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Zahra Mohammadi
University of Isfahan
Rasoul Bakhshi
r.bakhshi@ase.ui.ac.ir
University of Isfahan https://orcid.org/0009-0008-1685-9545
Mohammad Vaez Barzani
University of Isfahan

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Credit Contraction, Loan Renewal Decisions, and Social Sustainability in the U.S. Economy

Zahra Mohammadi*
PhD Student in Monetary Economics, Faculty of Economics, University of Isfahan, Isfahan, Iran
Rasoul Bakhshi Dastjerdi∗
Associate Professor, Faculty of Economics, University of Isfahan, Isfahan, Iran
Mohammad Vaezi Barzani†
Associate Professor of Economics, Faculty of Economics, University of Isfahan, Isfahan, Iran

Abstract
This paper develops a New Keynesian DSGE model to examine how default risk and bank loan-renewal decisions shape credit contraction and its implications for social sustainability. Moving beyond the traditional intermediation-of-loanable-funds view, the model endogenizes bank balance-sheet adjustments by incorporating loan rollovers and default-contingent credit supply. A key innovation of this study is the integration of heterogeneous household liquidity timing, which distinguishes between early-access, liquidity-constrained households and delayed-access, wealth-accumulating households. Using Bayesian estimation on U.S. data (2000–2024), we analyze how productivity shocks propagate through credit fragility and financial access. The findings reveal that negative productivity shocks induce banks to tighten loan-renewal conditions, disproportionately affecting liquidity-constrained households. Crucially, the model uncovers a liquidity-timing disparity: while liquidity-constrained households receive immediate credit support to maintain consumption, they remain unable to accumulate wealth. In contrast, delayed-access households leverage their financial buffers to accumulate deposits, thereby exacerbating wealth inequality during downturns. The interaction between central bank liquidity provision and bank risk assessment emerges as a key determinant of financial resilience. Overall, the results indicate that ignoring the endogenous nature of credit contraction and the timing of liquidity distribution significantly understates both financial fragility and the distributional costs of economic shocks

* z.mohammadi@ase.ui.ac.ir
DOI: 0009-0000-0881-2570
∗ r.bakhshi@ase.ui.ac.ir
DOI: 0009-0008-1685-9545
†

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1 Introduction

The stability of the banking system is a cornerstone of macroeconomic resilience, but its ultimate significance lies in its profound impact on social sustainability, household welfare, and equitable economic development. In modern economies, commercial banks do not merely intermediate pre-existing savings; they actively create and contract money and credit through endogenous balance-sheet adjustments (Werner, 2014; Jakab & Kumhof, 2015; McLeay et al., 2014). When macroeconomic conditions deteriorate, these institutions often respond by contracting lending, reducing loan renewals, and compressing outstanding debt. While these actions are rational from a risk-management perspective, they trigger systemic credit contractions that disproportionately affect vulnerable economic agents, thereby worsening social inequalities and undermining the foundations of sustainable social development.

Crucially, the resulting credit crunch is rarely neutral; it distributes economic pain unevenly, creating barriers for liquidity-constrained households and smaller enterprises, which directly threatens financial inclusion and long-term socio-economic stability (Mohammadi et al., 2026).

From a sustainability perspective, the critical issue is not only the aggregate volume of bank-created liquidity, but how the allocation and contraction of credit affect the real economy and social equity. Under adverse shocks, heightened default risk and stricter bank screening lead to credit rationing and a decline in loan rollovers. This dynamics acts as a transmission channel that limits the flow of financial resources to productive sectors, dampening employment and hindering sustainable investment (BIS, 2020; IMF, 2021; Chenarani et al., 2023; Sundaresan & Xiao, 2023). Crucially, the resulting credit crunch is rarely neutral; it distributes economic pain unevenly, creating barriers for liquidity-constrained households and smaller enterprises, which directly threatens financial inclusion and long-term socio-economic stability.

To design policies that foster sustainable governance, researchers require structural tools capable of capturing these complex feedback loops. Dynamic stochastic general equilibrium (DSGE) models provide a robust framework to analyze the interactions between financial frictions, banking decisions, and macroeconomic outcomes (Christiano et al., 2005; Gerali et al., 2010; Dib, 2010; Chenarani et al., 2023; Ahmadyan, 2024). However, conventional banking DSGE frameworks have paid limited attention to how default risk, loan-renewal decisions, and bank balance-sheet adjustments jointly determine the distribution of liquidity and its welfare implications across heterogeneous agents. This gap is a significant limitation, as understanding the social costs of credit contraction is essential for designing policies that balance financial stability with social equity.

This issue is highly relevant to the United States. Although the U.S. financial system is highly market-based, commercial banks remain vital for credit transmission, deposit generation, and household financing. When U.S. banks tighten credit standards or reduce loan rollovers in response to negative productivity shocks, the consequences extend far beyond bank balance sheets. The resulting credit contraction restricts credit access for lower-income and liquidity-constrained households, exacerbating wealth disparities and destabilizing household welfare. Consequently, the macroeconomic consequences of credit contraction depend heavily on how credit withdrawal propagates through these socio-economic channels.

While this study builds on the theoretical foundations of the endogenous liquidity framework developed by Tavakolian et al. (2023), it introduces key departures in institutional context, transmission mechanisms, and social outcomes. Unlike their focus on debt forbearance and inflationary liquidity expansion in Iran, this paper examines the U.S. economy, where the interaction between default risk and loan-renewal decisions drives a structural credit contraction. Rather than examining how debt forbearance generates inflation, we

analyze how a credit crunch—driven by tighter bank-level risk assessment and reduced rollovers—leads to asymmetric welfare losses and worsens inequality among heterogeneous U.S. households.

The contribution of this paper is threefold. First, it integrates endogenous default and loan-renewal decisions into a banking DSGE framework characterized by household heterogeneity, directly linking financial dynamics to socio-economic welfare. Second, it demonstrates how productivity shocks trigger credit contractions, showing how banks' defensive balance-sheet adjustments reduce outstanding debt and tighten lending conditions. Third, it provides a quantitative structure to evaluate how these banking dynamics generate uneven macroeconomic and distributional effects, highlighting how differences in households' credit exposure translate into divergent welfare outcomes.

Ultimately, this paper argues that bank-created liquidity and credit policies must be evaluated through the lens of social sustainability. Credit aggregates and their distribution across loans, deposits, and reserves are highly state-dependent. Adverse shocks not only reduce total credit but alter its distribution, disproportionately penalizing vulnerable groups. Capturing these dynamics is essential for designing resilient financial systems and sustainable policy frameworks that protect households from the destabilizing effects of systemic credit contractions.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical linkages between endogenous liquidity, credit distribution, and social sustainability. Section 3 outlines the model structure and banking sector. Section 4 presents the quantitative results. Section 5 evaluates the macroeconomic and welfare distribution implications. Section 6 analyzes the impulse response functions, and Section 7 concludes with policy recommendations for sustainable financial governance.

2 Literature Review

The literature linking banking dynamics to macroeconomic outcomes can be categorized into four interconnected strands, which collectively highlight the transition from pure financial modeling to socio-economic sustainability analysis.

The first strand contrasts the traditional "intermediation of loanable funds" view with the "credit creation" view (Werner, 2014; Jakab & Kumhof, 2015; McLeay et al., 2014). Rather than acting as passive conduits for pre-existing savings, commercial banks endogenously expand or contract purchasing power. Under adverse conditions, weaker loan originations and reduced loan renewals contract aggregate liquidity. From a sustainability perspective, this endogenous adjustment is not socially neutral; credit contraction acts as a structural barrier that impedes the equitable distribution of financial resources.

The second and third strands integrate these endogenous balance-sheet adjustments into macroeconomic models, particularly dynamic stochastic general equilibrium (DSGE) frameworks (Christiano et al., 2005; Gerali et al., 2010; Dib, 2010). While these models demonstrate how banking frictions and credit-market imperfections propagate shocks (Chenarani et al., 2023; Ahmadyan, 2024), they typically focus on aggregate credit volumes and interest rate spreads. They largely overlook how micro-level bank decisions—such as default risk assessments and loan-renewal policies—directly influence liquidity allocation, credit rationing, and long-term socio-economic resilience (BIS, 2020; IMF, 2021; Sundaresan & Xiao, 2023).

The fourth strand, which is central to this study, explores the heterogeneous and distributional effects of credit conditions across diverse economic agents. Aggregate financial shocks do not affect all households equally. Variations in debt exposure, asset holdings, and reliance on bank credit mean that bank-driven credit contractions generate severe distributional inequalities. Despite the significance of this issue for social equity and financial inclusion, the structural links between endogenous credit contraction, loan-

renewal decisions, and household-level welfare losses remain insufficiently integrated into banking DSGE frameworks.

