

Asymmetric Monetary Pass-Through and Bank Spread in Brazil: Evidence from a Bayesian DSGE with Banking Sector

Resumo

Este artigo apresenta um modelo DSGE Novo Keynesiano com um setor bancário explícito para o Brasil, estimado com métodos bayesianos, no qual as taxas de depósito e empréstimo – e o spread bancário – são endógenos. Dentro de uma única estrutura, (i) fornecemos uma decomposição estrutural do spread em risco de inadimplência, risco idiossincrático/poder de mercado e compulsório/financiamento; (ii) medimos as elasticidades e meias-vidas do repasse monetário sobre as margens de depósito e empréstimo; e (iii) executamos contrafactuais monetário-macprudenciais com métricas de bem-estar. Documentamos o repasse incompleto e assimétrico: a taxa de depósito se ajusta gradualmente (repasse de curto prazo $\approx 0,24$ por trimestre; meia-vida $\approx 2,5$ trimestres), enquanto a taxa de empréstimo reage mais rápida e fortemente, ampliando temporariamente o spread. Os riscos de inadimplência e idiossincrático explicam conjuntamente $\sim 70\text{--}75\%$ da variância do spread, enquanto os compulsórios/financiamento desempenham um papel secundário. Esses resultados são economicamente significativos para o investimento e a atividade e apoiam a calibração coordenada de instrumentos monetários e macprudenciais com foco na mitigação do risco de crédito.

Palavras-chave: *pass-through* bancário; *spread* bancário; modelo DSGE com setor bancário; política macprudencial; política monetária.

Abstract

This paper presents a New Keynesian DSGE model with an explicit banking sector for Brazil, estimated with Bayesian methods, in which deposit and lending rates – and the bank spread – are endogenous. Within a single framework, we (i) provide a structural decomposition of the spread into default risk, idiosyncratic risk/market power, and reserve requirements/funding; (ii) measure elasticities and half-lives of monetary pass-through on both deposit and lending margins; and (iii) run monetary–macroprudential counterfactuals with welfare metrics. We document incomplete and asymmetric pass-through: the deposit rate adjusts gradually (short-run pass-through ≈ 0.24 per quarter; half-life $\approx 2\frac{1}{2}$ quarters), whereas the lending rate reacts faster and more strongly, temporarily widening the spread. Default and idiosyncratic risk jointly explain $\sim 70\text{--}75\%$ of the spread’s variance, while reserve requirements/funding play a secondary role. These results are economically meaningful for investment and activity and support the coordinated calibration of monetary and macroprudential instruments focused on credit-risk mitigation.

Keywords: bank pass-through; bank spread; DSGE with banking sector; macroprudential policy; monetary policy.

JEL: E44; E52; G21.

1 Introduction

The cost of credit and its transmission to economic activity remain central to the Brazilian macroeconomy. The dynamics of the banking spread and the pass-through of the base rate to deposit and lending rates shape the trajectory of investment, output, and inflation. Despite the consensus on the determinants of the spread, the evidence for Brazil still lacks a structural decomposition, in general equilibrium, capable of quantifying with transparent identification the relative contribution of each component and their real and nominal effects throughout the cycle.

To fill this gap, we propose and estimate, for Brazil, a New Keynesian DSGE model with an explicit banking sector, estimated using Bayesian methods, which endogenizes deposit and lending rates, and the spread. The framework combines monopolistically competitive firms with price stickiness and the cost of adjusting investment; Ricardian households and income-constrained households; and monetary policy described by a Taylor rule with inertia. In the banking sector, (i) the pass-through of the base rate to the deposit rate incorporates inertia in the passive margin, and (ii) the spread is decomposed into three observable forces: default, funding costs/compulsory reserves, and risk/idiosyncrasy/market power (markup). Macroprudential policy is represented by reserve requirements as implicit taxation on deposits; In addition, regulatory capital and potential medium-term trade-offs are discussed. On the real side, the spread is included in the cost of using capital and Tobin's q , transmitting financial shocks to investment, output, and inflation.

Three questions guide the study: (i) what is the speed and degree of pass-through of the Selic rate to the deposit rates (passive margin) and lending rates (active margin)? (ii) what is the relative contribution of default, funding costs/compulsory reserves, and risk/idiosyncrasy/market power in the formation of the spread, in normal and stressed regimes? (iii) what are the quantitative effects – on spread, credit, investment, output and inflation – of changes in monetary and macroprudential instruments?

The guiding hypotheses align with international evidence and Brazilian institutional characteristics: (H1) the Selic rate's pass-through to the deposit rate is incomplete and slower than that to the lending rate, temporarily increasing the spread after contractionary shocks; (H2) in normal times, risk/idiosyncrasy/market power explain a significant portion of the spread, while in times of stress, defaults and funding/liquidity costs gain weight; (H3) reserve requirement reductions make funding cheaper and can accelerate the pass-through to the

passive margin; (H4) higher capital requirements increase resilience and reduce equilibrium defaults, but can increase spreads, creating measurable trade-offs.

The article offers (i) a structural decomposition of the spread that separates defaults, risk/idiosyncrasy/market power, and funding/requirement costs; (ii) the measurement of pass-through with elasticities and half-lives in the passive and active margins; and (iii) monetary and macroprudential policy counterfactuals with welfare metrics, in a DSGE estimated for Brazil. This combination, applied to recent Brazilian data, quantifies central mechanisms of spread formation and their interaction with monetary policy.

To this end, the article is organized into five sections in addition to this introduction. Section 2 discusses the related literature and the transmission mechanisms that underlie the empirical model. Section 3 presents empirical evidence. Section 4 describes the model structure. Section 5 presents the data, estimation, and results. Finally, concluding remarks follow.

2 Literature related to the financial system

The review related to the financial system is organized into four interconnected axes, namely: (i) monetary pass-through and spread formation; (ii) DSGE with financial intermediation; (iii) macroprudential instruments; and (iv) Brazilian specificities.

2.1 Monetary pass-through and spread formation

The transmission of the base rate to bank rates is typically and persistently incomplete, due to competitive frictions, adjustment costs, and risk perception present on both sides of banks' balance sheets. On the passive side, deposit remuneration exhibits strong inertia because the demand for transactional instruments is inelastic, given loyalty, switching costs, convenience, and the regulatory framework. On the active side, lending rates tend to adjust more frequently, whether through repricing during contract renewals, indexation clauses, or competitive pressures in specific segments. In contractionary shocks, the lending rate tends to rise before the deposit rate, which temporarily widens the difference between the two – that is, the banking spread. In expansionary shocks, the opposite movement is observed, although the rate at which the lending rate falls is usually slower than its rate of rise, revealing asymmetries in the pass-through.

Credit pricing incorporates credit risk components, such as the probability of default and the loss given default, and liquidity and funding components, such as funding premiums, liabilities, and liquidity constraints. In normal times, markups and operating costs account for a significant portion of the spread; in stressful periods, the contribution of risk tends to predominate, increasing premiums and compressing volumes. This dynamic is consistent with the credit channel (Bernanke and Gertler, 1995) and the financial accelerator (Bernanke, Gertler, and Gilchrist, 1999), according to which balance sheet deteriorations increase premiums, reduce investment, and amplify the cycle. In quantitative terms, the literature documents shorter half-lives for the lending rate than for the deposit rate, asymmetries in pass-through, and a strong dependence on the state of the cycle: risk and liquidity weigh more heavily in recessions, while market power and operating costs gain prominence in calm periods. At the macroeconomic level, the spread enters into the cost of using capital and the installation value of capital, in Tobin's sense, so that its widening tends to reduce investment and output with lags.

2.2 DSGE with the banking sector and endogenous spreads

Dynamic stochastic general equilibrium models with financial intermediation make spreads endogenous and explain the interaction between monetary policy, financial shocks, and real decisions. In Gerali et al. (2010), banks simultaneously choose the deposit rate (passive margin) and the lending rate (active margin) under market power, adjustment costs, and regulatory constraints, generating spreads that vary throughout the cycle. In Cúrdia and Woodford (2010), heterogeneity among borrowers – with types that differ in default probability – places the credit premium at the center of the policy problem. The family of models by Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) highlights balance sheet frictions and bank leverage limits; while Christiano, Motto, and Rostagno (2014) model risk shocks that shift premiums even without significant changes in the real cycle.

In this framework, the pass-through in the passive margin is slower than in the active margin because the fundraising structure imposes inertia on the deposit rate, including through regulatory instruments such as reserve requirements, which function as an implicit tax on deposits. The formation of the banking spread arises from the combination of credit risk, cost of fundraising and liquidity, and market power (mark-up), with relative participation that varies throughout the cycle. This spread, in turn, affects the cost of using capital and the installed value of capital, reducing investment when it widens, even if the base rate moves little. For the

purposes of this study, the model allows us to measure the elasticities and half-lives of the pass-through in both margins, identify the contribution of risk, fundraising, and market power to the dynamics of the banking spread, and evaluate counterfactuals of monetary and macroprudential policy in general equilibrium, including welfare metrics.

