-chains) used to evaluate the stability of the estimation. The metrics plotted are:

1. Interval: The width of the confidence interval for the parameter estimate.
2. m2: The second moment, representing the variance of the parameter distribution.
3. m3: The third moment, indicating the skewness of the distribution.

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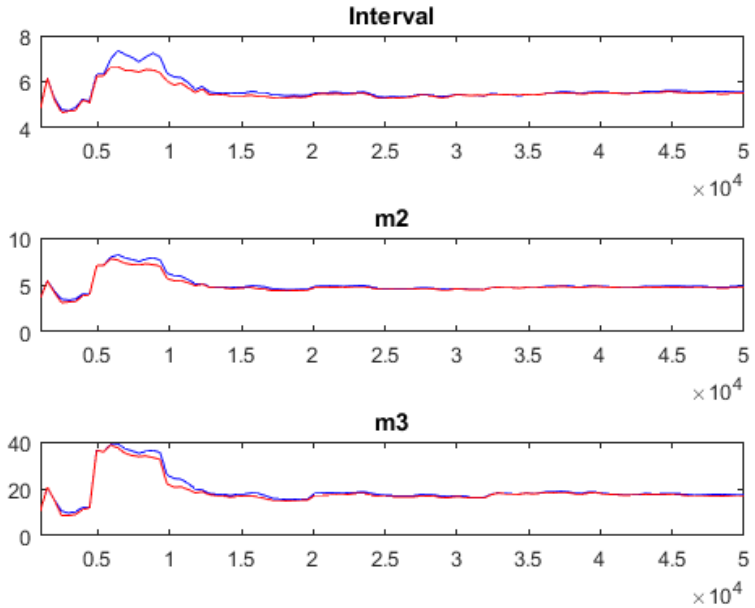

Figure-D-6. MCMC Sampling Convergence in the Bayesian Estimation of the DSGE Model
Source: Research Findings

The figure shows MCMC trace plots and moment diagnostics (variance and skewness) over 50,000 iterations. The red and blue chains overlap significantly after ~20,000 iterations, indicating convergence and stability. This confirms reliable Bayesian estimates, suitable for further analysis like impulse response functions.

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Table D-2
Prior and Posterior Distributions of Key DSGE Model Coefficients under Bayesian Estimation

parameters

	prior mean	post. mean	95% HPD interval		prior	pstdev
rho_z	0.720	0.8418	0.8208	0.8638	beta	0.0500
alpha	0.400	0.3662	0.2993	0.4378	beta	0.0500
beta	0.990	0.9899	0.9878	0.9918	beta	0.0010
delta	0.010	0.0107	0.0000	0.0339	beta	0.0100
sigma	1.200	1.1968	1.1791	1.2141	norm	0.0100
b	2.450	2.4513	2.4325	2.4696	norm	0.0100
h	0.510	0.5104	0.4924	0.5282	beta	0.0100
tota	4.260	4.2599	4.2380	4.2794	norm	0.0100

Source: Research findings

The posterior distributions appear relatively tight, which indicates that the data are informative regarding these parameters. Although Table D-2 presents our baseline estimations based on literature-based priors, we have verified the stability of these results through supplementary sensitivity analyses using alternative prior specifications and varying MCMC initialization settings, which validates the robustness and reliability of our findings.

Appendix E

The L-household's optimization problem is solved by constructing a Lagrangian that augments the utility function with the relevant constraints. Taking derivatives of the Lagrangian 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 Lagrange multipliers λ_t , μ_t, and V_t represent the shadow values of the cash-in-advance constraint, the budget constraint, and the time-deposit accumulation condition, respectively.

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

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

$$\frac{\partial L}{\partial m_t} = 0 \,.\, E_t\beta^t \frac{(1-b)}{(1-b)} m_t^{-b} - E_t\beta^t \lambda_t + \frac{E_t\lambda_{t+1}\beta^{t+1}}{\Pi_t(1+n)} + V\frac{E_{t+1}\beta^{t+1}}{\Pi_t(1+n)} = 0 \tag{E-3}$$

$$\frac{\partial L}{\partial A_t} = 0 \,.\, E_t\lambda_t\beta^t\left(r_t{}^k k_{t-1} - \acute{\Psi}(A_t)k_{t-1}\right) = 0 \tag{E-4}$$

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

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$$\frac{\partial L}{\partial I_t} = 0 \,.\, -\lambda_t + \mu_t - \mu_t, S\left(\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right)\right) - \mu_t I_t \acute{S}\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right)\left(\frac{\varepsilon_t^I}{I_{t-1}}\right) +$$

$$\beta\mu_{t+1}, \acute{S}\left(\frac{\varepsilon_{t+1}^I I_{t+1}}{I_t}\right)\varepsilon_{t+1}^I\left(\frac{I_{t+1}}{I_t}\right)^2 = 0 \qquad \text{(E-6)}$$

$$\frac{\partial L}{\partial d_t} = 0 \,.\, -E_t V_t \beta^t - E_t \beta^{t+1} V_{t+1} \frac{\left(1+{i_t}^d\right)}{(1+\pi_t)} = 0 \qquad \text{(E-7)}$$

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