This paper addresses this gap by building on the endogenous liquidity framework of Tavakolian et al. (2023). We transition the analysis of credit dynamics from aggregate metrics to socio-economic welfare outcomes. By embedding default risk, loan-renewal decisions, and household heterogeneity within a unified framework, this study evaluates how defensive bank behaviors under productivity shocks trigger credit contractions. The contribution of this paper lies in demonstrating that credit contractions are not merely balance-sheet adjustments, but key drivers of asymmetric welfare losses and social instability in the U.S. economy.

3 Model Structure

The model economy consists of heterogeneous households, productive firms, commercial banks, and a monetary authority. Expanding on the endogenous liquidity framework of Tavakolian et al. (2023), we incorporate a structural mechanism where default risk, bank screening, and loan-renewal decisions directly shape credit access, income distribution, and social welfare.

Following the default logic of Hristov (2017) and the rollover dynamics of Forlati and Lamberti (2014), commercial banks under adverse shocks must decide whether to roll over outstanding loans or trigger credit contraction. Unlike simple macroeconomic models, our framework highlights that a credit contraction does not affect households uniformly. We distinguish between liquidity-constrained (borrowing) households and profit-receiving (saving) households.

When banks tighten loan-renewal conditions, the resulting credit contraction limits credit access primarily for liquidity-constrained households, hindering their financial inclusion and reducing their consumption. Conversely, wealth-holding households are insulated from immediate credit shocks but experience delayed effects through the distribution of bank and firm profits. Consequently, the dynamics of default risk and bank balance-sheet adjustments are directly linked to household inequality, rendering credit allocation a key determinant of social sustainability and macroeconomic resilience.

3.1 Households

The household sector is divided into two groups in order to capture differences in labor-market participation, liquidity access, and exposure to credit conditions. This distinction is essential for analyzing the social consequences of credit contraction, because changes in bank lending do not affect all households symmetrically.

Household L consists of workers and liquidity-constrained agents. It supplies labor, earns wage income, and makes consumption and saving decisions under a cash-in-advance constraint. Because this group relies on transaction balances for day-to-day expenditure, its welfare is highly sensitive to loan renewals, deposit creation, and the timing of liquidity availability. In periods of credit tightening, Household L experiences a direct loss in purchasing power and financial inclusion.

Household H represents profit-receiving agents with stronger access to bank deposits and financial income. It receives income from firms and banks and accumulates resources through interest-bearing deposits. Compared with Household L, this group is less exposed to immediate credit shortages and is therefore better insulated from short-run liquidity shocks. As a result, the model captures an important distributional

channel: bank behavior can widen the gap between liquidity-constrained households and wealth-holding households, with direct implications for inequality and social sustainability.

3.1.1 Household L (Workers and Cash Users)

Household L is infinitely lived and chooses consumption, labor supply, money balances, and capital accumulation to maximize expected lifetime utility. Its preferences are defined over consumption, real money balances, and labor, and include external habit formation in consumption. The household's objective function is:

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

This preference structure implies that household welfare increases with consumption and real liquidity holdings, but decreases with labor supply. The inclusion of external habit formation captures consumption persistence, reflecting how past living standards shape current welfare expectations—a key dimension of socio-economic well-being. Crucially, real liquidity holdings only include the balances accessible to Household L when current consumption decisions are made. Any liquidity generated within the period but not yet distributed is excluded from their immediate budget, directly affecting their short-term consumption smoothing and financial security.

Under this setup, Household L acts as the early recipient of bank-created liquidity, representing how credit policies can target financial inclusion. At the beginning of period t, banks generate new deposits through credit expansion, refinancing, or loan rollovers. Before the goods market opens, a fraction of these newly created deposits is transferred to the transaction accounts of Household L. The remaining fraction is retained within the borrowing and production sectors, making it temporarily unavailable to Household H during period t. This wealth-holding group only receives these funds in subsequent periods through profit and dividend distributions.

Let Λ_t^L denote the nominal amount of newly created liquidity transferred to Household L before the goods market opens, and let $\ell_t^L=\frac{\Lambda_t^L}{P_t}$ represent its real value. Because Λ_t^L is credited before current transactions occur, it directly supports the consumption and purchasing power of Household L in period t. Conversely, liquidity retained in the production sector cannot finance current consumption for either household group. This asymmetric timing of liquidity transmission serves as a key channel through which credit contractions generate immediate welfare disparities and undermine social sustainability.

Output is allocated between consumption and investment according to the aggregate resource constraint,

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

while investment determines capital accumulation through

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

Production is generated by a standard Cobb–Douglas technology,

$$Y_t=Z_t{K^{\alpha}}_t L_t^{1-\alpha} \qquad (4)$$

where Z_t denotes total factor productivity. In per-worker terms, output can be expressed as a function of the capital-labor ratio. Productivity follows a first-order autoregressive process,

$$\ln(Z_t)=\rho\ln(Z_{t-1})+\varepsilon_{t+1} \qquad (5)$$

3.1.2 Budget Constraint of Household L

In real terms, the budget constraint of household L is given by:

$$c^L{}_t + m^L{}_t + b^L{}_t + I_t = \omega L_t + \ell_t^L + \frac{m^L{}_{t-1}}{\Pi_t(1+n)} + (1+i_{t-1})\frac{b^L{}_{t-1}}{\Pi_t(1+n)} + \left(\frac{r_t^k k_{t-1} A_t}{1+n} - \frac{\psi(A_t)k_{t-1}}{1+n}\right) \quad (6)$$

This constraint states that expenditures on consumption, money balances, bond holdings, and investment are financed through labor income, previously accumulated monetary assets, returns on financial holdings, net capital income, and the early liquidity transfer received before current expenditure decisions are made. The variable $\ell_t^L = \frac{\Lambda_t^L}{P_t}$ represents the real value of newly created liquidity transferred to household L before the goods market opens in period t.

Capital evolves according to:

$$k_t = (1-\delta)k_{t-1} + I_t\left[1 - s\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right)\right] \quad (7)$$

where the adjustment term captures investment frictions in capital accumulation.

Because household L is subject to a cash-in-advance constraint, current consumption expenditures must be financed using balances that are available before purchases take place. Accordingly,

$$P_t C^L{}_t \leq B^L{}_{t-1} + W_t L_t + M^L{}_t + \Lambda_t^L - T_t \quad (8)$$

Here, Λ_t^L denotes the nominal amount of newly created liquidity that becomes available to household L before current consumption decisions are made. This condition implies that household L purchases goods using demand deposits carried over from the previous period, labor income available before the goods market opens, funds withdrawn from time deposits, and its early share of newly created liquidity. Deposits created during period t but distributed after the goods market closes cannot finance current consumption.

3.1.3 Deposit Dynamics and the Timing of Liquidity Distribution

Time deposits held by household L evolve according to

$$D^L{}_t = D^L{}_{t-1}\left(1 + i_{t-1}^d\right) - M^L{}_t \quad (9)$$

Demand deposits are determined by

$$B^L{}_t = B^L{}_{t-1} + W_t L_t + M^L{}_t - T_t - P_t C^L{}_t + \Lambda_t^L \quad (10)$$

The early liquidity transfer is credited to the transaction account of household L before current purchases take place. Any part of this transfer that is not used for current consumption remains in the household's end-of-period demand deposit balance.

Combining the cash-in-advance constraint with the law of motion for time deposits yields the effective liquidity constraint:

$$P_t C^L{}_t \leq W_t L_t + D^L{}_{t-1}\left(1 + i_{t-1}^d\right) + D^L{}_t - T_t + \Lambda_t^L \quad (11)$$

The early liquidity transfer is defined as

$$\Lambda_t^L = \lambda_t . \Delta D_t{}^{new} \qquad 0 \leq \lambda_t \leq 1 \qquad (12)$$

where ΔD^{new} denotes deposits newly created through additional lending, refinancing, or the capitalization of unpaid obligations, and λ_t denotes the fraction made available to household L before its current consumption decision. A pure extension of loan maturity is excluded from $\Delta D_t{}^{new}$ because it preserves existing deposits but does not create new ones.

The complementary fraction, (1-λ_t) ΔD_t^{new}, is not immediately transferred to household H. Instead, it remains temporarily in the deposit accounts of the borrowing and production sectors. Let S_t denote the end-of-period nominal stock of these retained deposits. Its law of motion is

$$S_t = (1 - \emptyset_t)S_{t-1} + (1 - \lambda_t)\Delta D_t^{new} \qquad 0 \le \emptyset_t \le 1 \qquad (13)$$

At the beginning of period t, household H receives a fraction $\emptyset_t$ of the retained deposit stock inherited from period t-1. The delayed liquidity transfer is therefore defined as

$$\wedge_t^H = \emptyset_t S_{t-1} \qquad (14)$$

Because $\wedge_t^H$ is paid from S_{t-1}, it originates from liquidity created in previous periods and cannot be used by household H in the period in which that liquidity was initially created. The timing mechanism consequently satisfies the accounting identity

$$\Delta D^{new} = \wedge_t^L + \wedge_t^H + (S_t - S_{t-1}) \qquad (15)$$

This identity allocates newly created deposits among three destinations: the amount transferred immediately to household L, the amount released from previously retained deposits to household H, and the change in the stock of deposits that remains temporarily undistributed.