2.3 Macroprudential, reserve requirements, and capital: interaction with monetary policy

Macroprudential policy operates primarily through regulatory capital and borrowing requirements. Regulatory capital increases loss-absorbing capacity reduces the likelihood of crises and improves the system's resilience. However, because it is an expensive input, it tends to widen spreads and compress quantities in normal times, with benefits that materialize primarily in the medium term (Meh and Moran, 2010). Borrowing requirements – like reserve requirements – directly affect the cost of raising funds: by immobilizing part of low-yield liabilities, they increase funding costs, compress depositor remuneration, and slow down the transfer of funds into the passive margin. When reduced or temporarily relaxed, they tend to close the spread and sustain credit volumes, especially in contexts of slack.

The interaction with monetary policy depends on the state of the cycle. During tightening periods, the sticky nature of the deposit rate temporarily widens the spread; in this situation, adequate calibration of reserve requirements can cushion the widening without compromising the anchoring of expectations. In episodes of financial stress, higher capital levels increase the robustness of the system, but, if combined with a high cost of funding, can induce excessive credit contraction; in this case, temporary relief in the passive margin helps maintain intermediation while monetary policy pursues its objectives. Empirically, changes in these instruments leave observable signatures: reserve requirement releases tend to reduce the differential between the base rate and the funding rate and compress the spread; tightening of capital requirements tends to gradually increase the spread and improve risk indicators. Such events offer useful variation for identification in estimation.

2.4 Evidence and specificities of Brazil: series and identification

The Brazilian case presents institutional features that shape the formation and dynamics of the spread. The history of high reserve requirements and the intense use of stable funding sources – demand and time deposits, in addition to savings – make the deposit rate relatively inelastic in the short term. The regulatory segmentation between free and earmarked credit

alters both the level and sensitivity of the spread to policy: in free credit, financial conditions are transmitted more directly; in earmarked credit, rules and subsidies dampen the response. Heterogeneity by borrower and product – individuals and legal entities; revolving credit, payroll loans, working capital, vehicles, and real estate – implies different repricing frequencies and diverse guarantee structures, which translate into specific half-lives and asymmetries in the transfer. In several episodes, public banks played a countercyclical role, affecting credit volumes and composition and, consequently, influencing aggregate spread measures.

These characteristics require careful empirical choices. Alignment of scope between the series is crucial: the deposit rate and lending rate must cover the same universe of transactions, by borrower type and credit nature, to avoid compositional distortions. Risk indicators, such as default rates, must be consistent with the universe of transactions used for the lending rate; when there is no perfect match, it is prudent to recognize and model the measurement error. Liquidity and funding premiums can be approximated by funding spreads, while reserve requirement shocks should be treated as implicit taxation on deposits.

From a statistical perspective, it is advisable to express rates in percentage points, transform real variables into logarithms of deviations from the reference level, verify structural breaks associated with regulatory frameworks, and ensure frequency consistency with the reference model. Finally, regulatory events – changes in reserve requirements, changes in earmarked credit, and new capital and liquidity requirements – offer valuable quasi-exogenous variation for identifying the relative contribution of funding and liquidity, credit risk, and market power in the dynamics of the bank spread.

3 Analysis of empirical literature on the topic

The empirical literature on this topic for Brazil has repeatedly highlighted the central role of the banking sector in both the transmission of economic policy and the dynamics of cycles. Various studies, using approaches ranging from traditional econometric models – ordinary least squares (OLS), vector autoregression (VAR), vector error correction (VECM), data envelopment analysis (DEA), and probit – to structural models inspired by DSGE, have demonstrated that financial intermediation exerts an amplifying or attenuating effect on macroeconomic shocks, depending on the context and institutional design. In this sense, topics such as default rates, credit cycles, the impact of monetary and prudential policy on bank behavior, and the operational efficiency of the banking system have been the subject of detailed

analyses, revealing both the vulnerability of credit to cycles and the possibilities for policies that ensure greater stability and efficiency.

Chu (2001) analyzed the period from 1994 to 2000 using a VECM model to identify the macroeconomic determinants of aggregate bank defaults in Brazil. The author showed that GDP growth reduces bank default expenses by approximately 5%, while increases in unemployment and interest rates tend to increase them, although the effect of interest rates is nuanced. He also found that higher spreads are associated with greater future defaults, revealing the procyclical nature of credit risk.

Souza and Feijó (2007) studied the period from 2000 to 2006, applying OLS regressions and VECM models to compare public and private banks. The objective was to determine how institutions react to macroeconomic shocks that affect defaults. The results showed that both public and private banks are sensitive to cyclical fluctuations, but private banks adjust more quickly, increasing provisions and restricting credit, while public banks act more countercyclically, absorbing part of the shock.

Staub, da Silva, and Tabak (2010) applied the stochastic frontier methodology to assess the efficiency of Brazilian banks from 2000 to 2007. The study sought to measure relative costs and identify differences between bank types. The results indicated average efficiency around 80%, with domestic and foreign private banks more efficient than public banks and pointed to efficiency gains resulting from the inflow of foreign capital and mergers.

Marins and Neves (2013) used probit models to investigate the probability of default among borrowing companies, using data from the early 2010s. The objective was to relate economic cycles and credit risk. The results showed that periods of growth significantly reduce corporate default, while recessions substantially increase the probability of default, confirming the procyclical behavior of credit.

Wanke and Barros (2014) used dynamic DEA for the period 2002 to 2010 to analyze the evolution of efficiency in different banking segments. The authors found that retail banking increased its efficiency over the decade, driven by digitalization and new management practices, while wholesale banking maintained high and stable efficiency.

Tiryaki, Gavazza, Andrade, and Mota (2017) analyzed credit cycles, defaults, and economic fluctuations in Brazil between 2001 and 2013, using VAR and Markov-Switching/VAR models. The study aimed to differentiate the reaction of household and corporate defaults to macroeconomic shocks. The results showed that household defaults are more sensitive to interest rates and unemployment, while corporate defaults respond more to

GDP. However, in both cases, a worsening economic cycle increases defaults and restricts credit supply, worsening the recession.

Nunes and Portugal (2018) incorporated financial intermediaries into a DSGE model applied to Brazil to assess how credit frictions amplify macroeconomic shocks. The simulations showed that the presence of the credit channel increases the intensity and persistence of GDP fluctuations in the face of adverse shocks, but that public credit policies, such as the actions of public banks, can mitigate the recessive effects of financial crises.

Vinhado and Divino (2015) used a VAR on a panel of 56 Brazilian banks between 2001 and 2013 to investigate the effects of monetary and macroprudential policy on institutional behavior. The objective was to examine how interest rates and reserve requirements affect bank risk and liquidity. The results indicated that increases in the Selic rate or reserve requirements lead banks to reduce risk exposure and accumulate liquidity, but also reduce short-term financial stability, highlighting the need for coordination between monetary and prudential policy.

Kava (2019) estimated a Bayesian DSGE model with financial frictions for Brazil, aiming to capture the interaction between bank credit and macroeconomic dynamics. The study showed that monetary and fiscal shocks have more persistent and intense effects when the banking sector is explicitly incorporated, as credit constraints amplify GDP and inflation responses, reinforcing the role of the financial accelerator.

Smaniotto, Alves, and Lélis (2019) applied VAR and VECM models to the period 2003 to 2015 to analyze the relationship between economic activity and credit, separating free and earmarked resources and identifying the effects of monetary policy shocks (SELIC/TJLP). The authors show that the expansion of activity affects both segments, but free resources respond more in line with the theory; furthermore, shocks to the SELIC and TJLP rates contract earmarked credit, as evidenced in the impulse-response functions and causality tests.

Cunha, Lélis, Perfeito da Silva and Lopes (2019) estimated Markov-Switching models with duration and VECM for the period from 2004 to 2015, with the aim of comparing the behavior of public and private credit throughout the cycle, especially after 2008. The results support that public credit acted countercyclically, cushioning the slowdown, while private credit presented pro-cyclical behavior, reinforcing fluctuations, which corroborates the reading of financial amplification in the recessionary phase.

Takahashi and Vasconcelos (2022) examined the period from 2010 to 2019 using a two-stage DEA model, seeking to identify determinants of banks' technical efficiency. The results showed that large and foreign banks are more efficient than medium and small banks, and that

profit margins and service revenues increase efficiency. Conversely, higher default rates, inflation, and capital requirements reduce efficiency, revealing the limits imposed by macroeconomic and regulatory conditions.

Finally, the Central Bank of Brazil (2023), in its Banking Economy Report, highlighted the recent improvement in banking efficiency, measured by the decline in the operating cost-to-assets ratio. The report noted that digitalization, technological innovations, and the entry of fintechs have increased competition, inducing large banks to reduce spreads and improve processes, which has contributed to greater allocative and operational efficiency.