In this framework, household L may hold time deposits, but these holdings serve only as a liquidity-management device under the cash-in-advance restriction. Household L is therefore not the primary source of persistent interest-bearing wealth accumulation. Instead, sustained deposit accumulation is attributed to household H, which is introduced to capture the concentration of bank-created liquidity in the hands of profit-receiving agents.

The intratemporal optimality condition for labor supply is

$$w_t = \frac{\chi\left(l_t^{\eta}\right)}{(c_t - H_t)^{-\sigma}} \qquad (16)$$

3.1.4 Household H (Profit Receivers and Savers)

Household H is a non-optimizing agent that represents the segment of the economy receiving delayed income from the banking and production sectors. It does not supply labor, does not participate in cash-in-advance transactions, and does not choose consumption or investment within the household optimization block. Instead, it receives bank profits, a fixed share of firm profits, and the delayed transfer of bank-created liquidity that is not initially made available to household L. Accordingly, household H captures the accumulation of liquidity with a temporal lag. The resources allocated to this household are credited to interest-bearing time deposits after profits are realized and distributed. Its deposit holdings evolve according to:

$$D^H{}_t = D^H{}_{t-1}\left(1 + i_{t-1}^d\right) + \wedge_t^H + \Pi_t^b + \vartheta\Pi_t^f + \Pi_t^k \qquad (17)$$

where $\wedge_t^{\boldsymbol{H}}$ denotes the delayed transfer of undistributed liquidity, $\boldsymbol{\Pi_t^b}$ is net bank profit after all interest and operating expenses, and $\boldsymbol{\Pi_t^f}$ is net firm profit. This specification avoids double counting by ensuring that only net distributable profits and delayed liquidity transfers are added to household H's time deposits. Household H therefore serves as the recipient of postponed liquidity distribution, allowing the model to capture the concentration of bank-created liquidity in non-transactional deposits and the temporal asymmetry in access to liquidity across household groups.

3.1.5 Aggregation and Liquidity Distribution

Aggregate deposits in the banking system are the sum of transaction deposits held by household L and time deposits held by households L and H. Accordingly,

$$D_t = D_t^L + D_t^H \qquad (18)$$

$$B_t = B_t^L \quad (19)$$

Household H holds no transaction deposits, since it does not participate in current goods-market purchases. Its deposit balances represent delayed receipt of liquidity and accumulated profit distributions rather than means of current transactions. To quantify the endogenous concentration of bank-created liquidity, we define the liquidity concentration index as

$$\omega_t{}^H = \frac{D_t^H}{D_t^H + D_t^L} \quad (20)$$

This index measures the share of aggregate time deposits held by household H and captures the extent to which liquidity is retained in non-transactional form with a delay relative to household L. An increase in $\omega_t{}^H$ indicates that a larger portion of bank-created liquidity is distributed later and held by profit-receiving agents rather than being immediately available for current spending.

3.2 Final-Goods-Producing Firm

A representative competitive firm combines a continuum of intermediate goods indexed by j∈[0,1] into a homogeneous final good using a standard Dixit–Stiglitz aggregator:

$$Y_t = \left[\int_0^1 \omega_j^Y Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (21)$$

where $Y_t(j)$denotes intermediate good j, ε>1is the elasticity of substitution across varieties, and ω_j^Y is a firm-specific demand weight. The final-goods producer operates under perfect competition and chooses {Yt(j)}j∈[0,1] to minimize the cost of producing one unit of the final good, taking intermediate prices $P_t(j)$ and the final-good price P_t as given.

Cost minimization yields the standard demand function for each intermediate good:

$$Y_t(j) = \left(\omega_j^Y \frac{P_t(j)}{P_t}\right)^{-\varepsilon} Y_t \quad (22)$$

This expression implies that demand for each variety is decreasing in its relative price and increasing in aggregate final output. The elasticity parameter ε>1 ensures that the demand schedule faced by monopolistically competitive firms is price elastic.

Under zero profits in the final-goods sector, the corresponding aggregate price index is given by

$$P_t = \left[\int_0^1 \omega_j^{Y\frac{\varepsilon-1}{\varepsilon}} P_t(j)\, d_j\right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (23)$$

This price index aggregates the prices of differentiated intermediate goods into the unit cost of final-good production.

3.3 Intermediate-Goods-Producing Firms

3.3.1 Production Function

A continuum of monopolistically competitive firms produces differentiated intermediate goods. Each firm j uses capital and labor to produce output according to the Cobb–Douglas technology:

$$Y_{j,t} = Z_{j,t} K^{\alpha}{}_{j,t-1} L_{j,t-1}^{1-\alpha} \quad (24)$$

where $k_{j,t-1}$denotes predetermined capital and $L_{j,t-1}$ denotes contemporaneous labor input. Firm-level productivity consists of an aggregate and an idiosyncratic component.

$$Z_{j,t} = \omega_j^Y Z_t \quad (24)$$

where Z_t is aggregate productivity and ω_j^Y is a time-invariant firm-specific term. Aggregate productivity follows a first-order autoregressive process:

$$lnZ_t = \rho\, lnZ_{t-1} + \varepsilon \qquad \varepsilon \sim (0, \partial_Z^2) \qquad (25)$$

The idiosyncratic productivity term is drawn from a continuous distribution with unit mean:

$$\omega_j^Y \sim uniform\left[\underset{\smile}{\omega^Y}, \overline{\omega^Y}\right] \qquad E\left[\omega_j^Y\right] = 1 \qquad (26)$$

This specification allows firms to differ in production efficiency while remaining exposed to common aggregate disturbances. A negative aggregate productivity shock lowers output and firm profitability, thereby weakening debt-servicing capacity and amplifying financial fragility through the banking sector.

3.3.3 Determination of the Default Cutoff for Debt Service Installments

Default on the firm's principal and interest installments occurs when the value of output, net of inventory investment allocated for next period's production and wage payments, is insufficient to meet the scheduled debt service obligations to the bank. This condition is examined in equation (27).

$$P_t Z_{j,t} K^{\alpha}{}_{j,t-1} L_{j,t-1}^{1-\alpha} - W_t L_{j,t} - PAC_{j,t} < \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1} \qquad (27)$$

$DEBT_{j,t-1}$ ، $\Phi_d \epsilon (0,1)$ ،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. Following Ireland (2007) and Schmitt-Grohé and Uribe (2012), prices are assumed to be indexed to long-run inflation and lagged inflation. Accordingly, the price adjustment cost is defined as follows:

$$PAC_{j,t} = \frac{\theta}{2}\left(\frac{P_{j,t}}{P_{j,t-1}\left(\Pi_{t-1}^{fe}\right)^{\mu}(\overline{\Pi}.fe)^{1-\mu}} - 1\right)^2 P_t Y_t \qquad (28)$$

In this equation, θ ،Π و $x \in [0,1]$ و $\mu \in [0,1]$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:

$$\widetilde{\omega}_t^Y = \frac{W_t L_t + PAC + \left(\Phi_d + i_{t-1}^l\right) DEBT_{t-1}}{P_t Z_t K^{\alpha}{}_{t-1} L_{t-1}^{1-\alpha}} \qquad (29)$$

According to equation (29), an increase in the firm's costs—including its debt obligations to the bank, wage payments, the storage of a fraction of output as inventories for use as intermediate inputs, and price adjustment costs—together with a decline in production, raises the probability of debt default.

3.3.4 Determination of the Forbearance Cutoff for Non-Performing Loans

The bank continues to forbear on non-performing loans as long as the value of the firm's total liabilities remains below the value of its total assets. To capture this mechanism, it is assumed that after production takes place, an idiosyncratic shock hits the undepreciated capital stock, thereby altering the value of capital. This assumption is introduced solely to derive the cutoff threshold for loan forbearance, the details of which are discussed below. The idiosyncratic capital shock is assumed to follow a continuous uniform distribution over the interval $\left[\underset{\smile}{\omega^k}, \overline{\omega^k}\right]$.

$$\omega_j^k \sim uniform\left[\underset{\smile}{\omega^k}, \overline{\omega^k}\right] \qquad E\left[\omega_j^k\right] = 1 \qquad (30)$$

Therefore, the condition for loan forbearance is defined as follows:

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3 Rate of Amortization

$$P_t Y_{j,t} - W_t L_{j,t} - PAC_{j,t} + p_t^k(1-\delta)\omega_{j,t}^k k_{j,t-1} \geq \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1} \quad (31)$$

3.3.4.1 The Bank's Default and Forbearance Rule

Banks follow a rule-based decision rule: if a firm's cash flow plus pledgeable assets ≥ debt due, the bank avoids default recognition and rolls over the loan (cosmetic forbearance). Otherwise, default and asset seizure occur. This rule reflects profit maximization, balancing default costs against benefits of maintaining lending relationships. Even after a negative productivity shock reducing output and cash flow, firms may remain solvent on balance-sheet grounds and thus trigger forbearance rather than default.

Forbearance Regime:

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

Default Regime:

then $DEBT_{j,t} = \left(\Phi_d + i_{t-1}^l\right) DEBT_{j,t-1}$ $(32^{\cdot})$

Otherwise: Default and Seizure $(32^{\cdot\cdot})$

This bank forbearance rule forms the basis for defining the probability of cosmetic forbearance on non-performing loans under the continuous uniform distribution, as well as for the firm's debt accumulation law in equation (33).

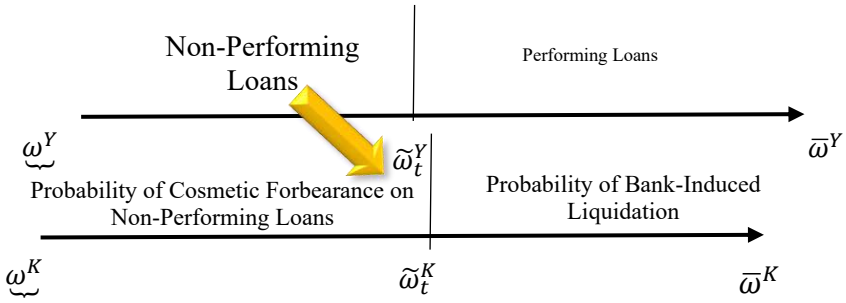
The cutoff threshold for forbearance on non-performing loans, defined by the value of the idiosyncratic shock that renders the above inequality binding, is given by:

$$\tilde{\omega}_t^k = \frac{W_t L_t + PAC + \left(\Phi_d + i_{t-1}^l\right) DEBT_{t-1} - P_t Y_t}{p_t^k(1-\delta)k_{t-1}} \quad (33)$$

According to this relationship, when ω_t^k falls below the cutoff value $\tilde{\omega}_t^k$, the value of the firm's capital increases, thereby reducing the likelihood that the bank seizes all of the firm's assets. For instance, an increase in the firm's outstanding debt, or a decline in inflation, output, or the value of capital, raises the forbearance cutoff. As a result, the probability of debt forbearance declines, while the likelihood of full asset seizure by the bank increases.

The probability of a firm's debt being forborne is derived from the following figure and calculations.

***Figure* 1. Estimated Probability of Cosmetic Forbearance on Non-Performing Loans**



Source: Research Findings

Based on Fig 4, firms are primarily categorized into two broad groups: those capable of debt repayment and those unable to repay their debt. The sum of their estimated probabilities is equal to one.

$$\int_{\underset{\sim}{\omega}^Y}^{\tilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y + \int_{\tilde{\omega}_t^Y}^{\bar{\omega}^Y} f(\omega_t^Y) d\omega_t^Y = 1 \quad (34)$$

$$\int_{\widetilde{\omega}_t^Y}^{\overline{\omega}^Y} f(\omega_t^Y)d\omega_t^Y = \int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^K} f(\omega_t^k)d\omega_t^k + \int_{\widetilde{\omega}_t^K}^{\overline{\omega_t}^k} f(\omega_t^k)d\omega_t^k \quad (35)$$

Combining Equations (34) and (35) yields Equation (36).

$$\int_{\underbrace{\omega^Y}}^{\widetilde{\omega}_t^Y} f(\omega_t^Y)d\omega_t^Y + \int_{\underbrace{\omega^k}}^{\widetilde{\omega}_t^K} f(\omega_t^k)d\omega_t^k + \int_{\widetilde{\omega}_t^K}^{\overline{\omega_t}^k} f(\omega_t^k)d\omega_t^k = 1 \quad (36)$$

$$\Phi_t^F = 1 - \int_{\underbrace{\omega^Y}}^{\widetilde{\omega}_t^Y} f(\omega_t^Y)d\omega_t^Y - \int_{\widetilde{\omega}_t^K}^{\overline{\omega_t}^k} f(\omega_t^k)d\omega_t^k \quad (37)$$

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:

$$\int_{\underbrace{\omega^Y}}^{\widetilde{\omega}_t^Y} \left[(1-\Phi_d)DEBT_{j,t-1}\right] f(\omega_{j,t}^Y)d\omega_{j,t}^Y \quad (38)$$

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

$$\left[DEBT_{j,t-1}\left(1 - \int_{\underbrace{\omega^Y}}^{\widetilde{\omega}_t^Y} f(\omega_t^Y)d\omega_t^Y - \int_{\widetilde{\omega}_t^K}^{\overline{\omega_t}^k} f(\omega_t^k)d\omega_t^k\right)\right](1 + i_{t-1}^l) \quad (39)$$

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.

3.3.4.2 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 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 (32), maturing debts are not repaid and are instead rolled over to subsequent periods. Firm-level debt therefore evolves endogenously according to:

$$DEBT_{j,t} = Loan_{j,t} + \int_{\underset{\sim}{\omega}^Y}^{\tilde{\omega}_t^Y} \left[(1-\Phi_d) DEBT_{j,t-1}\right] f\left(\omega_{j,t}^Y\right) d\omega_{j,t}^Y + \left[DEBT_{j,t-1} \left(1 - \int_{\underset{\sim}{\omega}^Y}^{\tilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y - \int_{\tilde{\omega}_t^K}^{\overline{\omega_t}^k} f\left(\omega_t^k\right) d\omega_t^k \right) \right] \left(1 + i_{t-1}^l\right) \quad (40)$$

As equation (40) indicates, debt forbearance increases firms' outstanding liabilities to banks at a compounded interest rate. Since the default threshold itself is increasing in the level of outstanding debt, this mechanism amplifies the probability of default in subsequent periods.

At the aggregate level, the bank's balance-sheet identity is given by:

$$D_t + BT_t + BD_t = R_t + DEBT_t \quad (41)$$

where D_t denotes aggregate time deposits, BT_t transaction (demand) deposits, and BD_t borrowing from the central bank.

An increase in firms' debt $DEBT_t$ expands the asset side of banks' balance sheets and therefore requires a corresponding increase on the liability side to satisfy equation (41). Within the model, this adjustment occurs endogenously through a combination of deposit creation and central bank borrowing. Consequently, changes in outstanding firm debt mechanically lead to changes in the volume and composition of bank deposits.

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.

3.3.4.3 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. Deposit accumulation is driven by labor income and interest earned on time deposits. The model assumes uniformly distributed, bank-created liquidity. Household H's deposits evolve according to the equation (42):

$$D^H{}_t = D^H{}_{t-1}\left(1 + i_{t-1}^d\right) + \Pi_t^b + \vartheta \Pi_t^f + \Pi_t^k \quad (42)$$

This mechanism transmits liquidity changes through payments and withdrawals, affecting the distribution of deposits. A fall in productivity causes a negative productivity shock, leading to a decline in loan forbearance, which reduces the expansion of bank balance sheets and alters the asymmetry of income and profit flows, causing newly created liquidity to be distributed unevenly among deposit holders.

The profit of firm j is specified by the following condition:

$$\Pi_{j,t}^{f} = \{[P_{j,t}Y_{j,t} - w_t l_{j,t} - PAC_{j,t} - (\Phi_d + i_{t-1}^{l})DEBT_{j,t-1}] \quad \text{Non} \quad (43)$$
$$- \text{default}\}$$

0 default

In fact, the firm maximizes the following profit function, conditional on the intermediate default threshold:

$$maxE_0\left[\sum_{t=0}^{\infty}\beta^t \int_{\underset{\sim}{\omega}^{Y}}^{\widetilde{\omega}_{j,t}^{Y}} [P_{j,t}Y_{j,t} - w_t l_{j,t} - PAC_{j,t} \quad (44)$$
$$- (\Phi_d + i_{t-1}^{l})DEBT_{j,t-1}]\, f(\omega_{j,t}^{Y})d\omega_{j,t}^{Y}\right]$$