4 New Keynesian DSGE model with government and banking sector

The model expands the standard New Keynesian framework with: (i) Ricardian and non-Ricardian (hand-to-mouth) households; (ii) monopolistically competitive firms with nominal price and wage rigidities, both Calvo (1983) type with indexation; and (iii) an explicit banking sector that determines an endogenous spread. The government collects taxes on consumption, labor, and capital, carries out current expenditures, public investment subject to inefficiency, and transfers, and follows parsimonious fiscal rules with inertia and responsiveness to debt. The monetary authority sets the basic interest rate using a Taylor rule with smoothing.

On the financial side, the lending rate (asset rate) is the sum of the banks' funding cost and the spread. The funding cost incorporates the remunerated reserve requirement and a regulatory/tax wedge. The spread results from banking frictions – default, idiosyncratic risk or market power, and effects related to reserves/requirements. There is also a common, independent, and identically distributed (i.i.d.) banking factor that simultaneously impacts default and the risk component, allowing for co-movements between financial variables.

All model relationships are evaluated near the steady state and, where appropriate, presented in terms of levels for ease of reading.

4.1 Savers (Ricardian family)

Ricardian families choose $\{C_{R,t}, L_{R,t}, K_{t+1}^P, U_t, B_{R,t+1}\}_{t \geq 0}$ to maximize:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{R,t} - \varphi_C C_{R,t-1})^{1-\sigma}}{1-\sigma} - \frac{L_{R,t}^{1+\phi}}{1+\phi} \right] \quad (1)$$

where $C_{R,t}$ is Ricardian consumption, $L_{R,t}$ is the hours worked, $\beta \in (0,1)$ is the discount factor, φ_C is the external consumption habit, σ is the relative risk aversion, and ϕ is the curvature of the disutility of labor.

The budget constraint, in units of consumer goods, is defined as:

$$\begin{aligned} P_t(1 + \tau_t^C)C_{R,t} + P_t I_t^P + \frac{B_{t+1}}{R_t^B} \\ = (1 - \tau_t^L)W_t L_{R,t} + (1 + \tau_t^K) \frac{R_t^K}{P_t} U_t K_t^P \\ - P_t K_t^P \left[\psi_1 U_t + \frac{\psi_2}{2} (U_t - 1)^2 \right] + B_t + \omega_R P_t H_t \end{aligned} \quad (2)$$

where τ_t^C, τ_t^L e τ_t^K are the consumption, labor and capital tax rates; I_t^P is private investment; K_t^P the private capital stock; R_t^K the rent for capital services; U_t the utilization rate; $\psi_1, \psi_2 > 0$ parameterize the cost of using capital; B_t are government bonds with gross return R_t^B , W_t is the real wage; H_t are government transfers and $\omega_R \in (0,1)$ is the share of Ricardian households.

The law of motion of private capital is given by:

$$K_{t+1}^P = (1 - \delta)K_t^P + I_t^P S\left(\frac{I_t^P}{I_{t-1}^P}\right), \quad S(1) = S'(1) = 0, S''(\cdot) > 0 \quad (3)$$

with δ referring to depreciation.

The first-order conditions generate:

- Intertemporal Euler (with consumption tax):

$$1 = \mathbb{E}_t \left[\beta \frac{\Lambda_{R,t+1} \frac{R_{t+1}^B}{\Pi_{t+1}}}{\Lambda_{R,t}} \right], \quad \Lambda_{R,t} \equiv \frac{(C_{R,t} - \varphi_C C_{R,t-1})^{-\sigma}}{(1 + \tau_t^C) P_t} \quad (4)$$

Where $\Pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$. Higher real interest rates reduce $C_{R,t}$.

- Capital utilization (cost of use with spread):

$$(1 - \tau_t^K) \frac{R_t^K}{P_t} = \psi_1 + \psi_2(U_t - 1) - s_t \quad (5)$$

where s_t is the financial wedge (component of the spread) that increases the cost of capital, pushing U_t down when it increases.

- Tobin's q and investment (the shadow price of installed capital obeys the Euler condition implied by optimal investment and capital-adjustment costs):

$$Q_t = \mathbb{E}_t \left[\beta \frac{\Lambda_{R,t+1}}{\Lambda_{R,t}} \left((1 - \delta)Q_{t+1} + (1 - \tau_{t+1}^K) \frac{R_{t+1}^K}{P_{t+1}} \right) \right] - \psi_1 U_t, \quad (6)$$

while the investment adjustment follows an accelerator rule (quadratic cost in variations):

$$\chi(I_t^P - I_{t-1}^P) = Q_t - (1 + \tau_t^C)\Lambda_{R,t}P_t \quad (7)$$

with $\chi > 0$ governing investment inertia. A higher Q_t induces more I_t^P , smoothed by the adjustment cost χ .

Thus, the base rate R_t^B (via equation 4) and the spread s_t (via equation 5) change, respectively, the price of present consumption and the cost of using capital. With a higher s_t , the optimal use U_t falls. This reduces the effective service of capital ($U_t K_t^P$), lowers Q_t , and, via the accelerator, contracts investment I_t^P – with second-order effects on output and inflation.

4.2 Non-savers (non-Ricardian – hand-to-mouth)

Non-Ricardian households choose $(C_{NR,t}, L_{NR,t})$ maximizing $\sum_t \beta^t \left[\left(\frac{C_{NR,t} - \varphi_C C_{NR,t-1}}{(1-\varphi)} \right)^{1-\varphi} - \frac{L_{NR,t}^{1+\varphi}}{(1+\varphi)} \right]$, without accessing financial assets, subject to the current budget constraint:

$$P_t(1 + \tau_t^C)C_{NR,t} = (1 - \tau_t^L)W_t L_{NR,t} + (1 - \omega_R)P_t H_t \quad (8)$$

Since these households do not accumulate assets, consumption follows current disposable income (net wages plus transfers). The marginal utility of consumption (in real terms and net of consumption tax) is:

$$\Lambda_{NR,t} = \frac{(C_{NR,t} - \phi_C C_{NR,t-1})^{-\sigma}}{(1 + \tau_t^C)P_t} \quad (9)$$

The aggregation of consumption and labor takes the following form:

$$\begin{aligned} C_t &= \omega_R C_{R,t} + (1 - \omega_R) C_{NR,t} \\ L_{R,t} &= \frac{\lambda_L}{\omega_R} L_t \\ L_{NR,t} &= \frac{1 - \lambda_L}{1 - \omega_R} L_t \end{aligned} \quad (10)$$

$\omega_R \in (0,1)$ is the share of Ricardian families in the population; $\lambda_L \in (0,1)$ is the share of aggregate hours offered by Ricardians; ϕ_C measures consumption habits; σ is the relative risk aversion; φ governs the disutility of work; τ_t^C and τ_t^L are the tax rates on consumption and work; H_t are public transfers.

Without assets, hand-to-mouth households have a high marginal propensity to consume. Thus, shocks to net wages $(1 - \tau_t^L)W_t$ or to transfers H_t are transmitted almost one-to-one to $C_{NR,t}$. This reinforces the sensitivity of aggregate consumption C_t to fiscal policy (via H_t, τ_t^C, τ_t^L) and to real shocks affecting wages. Thus, the fractionation of labor via λ_L allows the non-Ricardians' labor margin to affect the wage bill and, therefore, the hand-to-mouth component of consumption.

4.3 Firms, technology, and marginal cost

The representative firm produces with service capital $K_t^S = U_t K_t^P$, labor L_t , and public capital K_t^G , according to a Cobb-Douglas function with constant returns:

$$Y_t = A_t (K_t^S)^{\alpha_1} L_t^{\alpha_2} (K_t^G)^{\alpha_3}, \quad \alpha_1 + \alpha_2 + \alpha_3 = 1 \quad (11)$$

where A_t is total factor productivity (TFP); $\alpha_1, \alpha_2, \alpha_3 \in (0,1)$ are output elasticities with respect to capital in services, labor, and public capital, respectively. Minimizing the cost (Y_t, A_t, K_t^G) and taking prices as given, the factor demand conditions (in real terms) are:

$$\frac{W_t}{P_t} = \alpha_2 CM_t \frac{Y_t}{L_t} \quad (12)$$

$$\frac{R_t^K}{P_t} = \alpha_1 CM_t \frac{Y_t}{K_t^S} \quad (13)$$

where W_t is the wage, R_t^K is the rent for capital services, and CM_t is the real marginal cost.

4.4 Nominal rigidities: prices and wages

The Phillips price curve (Calvo hybrid) is determined as follows:

$$\pi_t = \frac{\beta}{1 + \beta_{l_p}} \mathbb{E}_t[\pi_{t+1}] + \frac{l_p}{1 + \beta_{l_p}} \pi_{t-1} + \frac{k_p}{1 + \beta_{l_p}} cm_t + \frac{1}{1 + \beta_{l_p}} u_t^p \quad (14)$$

with $k_p = \frac{(1-\theta)(1-\beta\theta)}{\theta}$; β is the intertemporal discount factor, l_p is the price indexation; θ is the Calvo parameter – the probability of no price adjustment in the period; k_p is the structural slope of the Phillips curve; cm_t is the marginal cost; and u_t^p is the price markup shock.