The firm's Cash-in-Advance (CIA) constraint for capital purchases will be defined by Equation (45):

$$P_t^k k_{j,t} - (1-\delta)P_t^k k_{j,t-1} + \int_{\widetilde{\omega}_t^{K}}^{\overline{\omega_t}^{k}} [(1-\delta)P_t^k k_{j,t-1}]\, f(\omega_{j,t}^{k})d\omega_{j,t}^{k} \quad (41)$$
$$\leq (P_{j,t}Y_{j,t} - w_t l_{j,t})\left[1 - \int_{\widetilde{\omega}_t^{k}}^{\overline{\omega_t}^{k}} f(\omega_{j,t}^{k})d\omega_{j,t}^{k} \quad \right]$$
$$- \int_{\underset{\sim}{\omega}^{Y}}^{\widetilde{\omega}_{j,t}^{Y}} [(\Phi_d + i_{t-1}^{l})DEBT_{j,t-1}]\, f(\omega_{j,t}^{Y})d\omega_{j,t}^{Y} - \vartheta\Pi_{j,t}^{f}$$
$$+ Loan_{j,t}$$

Differentiating the objective function (44) with respect to constraint (45) will systematically yield the following first-order conditions:

$$\mu_{A,t} = \frac{1}{(1-\vartheta)} \quad (46)$$

$$E_t\beta^t\mu_{A,t} = -E_t\beta^t\mu_{C,t} \quad (47)$$

$$\mu_{C,t} = \beta\frac{1}{1+\pi_{t+1}}\left(\int_{\widetilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}} f(\omega_{j,t+1}^{Y})d\omega_{j,t+1}^{Y}\right).\left((\phi_d + i_t^{l})(1 \quad (48)\right.$$
$$+ \mu_{A,t+1}(1-\vartheta)) - \mu_{C,t+1}.(1-\phi_d)\Big)$$
$$- \frac{1}{1+\pi_{t+1}}\beta.\mu_{C,t+1}\Bigg(1$$
$$- \int_{\widetilde{\omega}_{j,t+1}^{Y}}^{\bar{\omega}^{Y}} f(\omega_{j,t+1}^{Y})d\omega_{j,t+1}^{Y}$$
$$\left. - \int_{\underset{\sim}{\omega}^{k}}^{\widetilde{\omega}_{t+1}^{k}} f(\omega_{j,t+1}^{k})d\omega_{j,t+1}^{k}\,(1+i_t^{l}))\right)$$
$$- \int_{\widetilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} f(\omega_{j,t}^{Y})d\omega_{j,t}^{Y} \quad (49)$$

$$\mu_{A,t} = \frac{}{\left[\left[1 - \int_{\underset{\sim}{\omega}^{k}}^{\widetilde{\omega}_t^{k}} f(\omega_{j,t}^{k})d\omega_{j,t}^{k}\right] + \left[\vartheta\left(\int_{\widetilde{\omega}_{j,t}^{Y}}^{\bar{\omega}^{Y}} f(\omega_{j,t}^{Y})d\omega_{j,t}^{Y}\right)\right]\right]}$$

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

As mentioned in previous sections, the idiosyncratic shocks to productivity and physical capital follow continuous uniform distributions with supports $\left[\underbrace{\omega^Y}, \overline{\omega^Y}\right]$, $\left[\underbrace{\omega^k}, \overline{\omega^k}\right]$ respectively, and a unit mean. Given that the mean and median of a continuous uniform distribution are identical, the supports of these two distributions can be considered as $[1-q^Y, 1+q^Y]$, $[1-q^K, 1+q^K]$ respectively. Accordingly, and based on the properties of the continuous uniform distribution, the following equations can be defined:

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

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

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:

$$\Phi_t^K = \int_{\underbrace{\omega}^k}^{\widetilde{\omega}_t^k} f\left(\omega_{j,t}^k\right) d\omega_{j,t}^k = \frac{\widetilde{\omega}_t^K-(1-q^K)}{(1+q^K)-(1-q^K)} = \frac{\widetilde{\omega}_t^K-(1-q^K)}{2q^K} \qquad (51)$$

In this equation, Φ_t^K represents the probability of the bank seizing all of the firm's assets.

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

$$\Phi_t^N = \int_{\underbrace{\omega}^Y}^{\widetilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y = \frac{\widetilde{\omega}_t^Y-1-q^Y}{2q^Y} \qquad (52)$$

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

$$\mu_{A,t+1} = \frac{-\alpha.\beta.\left[\frac{P_{t+1}(j)}{P_{t+1}}\omega_{j,t+1}^Y\left(\frac{P_{t+1}(j)}{P_{t+1}}\right)\frac{Y_{t+1}}{k_{j,t}}^{-\varepsilon}\right].\Phi_{t+1}^N+\left(\mu_{A,t}.p_t^k\right)}{\beta.\alpha.\left[\frac{P_{t+1}(j)}{P_{t+1}}\omega_{j,t+1}^Y\left(\frac{P_{t+1}(j)}{P_{t+1}}\right)\frac{Y_{t+1}}{k_{j,t}}^{-\varepsilon}\right].\Phi_{t+1}^N(1-\vartheta)+(1-\delta).p_{t+1}^k.(1-\omega_{j,t+1}^k K_{j,t})\Phi_{t+1}^K\left[\left[\frac{\theta}{2.P_{t+1}}\left(\left(\frac{P_{j,t+1}}{P_{j,t}(\Pi_t^{fe})^{\mu}(\Pi.fe)^{1-\mu}}-1\right)^2\right)\right]\Phi_{t+1}^N(\vartheta-1)\right]} \qquad (54)$$

$$\mu_{A,t+1} = \frac{-\left(\mu_{A,t}.p_t^k\right)}{\beta(1-\vartheta)} \qquad (55)$$

$$\mu_{A,t+1} = -\left(\frac{-\Phi_t^N}{\left[[1-\Phi_t^K]+[\vartheta(\Phi_t^N)]\right]}\right)\frac{p_t^k}{\beta(1-\vartheta)} \qquad (56)$$

$$\frac{-\Phi_t^N}{\left[[1-\Phi_t^K]+[\vartheta(\Phi_t^N)]\right]} = \frac{1}{(1-\vartheta)} \qquad (57)$$

$$\Phi_t^K - \Phi_t^N = 1 \qquad (54)$$

$$\mu_{C,t} = \beta\frac{\left(\phi_d+i_t^l\right)}{1+\pi_{t+1}}(\Phi_{t+1}^N)(1+\mu_{A,t+1}(1-\vartheta)-\frac{\beta.\mu_{C,t+1}}{1+\pi_{t+1}}(1-\Phi_{t+1}^F) \qquad (58)$$

$$\mu_{C,t} = -\mu_{A,t} \qquad (59)$$

$$\mu_{C,t+1} = -\mu_{A,t+1} \qquad (60)$$

$$\mu_{C,t} = \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N)(1+\mu_{A,t+1}(1-\vartheta) - \frac{\beta.\mu_{C,t+1}}{1+\pi_{t+1}}(1 - \Phi_{t+1}^F) \quad (61)$$

$$\frac{1}{(1-\vartheta)} = \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N)(1-\mu_{C,t+1}(1-\vartheta) - \frac{\beta.\mu_{C,t+1}}{1+\pi_{t+1}}(1-\Phi_{t+1}^F) \quad (62)$$

$$\frac{1}{(1-\vartheta)} = \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N) - \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N)\mu_{C,t+1}(1-\vartheta) - \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N).\frac{\beta.\mu_{C,t+1}}{1+\pi_{t+1}}(1 - \Phi_{t+1}^F) \quad (63)$$

$$\beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N).\frac{\beta.\mu_{C,t+1}}{1+\pi_{t+1}}(1-\Phi_{t+1}^F) + \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N)\mu_{C,t+1}(1-\vartheta) = \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N) - \frac{1}{(1-\vartheta)} \quad (64)$$

$$\beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N).\frac{\beta.\mu_{C,t+1}}{1+\pi_{t+1}}\Big((1-\Phi_{t+1}^F) + (1-\vartheta)\Big) = \beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N) - \frac{1}{(1-\vartheta)} \quad (65)$$

$$\mu_{C,t+1} = \frac{(\beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N) - \frac{1}{(1-\vartheta)})}{\beta \frac{(\phi_d + i_t^l)}{1+\pi_{t+1}}(\Phi_{t+1}^N).\frac{\beta}{1+\pi_{t+1}}\big((1-\Phi_{t+1}^F) + (1-\vartheta)\big)} \quad (66)$$

$$\Phi_t^F = 1 - \Phi_t^N - \Phi_t^K \quad (67)$$

$$\Phi_t^K = 1 + \Phi_t^N \quad (68)$$

$$\Phi_t^F = 1 - \Phi_t^N - 1 - \Phi_t^N \quad (69)$$

$$\Phi_t^F = -2\Phi_t^N \quad (70)$$

Based on the aforementioned properties, the Cash-in-Advance (CIA) constraint can be obtained as follows:

$$\begin{aligned} P_t^k k_{j,t} - (1-\delta)P_t^k k_{j,t-1} + \int_{\tilde{\omega}_t^K}^{\overline{\omega_t}^k} \big[(1-\delta)P_t^k k_{j,t-1}\big] f\big(\omega_{j,t}^k\big) d\omega_{j,t}^k \\ \leq \big(P_{j,t}Y_{j,t} - w_t l_{j,t}\big)\left[1 - \int_{\tilde{\omega}_t^k}^{\overline{\omega_t}^k} f\big(\omega_{j,t}^k\big) d\omega_{j,t}^k \right] \\ - \int_{\underbrace{\omega^Y}}^{\tilde{\omega}_{j,t}^Y} \big[(\Phi_d + i_{t-1}^l) DEBT_{j,t-1}\big] f\big(\omega_{j,t}^Y\big) d\omega_{j,t}^Y - \vartheta \Pi_{j,t}^f \\ + Loan_{j,t} \end{aligned} \quad (71)$$