In turn, the Phillips wage curve is defined as:

$$\begin{aligned} \pi_t^w = & \frac{\beta}{1 + \beta_{l_w}} \mathbb{E}_t[\pi_{t+1}^w] + \frac{l_w}{1 + \beta_{l_w}} \pi_{t+1}^w \\ & + \frac{k_w}{1 + \beta_{l_w}} \left[\phi l_t - (\omega_R \lambda_{R,t} + (1 - \omega_R) \lambda_{NR,t}) + \frac{\tau_{l,ss}}{1 - \tau_{l,ss}} \tau_t^l \right] \end{aligned} \quad (15)$$

where $\pi_t^w = \Delta w_t \equiv \log W_t - \log W_{t-1}$ is wage inflation, $l_t \equiv \ln L_t$ and $k_w^{(b)}$ is the implicit Calvo coefficient with indexation for wages, determined by (θ_w, l_w) .

4.5 Utilization, investment, and Tobin's q

The use condition of equation 5 links U_t to the spread s_t . Equation 6 connects Q_t to future returns (with capital tax τ_t^K) and to the adjustment cost of I_t^P via χ .

In this sense, a financial tightening – whether via an increase in the base rate R_t^B (monetary policy) or an increase in the bank spread s_t (risk/market) – increases the cost of capital. In the model, the increase in R_t^B propagates to the funding rate $R_{D,t}$ (deposit pass-through) and, with $RL_t = RD_t + s_t$, raises the lending rate. A shock to s_t directly increases RL_t . With financing and capital use becoming more expensive, firms reduce their use of U_t (capital use condition), the shadow value of capital (Q_t , Tobin's q) falls, and, due to the investment accelerator, private sector investment I_t^P declines (investment equation).

4.6 Government, taxation, and public capital

The government chooses current expenditure G_t , public investment IG_t , and transfers H_t (to households), financing itself through taxes T_t and debt B_t . The budget constraint therefore takes the following form:

$$\frac{B_t}{R_t^B} - B_{t-1} + T_t = P_t G_t + P_t IG_t + P_t H_t \quad (16)$$

where R_t^B is the gross return factor on public debt; P_t is the price level. The left side of the equation shows how net debt increases when spending exceeds revenue, the right-side details primary expenditures.

Tax revenue aggregates taxes on consumption, labor, and capital:

$$T_t = \tau_t^C P_t (C_t + I_t^P) + \tau_t^L W_t L_t + \tau_t^K (R_t^K K_t^P - \delta P_t K_t^P) \quad (17)$$

where parameters $\tau_t^C, \tau_t^L, \tau_t^K$ are effective tax rates; C_t is aggregate consumption, I_t^P is private investment, W_t is the nominal wage, L_t is employment, R_t^K is the rent on capital, K_t^P is the private capital stock, and δ is depreciation. This equation links the tax base to activity: shocks in C_t, L_t, K_t^P change T_t .

Public capital K_t^P , in turn, evolves according to:

$$K_{t+1}^G = (1 - \delta_G)K_{t-1}^G + \delta_G[(1 - \zeta_{IG})IG_{t-1} - \zeta_{IG,t}] \quad (18)$$

where δ_G is depreciation; ζ_{IG} and $\zeta_{IG,t}$ capture average inefficiency and shocks. Thus, greater inefficiency implies lower conversion of IG_t into K_t^G .

To close the model, spending, investment, transfers, and tax rates follow simple rules with inertia ($\gamma \in (0,1)$, $\phi \geq 0$) and a response to debt misalignment \tilde{b}_{t-1} (excessive debt relative to activity/prices):

$$\begin{aligned} G_t &= \gamma_G G_{t-1} (1 - \gamma_G) \phi_G \tilde{b}_{t-1} + \varepsilon_{G,t} \\ IG_t &= \gamma_{IG} IG_{t-1} (1 - \gamma_{IG}) \phi_{IG} \tilde{b}_{t-1} + \varepsilon_{IG,t} \\ H_t &= \gamma_H H (1 - \gamma_H) \phi_H \tilde{b}_{t-1} + \varepsilon_{H,t} \\ \tau_t^j &= \gamma_{\tau j} \tau_{t-1}^j + (1 - \gamma_{\tau j}) \phi_{\tau j} \tilde{b}_{t-1} + \varepsilon_{\tau j,t}, \quad j \in \{c, l, k\} \end{aligned} \quad (19)$$

$\phi_j \geq 0$ are debt adjustment intensities: the higher they are, the more fiscal policy reacts to stabilize \tilde{b}_{t-1} .

4.7 Monetary policy, banking sector, and spread

The monetary authority sets the base interest rate (Selic-target) according to a Taylor rule with inertia:

$$R_t^B = \gamma_R R_{t-1}^B + (1 - \gamma_R)(\gamma_\pi \pi_t + \gamma_y y_t) + \varepsilon_{m,t} \quad (20)$$

where R_t^B is the target Selic rate; π_t is inflation; and y_t is the output gap. The parameter $\gamma_R \in (0,1)$ measures smoothing: the larger it is, the more gradual the adjustments. Determination requires $\gamma_\pi > 1$ (Taylor's principle) and $\gamma_y \geq 0$. The term $\varepsilon_{m,t}$ represents monetary policy shock.

Transmission to market rates occurs in two steps. First, the deposit rate (deposits) passes through the smoothed Selic rate:

$$R_t^D = \rho_{rd} R_{t-1}^D + (1 - \rho_{rd}) R_t^B, \quad 0 < \rho_{rd} < 1 \quad (21)$$

Second, the bank's funding cost combines remunerated reserve requirements and a regulatory/tax wedge on liabilities:

$$r_t^F = (1 - x_{RR})(R_t^D - \tau^{dep}) + x_{RR}R_t^B + \tau_D R_t^D, \quad 0 \leq x_{RR} \leq 1 \quad (22)$$

where x_{RR} is the fraction of deposits subject to remunerated reserve requirements; τ^{dep} and τ_D are regulatory/tax wedges. These terms are only included in the funding r_t^F , which avoids double counting.

The effective rate, in turn, is the sum of the funding and spread:

$$R_t^L = r_t^F + s_t \quad (23)$$

The bank spread is modeled by a reduced law of motion that aggregates its structural drivers:

$$s_t = \rho_s s_{t-1} + \rho_{npl} npl_t + \rho_\xi \xi_t + \rho_v RES_t + \varepsilon_t^s, \quad 0 < \rho_s, 1 \quad (24)$$

where ρ_s measures the persistence of the spread, ρ_{npl} captures the sensitivity of the spread to default npl_t , ρ_ξ summarizes risk/idiosyncrasy or market power ξ_t and ρ_v weights the cost associated with reserves/requirements RES_t .

Banking states follow AR(1) processes, defined as follows:

$$\begin{aligned} npl_t &= \rho_{npl} npl_{t-1} + c_{npl} e_{b,t} + \varepsilon_{npl,t} \\ \xi_t &= \rho_\xi \xi_{t-1} + c_\xi e_{b,t} + \varepsilon_{\xi,t} \\ RES_t &= \rho_v RES_{t-1} + \varepsilon_{v,t} \end{aligned} \quad (25)$$

With $e_{b,t} \sim i. i. d. (0, \sigma_b^2)$, c_{npl} and c_ξ are loadings of the common banking factor on npl and ξ , respectively.

Thus, when the spread s_t increases, the cost of using capital increases: the condition of use requires a reduction in U_t , the capital service $U_t K_{t-1}^P$ decreases, Tobin's q falls, and, through the accelerator, private investment I_t^P shrinks, with contractionary effects on output and inflation.

4.8 Goods market and shocks

The goods market closes due to a standard resource constraint: production is absorbed by private consumption, private investment, public investment, and current government spending:

$$Y_t = C_t + I_t^P + IG_t + G_t \quad (26)$$

We allow for three AR(1) processes capturing distinct real disturbances: total factor productivity, private capital utilization, and the (inverse) efficiency of public investment:

$$\begin{aligned} A_t &= \rho_A A_{t-1} + \varepsilon_{a,t} \\ u_t^P &= \rho_u u_{t-1}^P + \varepsilon_{p,t} \\ \zeta_{IG,t} &= \rho_\zeta \zeta_{IG,t-1} + \varepsilon_{\zeta,t} \end{aligned} \quad (27)$$

with $|\rho_A|, |\rho_u|, |\rho_\zeta| < 1$. All innovations $\varepsilon_{x,t}$ are i.i.d. over time and mutually orthogonal across x , with $\varepsilon_{x,t} \sim \mathcal{N}(0, \sigma^2)$. This orthogonality extends to the remaining monetary and fiscal innovations specified elsewhere in the model (e.g., $\varepsilon_{G,t}, \varepsilon_{IG,t}, \varepsilon_{H,t}, \varepsilon_{m,t}$, tax shocks, and price-markup shocks).