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

$$\Phi_t^N = \frac{\big(P_{j,t}Y_{j,t} - w_t l_{j,t}\big) - \vartheta \Pi_{j,t}^f + Loan_{j,t} - P_t^k k_{j,t} + (1-\delta)P_t^k k_{j,t-1} - \big[(1-\delta)P_t^k k_{j,t-1}\big]}{\big[(\Phi_d + i_{t-1}^l) DEBT_{j,t-1}\big] - \big(P_{j,t}Y_{j,t} - w_t l_{j,t}\big) - \big[(1-\delta)P_t^k k_{j,t-1}\big]} \quad (72)$$

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

3.4 Capital Goods Producing Firms

Capital goods producing firms operate in a competitive market. They purchase final goods to produce new capital goods, which are subsequently sold to intermediate goods producers. The expected nominal profit function for these firms is defined as follows:

$$\max E_0 \sum_{t=0}^{\infty} \frac{\beta^t}{P_t} \{[\Pi_t^k = p_t^k [K_t - (1-\delta)K_{t-1}] - P_t I_t]\} \quad (73)$$

According to Equation (73), 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:

$$K_t = (1-\delta)K_{t-1} + I_t - \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t \quad (74)$$

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:

$$p_t^k = \frac{P_t}{\left(1 + \frac{1}{P_t}\frac{\kappa}{2} 2\left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}} + \frac{1}{P_t}\frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right)} \quad (75)$$

3.5 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 deposit interest rate paid to individuals and the bank's borrowing interest rate is subtracted from the profit function. Their profit function will be defined as follows:

$$\begin{aligned} \Pi_t^b = & \int_{\underbrace{\omega^Y}}^{\tilde{\omega}_t^Y} i_{t-1}^l \, DEBT_{t-1} f(\omega_t^Y) d\omega_t^Y \\ & + i_{t-1}^l DEBT_{t-1} \left(1 - \int_{\underbrace{\omega^Y}}^{\tilde{\omega}_t^Y} f(\omega_t^Y) d\omega_t^Y \right. \\ & \left. - \int_{\tilde{\omega}_t^K}^{\overline{\omega_t}^k} f(\omega_t^k) d\omega_t^k \right) \\ & + \int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^k} [(1-\delta)p_t^k K_{t-1} + P_t Y_t - PAC_t - W_t L_t \\ & - DEBT_{t-1}] f(\omega_t^k) d\omega_t^k - i_{t-1}^d D_{t-1} \\ & - i_{t-1}^{bd} BD_{t-1} \end{aligned} \quad (76)$$

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 و 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.

One of the key assumptions of this framework is that, after creating liquidity through double-entry bookkeeping and in line with the endogenous money creation paradigm, banks 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:

$$BD_t = rr_b BT_t + rr_d D_t - \left[R_{t-1} - BD_{t-1}\left(1 + i_{t-1}^{bd}\right)\right] \quad (77)$$

Equation (74) 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.

The term in parentheses in equation (77) 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 (77).

$$\begin{aligned} L = \max E_t \Bigg[\sum_{t=0}^{\infty} \beta^t \Bigg(& \int_{\tilde{\omega}_t^Y}^{\overline{\omega_t}^Y} i_{t-1}^l \frac{debt_{t-1}}{(1+\pi_t)} f(\omega_t^Y) d\omega_t^Y \\ & + i_{t-1}^l \frac{debt_{t-1}}{(1+\pi_t)} \Bigg(1 - \int_{\tilde{\omega}_t^Y}^{\overline{\omega_t}^Y} f(\omega_t^Y) d\omega_t^Y \\ & - \int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^k} f\left(\omega_t^k\right) d\omega_t^k \Bigg) \\ & + \int_{\underbrace{\omega^k}}^{\tilde{\omega}_t^k} \left[\frac{(1-\delta)}{(1+\pi_t)} p_t^k K_{t-1} + Y_t - pac_t - w_t L_t \right. \\ & \left. - \frac{debt_{t-1}}{(1+\pi_t)} \right] f\left(\omega_t^k\right) d\omega_t^k - i_{t-1}^d \frac{d_{t-1}}{(1+\pi_t)} \\ & - i_{t-1}^{bd} \frac{bd_{t-1}}{(1+\pi_t)} \Bigg) \\ & + E_t \lambda_t \beta^t \left[d_t + bt_t + bd_t - \frac{R_t}{P_t} - debt_t \right] \\ & + E_t \mu_t \beta^t \Bigg[rr_b bt_t + rr_d d_t \\ & - \left[\frac{R_{t-1}}{(1+\pi_t)} - \frac{bd_{t-1}}{(1+\pi_t)} \left(1 + i_{t-1}^{bd}\right) \right] \\ & - bd_t \Bigg] \Bigg] \end{aligned} \quad (78)$$

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:

$$\lambda_t = \frac{\beta i_t^l \left[Q_{t+1}^N + Q_t^F - Q_t^k\right]}{(1+\pi_{t+1})(1+n)} \quad (79)$$

$$\mu_t = \frac{\frac{\beta i_t^d}{(1+\pi_{t+1})} - \lambda_t}{rr_d} \quad (80)$$

$$i_t^d = \frac{(1+\pi_{t+1})}{\beta} \quad (81)$$

Social welfare is derived from the representative household's utility, with fluctuations driven by consumption, labor supply, and inflation. Since households interact with goods, labor, and banking markets, firm and bank constraints transmit real and financial shocks to welfare. Shocks in banking and liquidity creation directly affect welfare via their impact on agents' optimization constraints.

3.6 Government

The government's budget constraint is given by:

$$g_t = T_t + gd_t - \frac{gd_{t-1}}{1+\pi_t} \quad (82)$$

According to this budget constraint, government revenues consist of tax revenues, T_t, and borrowing from the central bank, gd_t, which are used to finance government expenditures. It is assumed that government tax revenues depend on the level of output, as follows:

$$T_t = t.Y_t \quad (83)$$

where t denotes the income tax rate.

3.7 Market Clearing Conditions

The market clearing conditions for goods and asset markets are defined as follows:

$$Y_t = C_t + I_t + G_t + pac_t \quad (84)$$

4Model Solution and Analysis of Results

4.1 Calibration

The model is evaluated under a negative technology shock that reduces total factor productivity. The parameters are calibrated using three sources:

1. Standard values from the literature;
2. U.S. macroeconomic data for 2000–2024 to match key institutional features;
3. Estimates of the persistence and volatility of the technology process.

The calibrated parameter values are reported in Tables 2 and 3.

Table 1. ***Key Variables of the Model in the Steady State***

Source	Value	Symbol	Variable
Solving the steady-state	0.08	y	Output

The assumption of working one-third of a day	0.33	l	Working Hours
Central Bank data.	0.20	$\frac{k}{y}$	The Ratio of Physical Capital to Output
Central Bank data	0.15	$\frac{G}{y}$	The Ratio of Government Expenditures to Output
Central Bank data	0.82	$\frac{c}{y}$	The Ratio of Private Consumption to Output
Solving the steady-state	0.03	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	0.02	i_d	Deposit Interest Rate
Solving the steady-state	0.5	Q_Y	Probability of Default on Matured Installments and Debt Interest

Table 2. ***Calibrated Parameters***

Source	Value	symbol	Parameter
Albuquerquemello & Besarria (2018)	0.9925	β	Time Discount Rate
Albuquerquemello & Besarria (2018)	0.448	α	Production Elasticity with Respect to Capital
Albuquerquemello & Besarria (2018)	0.52	σ	Relative Risk Aversion Coefficient
Benchimol & Fourçans (2025)	1.447	b	Inverse Interest Elasticity of Demand for Real Money Balances
Word Bank data	0.02	n	Production Growth Rate
Smets & Wouters (2003)	0.998	ρ_Z	Autoregressive Coefficient of the Productivity Process
Sienknecht (2016)	9.55	$\theta\theta$	Price Adjustment Cost
Albuquerquemello & Besarria (2018)	0.015	δ	Capital Depreciation Rate
Albuquerquemello & Besarria (2018)	1	ŋ	Labor elasticity of substitution
Central Bank data	0.02	π	Average Inflation Rate

5 Model Fit and Performance Evaluation

Model performance is evaluated by comparing simulated moments with U.S. data. All variables are normalized using the min–max method to ensure comparability. As reported in Table 4, the model reproduces the relative ordering of average consumption and output but generates substantially greater

volatility than observed in the data, particularly for consumption and GDP. The discrepancies indicate that the model should be interpreted primarily as a framework for analyzing the mechanisms of endogenous money creation and liquidity distribution rather than as a forecasting model.