5 Estimation

We estimate the model with Bayesian methods in Dynare 6.4. The procedure involved applying the Kalman filter, which is suitable for handling dynamic state-space models and is essential for assessing conditional likelihood in the context of observable variables with noise and stochastic shocks.

Subsequently, Markov Chain Monte Carlo (MCMC) sampling was implemented with a total of 1.5 million replications distributed across four independent blocks, ensuring adequate chain convergence. To ensure initial stability, 50% of the initial observations were discarded to avoid the influence of the burn-in phase. A calibrated acceptance scale from the Metropolis-Hastings algorithm was used to maintain acceptance rates around 25-35%, considered adequate in Bayesian literature. The prior distributions were specified in accordance with the empirical literature for DSGE models, using initial variances as the covariance matrix for the MCMC

jump. Furthermore, a truncation limit of zero was set for the priors, meaning that values outside the stipulated support were excluded, ensuring statistical consistency.

Regarding the model's dynamic properties, Bayesian impulse-response functions were generated with a 40-period horizon and reported with a 95% confidence interval, allowing us to assess not only the model's average response to structural shocks but also the uncertainty associated with these estimates.

Taken together, these methodological choices ensure the robustness of the Bayesian estimation, the reliability of the inferences about the structural parameters, and the validity of the impulse-response functions used to analyze Brazilian macroeconomic dynamics during the period in question.

5.1 Data, calibration, and prior and posterior distributions

The Bayesian estimation of the model was performed using a set of ten observable variables that comprehensively represent the main blocks of the theoretical framework and the transmission mechanisms of the DSGE model. The real sector is captured by GDP and investment; the public sector by debt and primary expenditures; the price level by consumer inflation; monetary policy by the Selic rate and deposit remuneration; and financial intermediation by bank spreads and default rates.

The series were collected from official and supplementary databases, covering the period between the first quarter of 2012 and the first quarter of 2025, depending on the availability of information and the need to ensure sampling consistency. This time horizon ensured both the incorporation of a sufficiently long period of the inflation targeting regime in Brazil and the inclusion of recent shocks to adequately calibrate the modeled frictions. Ten observable variables were used, selected to represent the main blocks of the theoretical framework. These are presented in Table 1:

Table 1 – Variables, data source and transformations

Observed Variable	Source	Frequency	Measure	
RB	Selic accumulated in the month	BCB/SGS	Monthly→Quarterly	Quarterly average (%)
I^P	Gross Fixed Capital Formation (proxy)	IBGE/Quarterly National Accounts	Quarterly	% GDP
I^G	Public Sector Investment	National Treasury Secretariat (STN)/IBGE	Quarterly	% GDP
s	<i>Spread</i>	BCB/SGS	Monthly→Quarterly	Quarterly average (%)
npl	Default (<i>free + earmarked</i>)	BCB/SGS	Monthly→Quarterly	Quarterly average (%)
Y	Real GDP	IBGE/Quarterly National Accounts	Quarterly	$\Delta \ln$, seasonally adjusted
π	IPCA	IBGE	Monthly→Quarterly	Quarterly change
B	Gross Debt	BCB	Monthly→Quarterly	% GDP
G	Primary Expenditure	IBGE/Quarterly National Accounts	Quarterly	% GDP
R^D	Deposit rate (proxy – constructed) $R^D = R^L - s$	BCB/SGS	Monthly→Quarterly	Quarterly average (%)

Source: Authors' calculation.

Among the parameters used in the model, five were calibrated rather than estimated: (i) the discount rate ($\beta = 0.985$); (ii) the depreciation rate of private and public capital ($\delta = \delta^G = 0,025$); (iii) the elasticity of substitution between different types of labor ($\nu = 21$); (iv) the elasticity of output relative to public capital ($\alpha^G = 0,05$); and (v) the share of capital in the production function ($\alpha = 0.45$), the latter obtained from the SAMBA model (Castro et al. 2015). All other model parameters were estimated using Bayesian methods. The prior distributions were defined based on the literature that estimates similar DSGE models. Table 2 presents the estimated parameters, their prior distributions, and the resulting posterior distributions.

Table 2 – Estimated parameters (priors and posteriors)

Parameter	Description	Prior mean	Posterior mean	Highest posterior density interval	Standard deviation
τ_D	Effective regulatory wedge on deposit funding cost	0.03	0.03	[0.0139–0.0456]	0.01
x_{RR}	Share of deposits subject to reserve requirements	0.25	0.2503	[0.1685–0.3321]	0.05
σ	Coefficient of relative risk aversion	2	2.6431	[1.4682–3.8193]	0.75
ϕ	Curvature of labor disutility	1.5	1.5151	[1.0340–2.0069]	0.3
θ	Calvo price rigidity	0.8	0.7822	[0.7098–0.8566]	0.05
θ_W	Calvo wage rigidity	0.75	0.717	[0.6323–0.8015]	0.05
ψ	Elasticity of substitution across goods varieties (price markup)	10	9.8954	[6.5783–13.1065]	2
ψ_w	Elasticity of substitution across labor types (wage markup)	25	25.0837	[16.9562–33.3236]	5
ϕ_G	Response of current spending to debt-to-GDP in the fiscal rule	0.02	0.022	[–0.0116–0.0554]	0.02
ϕ_{IG}	Response of public investment to debt-to-GDP	0.02	0.0202	[–0.0131–0.0532]	0.02
ϕ_H	Response of transfers/benefits to debt-to-GDP	0.02	0.0058	[–0.0136–0.0269]	0.02
τ_t^c	Steady-state consumption tax rate	0.26	0.2113	[0.1396–0.2798]	0.05
τ_t^l	Steady-state labor income tax rate	0.227	0.2136	[0.1348–0.2904]	0.05
τ_t^k	Steady-state capital income tax rate	0.157	0.1492	[0.0721–0.2240]	0.05
φ_C	Degree of external habit in consumption	0.7	0.7032	[0.5447–0.8679]	0.1
ω_R	Share of Ricardian households	0.65	0.4836	[0.2306–0.7334]	0.15
χ	Investment adjustment cost	6	9.3953	[6.8602–11.9368]	2

ι_p	Price indexation to past inflation	0.3	0.3368	[0.1539–0.5090]	0.1
ι_w	Wage indexation to past inflation	0.35	0.3535	[0.1872–0.5166]	0.1
λ_L	Share of Ricardian labor in total hours	0.5	0.497	[0.1718–0.8301]	0.2
γ_G	Inertia of current spending in the fiscal rule	0.6	0.5967	[0.3531–0.8469]	0.15
γ_{IG}	Inertia of public investment in the fiscal rule	0.65	0.4577	[0.2146–0.7023]	0.15
γ_H	Inertia of transfers/benefits in the fiscal rule	0.6	0.5591	[0.3174–0.8004]	0.15
$\gamma_{\tau C}$	Inertia of the consumption tax	0.6	0.32	[0.1423–0.4904]	0.15
$\gamma_{\tau L}$	Inertia of the labor income tax	0.6	0.5595	[0.3274–0.7916]	0.15
$\gamma_{\tau K}$	Inertia of the capital income tax	0.6	0.5836	[0.3445–0.8257]	0.15
$\phi_{\tau C}$	Response of the consumption tax to debt-to-GDP	0.15	0.1643	[0.0846–0.2433]	0.05
$\phi_{\tau L}$	Response of the labor tax to debt-to-GDP	0.4	0.3995	[0.3183–0.4830]	0.05
$\phi_{\tau K}$	Response of the capital tax to debt-to-GDP	0.3	0.2993	[0.2161–0.3820]	0.05
ρ_A	Persistence of the TFP shock (A)	0.9	0.7918	[0.7012–0.8855]	0.05
ρ_G	Persistence of the current-spending shock	0.9	0.9011	[0.8276–0.9787]	0.05
ρ_{IG}	Persistence of the public-investment shock	0.9	0.8774	[0.7882–0.9712]	0.05
ρ_H	Persistence of the transfers shock	0.9	0.8871	[0.8082–0.9697]	0.05
$\rho_{\tau C}$	Persistence of the consumption-tax shock	0.9	0.8614	[0.7686–0.9585]	0.05
$\rho_{\tau L}$	Persistence of the labor-tax shock	0.9	0.8888	[0.8118–0.9699]	0.05
$\rho_{\tau K}$	Persistence of the capital-tax shock	0.9	0.8972	[0.8230–0.9762]	0.05

ρ_m	Persistence of monetary-policy shock (Taylor rule)	0.9	0.7504	[0.6452–0.8586]	0.05
ρ_p	Persistence of the price-markup shock	0.7	0.1264	[0.0192–0.2306]	0.2
γ_R	Interest-rate smoothing in the Taylor rule	0.6	0.5481	[0.4061–0.6912]	0.1
γ_π	Inflation coefficient in the Taylor rule	2.1	1.4877	[0.8545–2.1323]	0.4
γ_y	Output/output-gap coefficient in the Taylor rule	0.03	0.0314	[–0.0013–0.0639]	0.02
ρ_s	Persistence of the autoregressive component of the spread	0.5	0.2543	[0.0419–0.4533]	0.2
ρ_ξ	Persistence of the banking state (risk/idiosyncrasy/market power)	0.7	0.519	[0.2768–0.7598]	0.15
ρ_{npl}	Persistence of nonperforming loans (<i>npl</i>)	0.8	0.746	[0.5706–0.9304]	0.1
ρ_{rd}	Persistence of deposit-rate pass-through	0.6	0.7602	[0.5890–0.9346]	0.15
ρ_v	Persistence of the reserves/required-reserves state	0.6	0.5743	[0.3384–0.8146]	0.15
τ^{dep}	Regulatory tax/levy on deposits	0	0.0000	[–0.0328–0.0326]	0.02
c_{npl}	Loading of the common banking factor on <i>npl</i>	0.2	0.1503	[0.0055–0.2916]	0.1
c_ξ	Loading of the common banking factor on ξ	0.1	0.0856	[–0.0734–0.2406]	0.1

Source: Authors' estimates (Dynare 6.4).

5.2 Results

This section presents the empirical evidence produced by the estimated model, organized into four sections. First, we quantify the drivers of the banking spread through the Decomposition of the Forecast Error Variance (DFEV), highlighting the dominant role of default shocks (*npl*), the contribution of risk/idiosyncrasy shocks (ξ), and the smaller role of shocks associated with reserves/requirements (*RES*) and the common banking factor (*e_b*). Second (Section 5.2.2), we examine the historical trajectory of the spread, detailing, period by period, the contribution of each shock and explaining the meaning of each error label. Third,

we document the persistence of the spread and the pass-through of the base deposit rate, showing how these transmission margins connect monetary policy to the cost of funding. Finally, we discuss the mechanism of financial amplification and its implications for the cycle and policy, as well as its relationship with institutional heterogeneity and regulatory wedges.

5.2.1 What explains the spread?

The estimation indicates that fluctuations in the bank spread are dominated by default shocks (*NPL*), followed by risk/idiosyncrasy shocks (*xi*). In the variance decomposition of the forecast error, default shocks account for approximately 72% of the spread variance (and around 55% when measurement error is included), while risk/idiosyncrasy shocks explain $\approx 22\%$ (17% with measurement error). Shocks associated with reserve requirements (*RES*) and the common banking factor (*e_b*) have a small share (approximately 2–3%).

This pattern directly aligns with literature. First, the prominence of default shocks confirms that credit risk is procyclical and amplifies shocks: Chu (2001) finds a decrease in default shocks with higher GDP and an increase with higher interest rates and unemployment; Tiriyaki et al. (2017) show that a worsening cycle increases household and corporate defaults. In our model, *NPL* as a driver of the spread is the "price" side of this mechanism: when risk rises, banks widen spreads. Second, the significant contribution of risk/idiosyncrasy shocks (*xi*) is consistent with studies on efficiency and market power (Staub, da Silva, and Tabak, 2010; Takahashi and Vasconcelos, 2022) and with the Central Bank of Brazil Report (2023), which associates spread reductions with digitalization and increased competition: shocks to *xi* shift the spread even with constant credit risk. Third, the small weight of *RES*/requirements suggests that, in our sample, changes in reserve requirements explain little of the spread volatility – consistent with Vinhado and Divino (2015), who document the effects of monetary and macroprudential policy, particularly via liquidity and short-term risk.

5.2.2 Historical spread breakdown

Figure 1 presents, by period, the contributions of shocks to the spread and the smoothed trajectory of the spread itself:

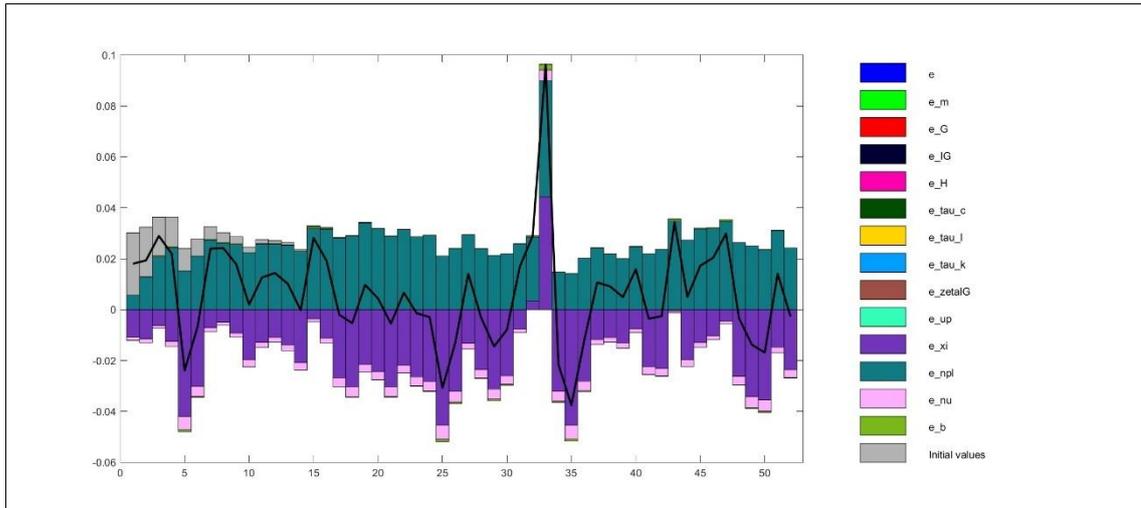


Figure 1 – Historical breakdown of the bank spread
Source: Authors' estimates (Dynare 6.4).

where:

- e : total factor productivity (TFP – A) shock;
- e_m : monetary policy shock;
- e_G : current government expenditure shock;
- e_{IG} : public investment shock;
- e_H : transfer shock;
- $e_{\tau a u_c}$: consumption tax shock;
- $e_{\tau a u_l}$: labor tax shock;
- $e_{\tau a u_k}$: capital tax shock;
- $e_{z e t a I G}$: public investment inefficiency shock;
- $e_{u p}$: price markup shock;
- $e_{x i}$: bank risk/idiosyncrasy/market power shock;
- $e_{n p l}$: default shock;
- $e_{n u}$: shock associated with reserves/requirements (regulatory liquidity);
- e_b : common i.i.d. banking factor (enters $n p l$ and ξ);
- Initial conditions: contribution of the initial state.

Figure 1 shows the predominance of contributions from $n p l s$ throughout virtually the entire period, reinforcing the results of the Forecast Error Variance Decomposition. In a stress episode around observation 34, there is a jump in the spread, with a strong positive contribution from $n p l s$ and a smaller but visible contribution from $x i$; the subsequent reversal accompanies the dissipation of these shocks. In several passages, $x i$ sometimes reinforces and sometimes

softens the *npl* effect, suggesting that variations in market power/idiosyncratic risk modulate the transmission of the credit cycle to bank prices – precisely the interaction described by bank efficiency studies and the Central Bank of Brazil report (2023).

5.2.3 Persistence and pass-through

The spread exhibits high persistence (first-order autocorrelation ≈ 0.80). This inertia reflects both its own reduced-form dynamics and the persistence of banking states: default (≈ 0.75), the risk/idiosyncratic component (≈ 0.52), and the reserve-requirements/funding state (≈ 0.57). In the transmission block, the deposit-rate smoothing is ≈ 0.76 , implying a short-run pass-through of ≈ 0.24 to deposits ($1 - \rho_{rd}$). Thus, the lending rate tends to react faster and more strongly than the deposit rate after a monetary tightening, temporarily widening the spread – while funding costs catch up gradually. This is consistent with evidence in the Brazilian literature.

5.2.4 Financial amplification and cycle

In the estimated model, the lending rate results from the sum of the cost of funding and the spread: when the spread increases, the optimal use of capital decreases, the shadow value of capital (Tobin's q) falls, and private investment contracts. By including the banking sector, the model activates the financial accelerator: monetary and fiscal policy shocks affect the cost of funding and the spread; higher spreads make the use of capital more expensive and reduce investment, amplifying and prolonging the effects on activity and inflation – in line with Nunes and Portugal (2018) and Kava (2019). The centrality of *npl* also aligns with the findings of Marins and Neves (2013) and Tiryaki et al. (2017): recessions increase the probability of default, which feeds back into spreads and deepens the decline in investment and output.