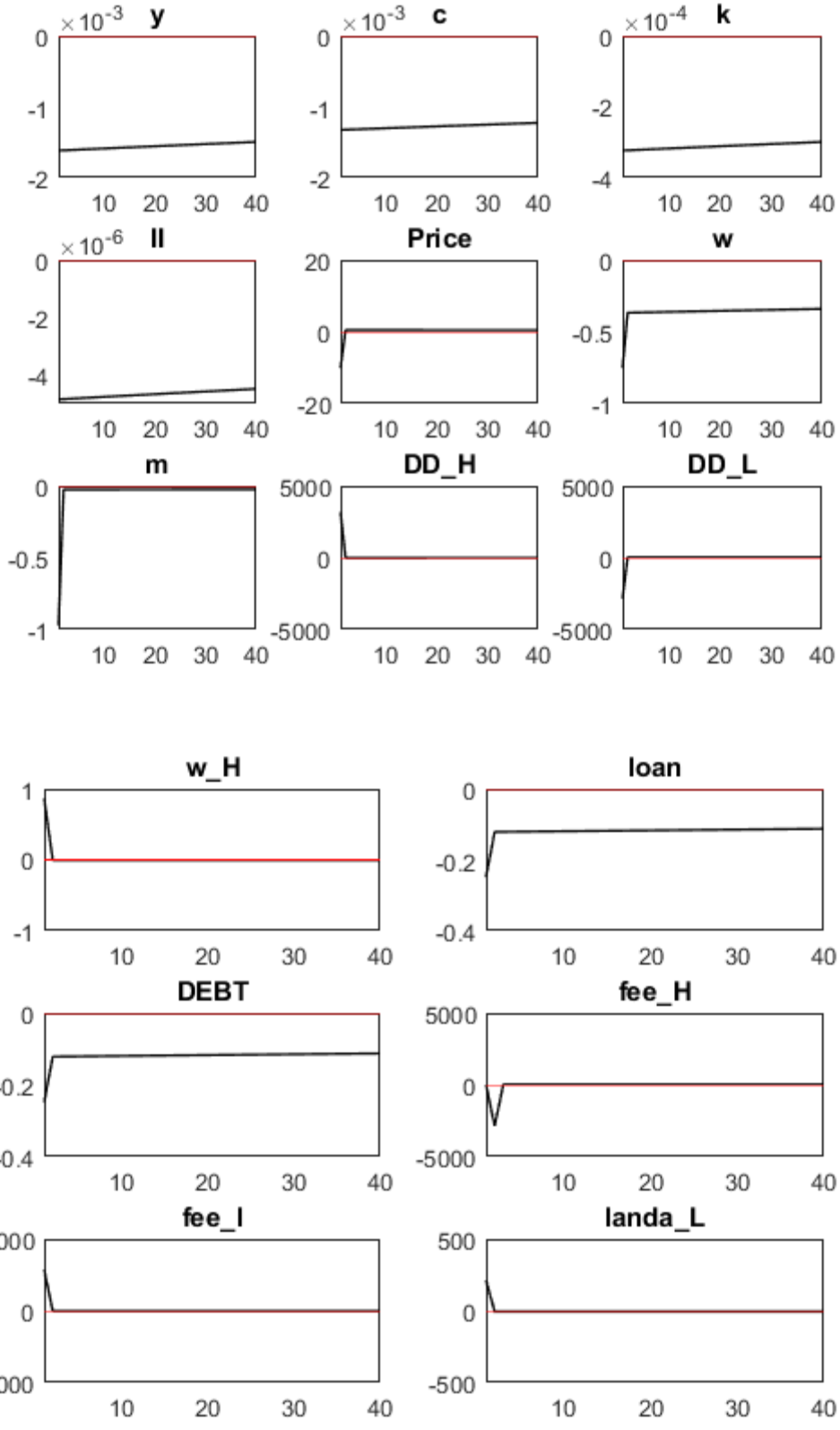
Table 3. Comparison of Model Moments with U.S. Data

	S.D		Average	Variable
Model	Data	Model	Data	
0.0210	0.0013	0.0733	0.0302	Consumption
0.0256	0.0014	0.0894	0.0304	GDP
0.0051	0.0034	0.0179	0.0288	Capital
0.0038	0.0009	0.0134	0.0285	Government Expenditures

6 Results Analysis

A negative productivity shock leads to a significant decline in economic activity and disrupts the distribution of liquidity between two household groups: Household L (liquidity-constrained and early recipient) and Household H (more liquid and late recipient). This shock initially begins with a decrease in output and firm productivity. Consequently, banks act more cautiously, reducing new lending. The overall decrease in aggregate supply and demand, coupled with a reduction in the economy's cash flow, leads to a decline in the general price level, nominal wages, physical capital, and investment.

***Figure* 2. Impulse Response to Negative Productivity Shock**



Source: Authors' Calculations

However, this shock has differential effects on the two household groups, primarily stemming from the difference in their liquidity timing and liquidity constraints. Household L, which receives liquidity early (mainly through new bank loans and firms' current payments), experiences an increase in its share of new bank loans, despite the overall decline in economic activity, as indicated by the simulation results. This could be due to banks prioritizing lending to this group during a shock to cover their minimal transaction needs. Nevertheless, due to a severe Cash-in-Advance constraint, the newly received liquidity is immediately spent on current expenses and maintaining minimum consumption, leaving no opportunity for accumulation as time deposits, which results in a decrease in this household's time deposit balances.

In contrast, Household H, which receives liquidity with a delay (through delayed income streams such as interest on time deposits), faces a reduction in its liquidity intake. However, due to the lack of immediate need for liquidity, possession of accumulated wealth (financial buffer), and a tendency to save in deposits as a safe asset in times of uncertainty, it prefers to save its limited liquidity. This leads to an increase in this household's time deposit balances.

These results clearly illustrate a fundamental difference in liquidity timing between the two households: Household L, despite receiving seemingly more cash flow during the shock, is unable to accumulate it as deposits, while Household H, despite receiving less liquidity, maintains its ability to accumulate wealth. This situation leads to a worsening inequality in the distribution of liquidity and wealth between the two households. While the banking system attempts to maintain a minimum cash flow for Household L, the delayed receipt mechanism for Household H results in a relative accumulation of wealth compared to Household L.

Finally, the overall decrease in new lending and reduced economic activity ultimately leads to a decrease in the total debt of firms to banks in the long run. These findings effectively demonstrate how differences in household liquidity timing and constraints lead to divergent financial situations and liquidity distributions when faced with economic shocks.

7 Conclusion

The analysis of the negative productivity shock reveals a crucial insight into the dynamics of wealth distribution: the timing of liquidity receipt plays a pivotal role in exacerbating economic inequality. Our model demonstrates that in the face of economic downturns, households with different liquidity access patterns experience vastly different outcomes.

Household L, characterized by its early liquidity receipt and severe Cash-in-Advance constraint, finds itself in a precarious position. Despite receiving a larger share of new loans during the shock, this liquidity is immediately consumed to meet pressing expenses, leaving no room for wealth accumulation. The increased cash flow serves merely to maintain a minimum level of consumption, preventing any meaningful savings. This highlights how immediate liquidity access, without the capacity for saving, can trap households in a cycle of financial vulnerability.

Conversely, Household H, with its delayed liquidity receipt and greater financial resilience, navigates the downturn more effectively. Although its incoming liquidity decreases, its ability to save and accumulate wealth remains intact. This is due to its lack of immediate spending pressures

and its tendency to prioritize saving in secure assets like time deposits. As a result, Household H not only weathers the storm better but also increases its relative wealth compared to Household L.

The stark contrast in outcomes between these two households underscores the significance of liquidity timing as a fundamental driver of inequality. The banking system's attempt to provide immediate liquidity to Household L, while seemingly supportive in the short term, ultimately fails to translate into sustainable wealth building due to the binding liquidity constraints. In parallel, Household H's delayed access, coupled with its capacity for saving, allows it to fortify its financial position.

In conclusion, our findings strongly suggest that the differential timing of liquidity access is not merely a feature of the economic system but a potent mechanism that can amplify existing inequalities and create new disparities during economic shocks. This underscores the need for policy interventions that consider not only the volume of liquidity but also its timely and equitable distribution across different segments of the population.