5.2.5 Institutional heterogeneity and public credit

The literature documents differences between public and private banks (Souza & Feijó, 2007) and countercyclical behavior of public credit (Cunha et al., 2019). The estimated model is parsimonious and does not differentiate between these segments, but the results suggest that policies that reduce *npl* (e.g., guarantees or rescheduling in recessions) and pro-competition

measures that compress ξ tend to stabilize spreads. Natural extensions include distinguishing public/private intermediaries and separating credit markets.

5.2.6 Efficiency and regulatory wedges

The regulatory/tax wedge on deposits was estimated at close to 3% and is relatively variable, which helps explain its modest role in the spread variance (via reserve/requirement ratios). This is consistent with the Central Bank of Brazil Report (2023): efficiency gains and greater competition primarily affect ξ and the level of the spread, while short-term volatility is primarily cyclical and linked to default.

5.3 Impulse-response analysis

This subsection presents impulse-response functions (IRFs) to 1-standard-deviation innovations, over a 40-quarter horizon, using the same Bayesian estimation method, with 95% credibility bands. We analyze shocks to monetary policy (e_m), default (e_{npl}), risk/idiosyncrasy/bank market power (e_{ξ}), and reserves/requirements (e_{nu}), in addition to the price markup shock (e_{up}) and the technology shock (e). We report responses to bank spread (s), deposit rate (RD), lending rate (RL), output (Y), inflation (PI), private investment (IP), capital utilization (U), and Tobin's q (Q).

5.3.1 Impulse-response function – contractionary monetary policy

According to Figure 2, the monetary policy shock is interpreted as a tightening of the benchmark interest rate (RB), which rises immediately and, due to the rule's inertia, gradually dissipates. The pass-through to the deposit rate (RD) is gradual and incomplete; the lending rate (RL) reacts more rapidly because the cost of funding incorporates the remunerated reserve requirement and the regulatory wedge. Thus, the banking spread (s) widens in the short term and begins to narrow when the deposit rate (RD) converges to the new level.

On the real side, the increase in the cost of capital depresses capital utilization (U) and reduces Tobin's q (Q), sharply and persistently compressing private investment (IP). The contraction in demand is transmitted to output (Y), with a trough after a few quarters and a slow return; Price inflation (PI) declines with a lag, without a price puzzle, in line with the

hybrid New Keynesian Phillips Curve and the low estimated persistence of the markup. Consistent with the DFEV, the monetary shock explains a small portion of the variance in the spread (s) – dominated by default (npl) and bank risk/idiosyncrasy (xi) – although it acts as a trigger for the "interest \rightarrow credit \rightarrow investment \rightarrow activity \rightarrow prices" cycle.

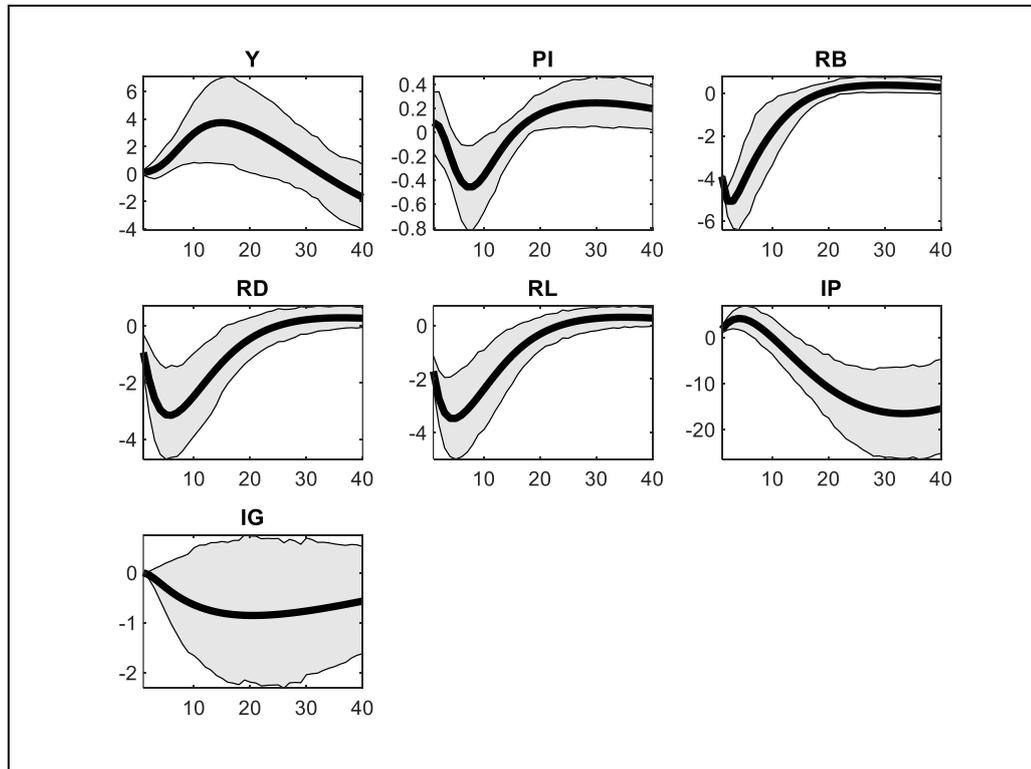


Figure 2 – Impulse-response functions to a contractionary monetary policy shock
Source: Authors' estimates (Dynare 6.4).

5.3.2 Impulse-response function – defaults

According to Figure 3, an unexpected increase in defaults (npl) increases credit risk and triggers an increase in funding and credit costs. The banking spread (s) opens immediately and closes only gradually; the lending rate (RL) rises more than the deposit rate (RD), reflecting the increased risk premium and the incomplete pass-through to liabilities. Monetary policy reacts countercyclically: the benchmark interest rate (RB) falls upon impact and only gradually returns, which explains the initial drop in RD and helps cushion the shock on the liabilities side.

In the real bloc, the worsening financial conditions sharply and persistently reduce private investment (IP); output (Y) shows a modest net response – with a small short-term boost and slow convergence – because the investment contraction is partially offset by

endogenous monetary easing. Price inflation (PI) declines with a lag, remaining below steady state for several quarters, consistent with lower demand and the hybrid New Keynesian Phillips Curve. Public investment (IG) also declines at the margin, in line with the fiscal rule that responds to the cycle. In short, the default shock acts primarily through the credit cost channel – s and RL rise, RD initially declines with RB, IP contracts – and the monetary response mitigates, but does not eliminate, its disinflationary effects and the weakening of activity.

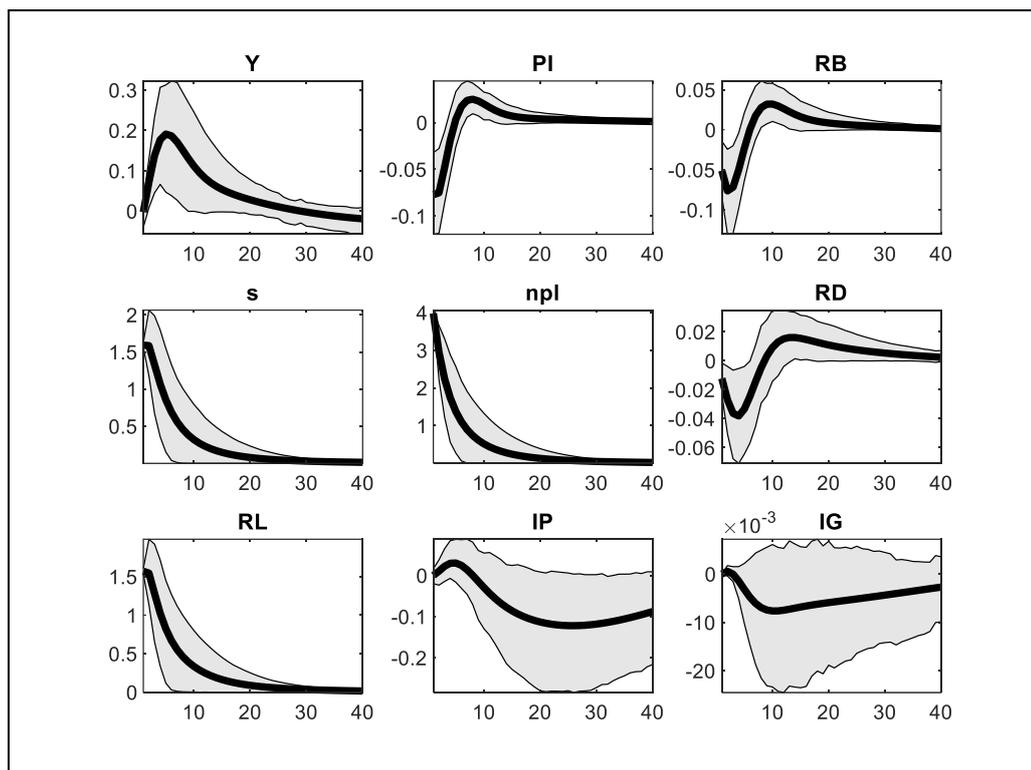


Figure 3 – Impulse-response functions to a default shock
Source: Authors' estimates (Dynare 6.4).