Declarations

1. Ethics approval and consent to participate

Not applicable. This study does not involve human participants, human data, human tissue, or animals.

2. Consent for publication

Not applicable.

3. Availability of data and materials

The data and materials used and/or analysed during the current study are available from the corresponding author upon reasonable request.

4. Competing interests

The authors declare that they have no competing interests.

5. Funding

The authors received no specific funding for this research.

6. Authors' contributions

ZM contributed to the conceptualization of the study, model development, data analysis, interpretation of the results, and drafting of the manuscript. RB contributed to the research design, model specification, interpretation of the findings, and critical revision of the manuscript. MVB contributed to the methodology, validation of the analysis, interpretation of the results, and revision of the manuscript. All authors read and approved the final manuscript.

7. Acknowledgements

Not applicable.

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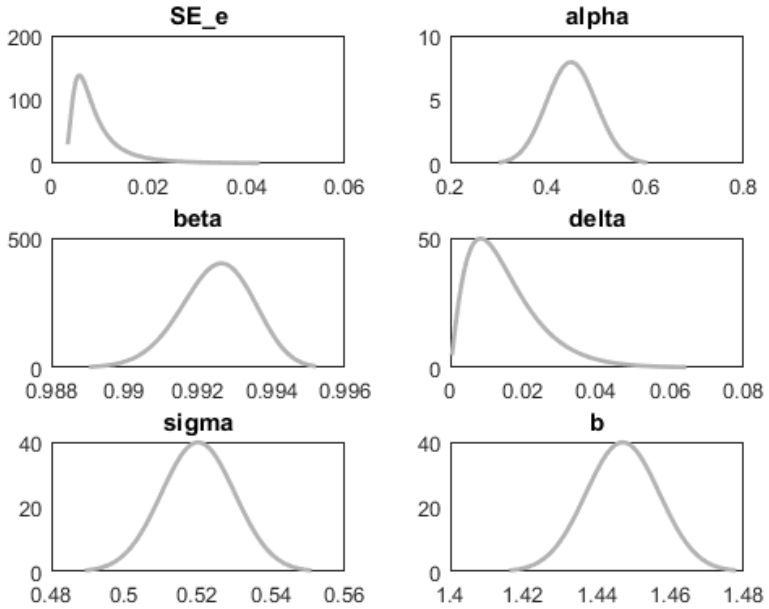
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Appendix B

B.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.

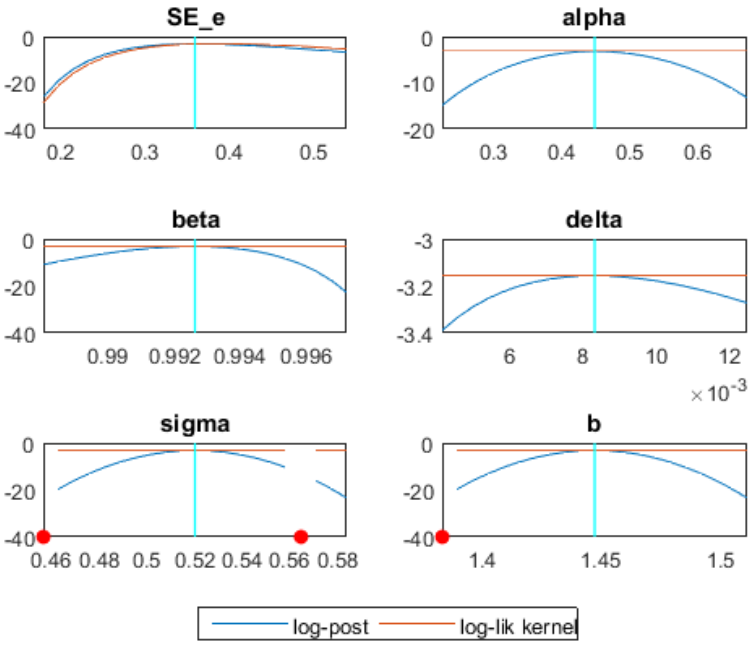
***Figure* B.1 Estimated Posterior Distributions of Key DSGE Model Parameters under Bayesian Inference**



Source: Authors' calculations

Fig B-1 shows posterior distributions for key DSGE model parameters, estimated using MCMC with annual data (2000–2024). Peaks represent modal values, and spread reflects uncertainty. Comparing them to calibrated benchmark values assesses model robustness and sensitivity to prior assumptions.

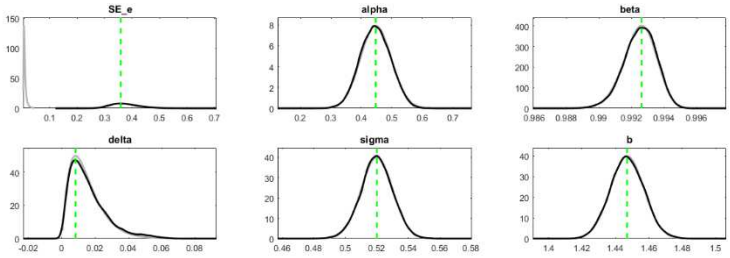
Figure B-2. Log-Likelihood Profiles of Key DSGE Model Coefficients under Bayesian Estimation



Source: Authors' calculations

This figure 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.

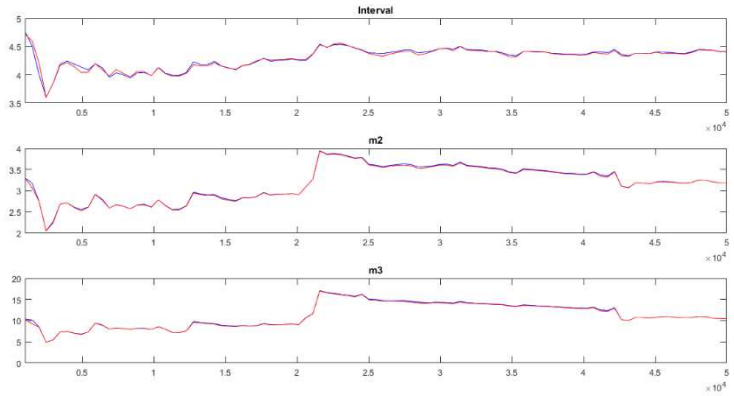
***Figure* B-3. Bayesian Estimation Analysis and Calibration Consistency in the DSGE Framework**



Source: Authors' calculations

Figure [B-3] presents the estimated posterior distributions for the key parameters of the DSGE model, obtained via the Markov Chain Monte Carlo (MCMC) estimation method. The green dashed lines represent the mode of the posterior distributions. As illustrated, parameters such as α (capital share), β (discount factor), σ, and b and concentrated distributions, indicating high identifiability and robust estimation precision. In contrast, the parameter δ (depreciation rate) displays a noticeable positive skew, reflecting its specific dynamic adjustment relative to the observed data. The concentration of probability mass around the modal values confirms the internal consistency of the model with the empirical data and provides evidence of the stability and convergence of the estimation algorithm. Overall, the narrow profiles of the majority of parameters suggest that the model is well-identified and that the posterior estimates are reliably centered around the benchmark values.

***Figure* B-4. Bayesian Estimation and MCMC Convergence Diagnostics in the DSGE Model**



Source: Authors' calculations

This figure shows MCMC trace plots and convergence diagnostics for key DSGE model quantities. The horizontal axis represents MCMC iterations, and the vertical axis shows simulated values. The red and blue lines (independent chains) overlap significantly, indicating convergence and estimation stability. The absence of trending behavior and flat evolution after the burn-in period confirm that posterior distributions are independent of initial conditions and that model parameters are well-behaved within the estimated posterior support.

Table B-1. ***Prior and Posterior Distributions of Key DSGE Model Coefficients under Bayesian Estimation***

parameters						
	prior mean	post. mean	90% HPD interval		prior	pstdev
alpha	0.448	0.4454	0.3627	0.5234	beta	0.0500
beta	0.993	0.9925	0.9910	0.9942	beta	0.0010
delta	0.015	0.0158	0.0008	0.0310	beta	0.0100
sigma	0.520	0.5198	0.5038	0.5365	norm	0.0100
b	1.447	1.4470	1.4304	1.4631	norm	0.0100

Table B-1 presents the Bayesian estimation results for the key structural parameters of the DSGE model. The posterior means for α,β,δ,σ , and b are remarkably close to their respective prior means, suggesting that

the model specification is highly consistent with the observed data. Notably, the 90% Highest Posterior Density (HPD) intervals are relatively narrow, indicating that the data provide substantial information for identifying these parameters. The stability of the posterior estimates relative to the prior distributions underscores the robustness of the model's calibration. Furthermore, the convergence of the Markov Chain Monte Carlo (MCMC) algorithm, combined with the tight HPD intervals, confirms the reliability of the estimation and suggests that the structural parameters are well-identified within the proposed framework.