5.3.3 Impulse-response function – risk/idiosyncrasy/bank market power

According to Figure 4, a positive shock to risk/idiosyncrasy/bank market power (ξ) increases the intermediation markup and makes credit more expensive for a given funding cost. The lending rate (RL) spikes upon impact and dissipates quickly, while the deposit rate (RD) initially declines – reflecting the endogenous easing of the benchmark interest rate (RB) – and then develops a bell shape before converging. As RL rises and RD falls, the banking spread (s) opens immediately and gradually closes as monetary policy eases and the shock weakens.

In the real bloc, the higher financing costs depress private investment (IP) in a pronounced and persistent manner; output (Y) exhibits a small short-term boost, sustained by

monetary easing, but slowly converges to the steady state. Price inflation (PI) falls upon impact and returns with a slight short-term positive overshooting, consistent with the hybrid New Keynesian Phillips Curve and the contraction in demand. Public investment (IG) declines marginally, in line with the fiscal rule. In summary, the shock at x_i operates primarily through the credit cost channel – s and RL rise, RD follows the dynamics of RB, IP contracts – generating disinflationary effects and weaker activity over the relevant horizon.

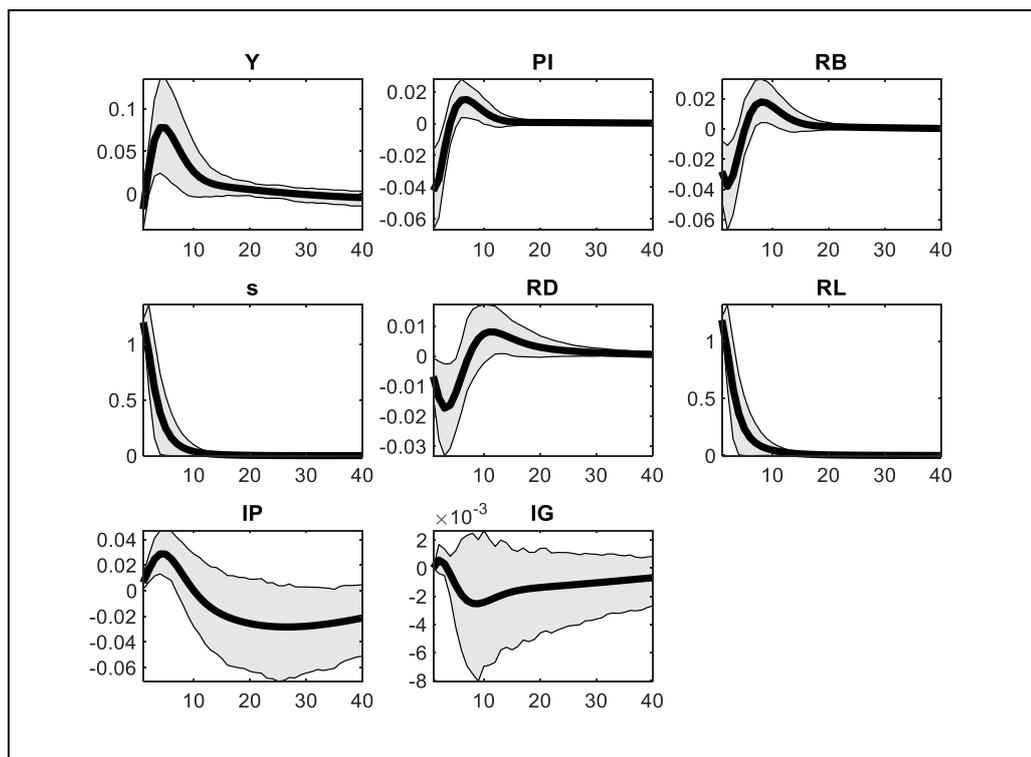


Figure 4 – Impulse-response functions to a risk/idiosyncrasy/bank market power shock
Source: Authors' estimates (Dynare 6.4).

5.3.4 Impulse-response function – reserves/requirements

According to Figure 5, a positive shock to reserves/requirements raises banks' effective funding costs and, through a pass-through to liabilities, makes credit more expensive. The lending rate (RL) spikes upon impact and dissipates quickly, while the deposit rate (RD) initially declines – reflecting an endogenous easing of the benchmark interest rate (RB) – and then describes a small "bell" before converging. As RL rises and RD falls, the banking spread (s) opens immediately and gradually closes as the shock weakens and monetary policy partially eases.

In the real block, the higher cost of financing persistently reduces private investment (IP); output (Y) shows a very short-term boost – sustained by the initial decline in $\frac{RB}{RD}$ – but demand cools, and Y slowly converges to levels below the steady state. Price inflation (PI) declines slightly, with a small transitory fluctuation, in line with the hybrid New Keynesian Phillips Curve and the financial contraction. Public investment (IG) also declines marginally, as the fiscal rule responds to the cycle.

In summary, the shock to reserves/requirements operates through the credit cost channel – s and RL rise, RD follows the dynamics of RB , IP contracts – producing moderate disinflation and a slowdown in activity over the relevant horizon, as indicated by the credible bands.

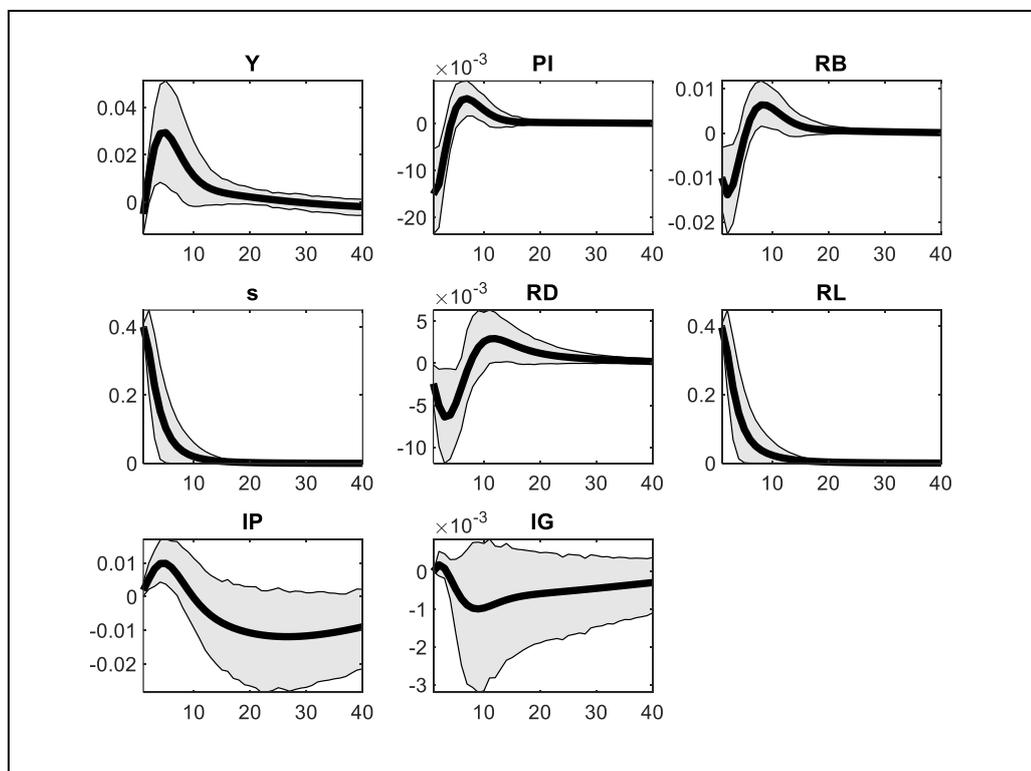


Figure 5 – Impulse-response functions to a shock in reserves/requirements
Source: Authors' estimates (Dynare 6.4).

5.3.5 Impulse-response function – price markup shock

As shown in Figure 6, a positive price markup shock shifts the hybrid New Keynesian Phillips Curve upward, producing an immediate acceleration in inflation (PI). The monetary authority reacts contractionarily according to the Taylor rule, raising the benchmark interest

rate (RB); the increase propagates to the deposit rate (RD) and the lending rate (RL), with gradual pass-through and some inertia.

Rising marginal costs and financial tightening reduce output (Y) in the short run, with a slow return to steady state. Private investment (IP) exhibits a typical overshooting profile: a small initial decline followed by a recovery above the reference level, consistent with the intertemporal reallocation induced by the monetary response and markup normalization; nevertheless, credible intervals indicate significant uncertainty in the medium term. Public investment (IG) reacts little and transiently, in line with the fiscal rule. In short, this is a cost shock: PI increases upon impact, $RB/RD/RL$ rise to contain it, and real activity weakens initially before gradually recovering.

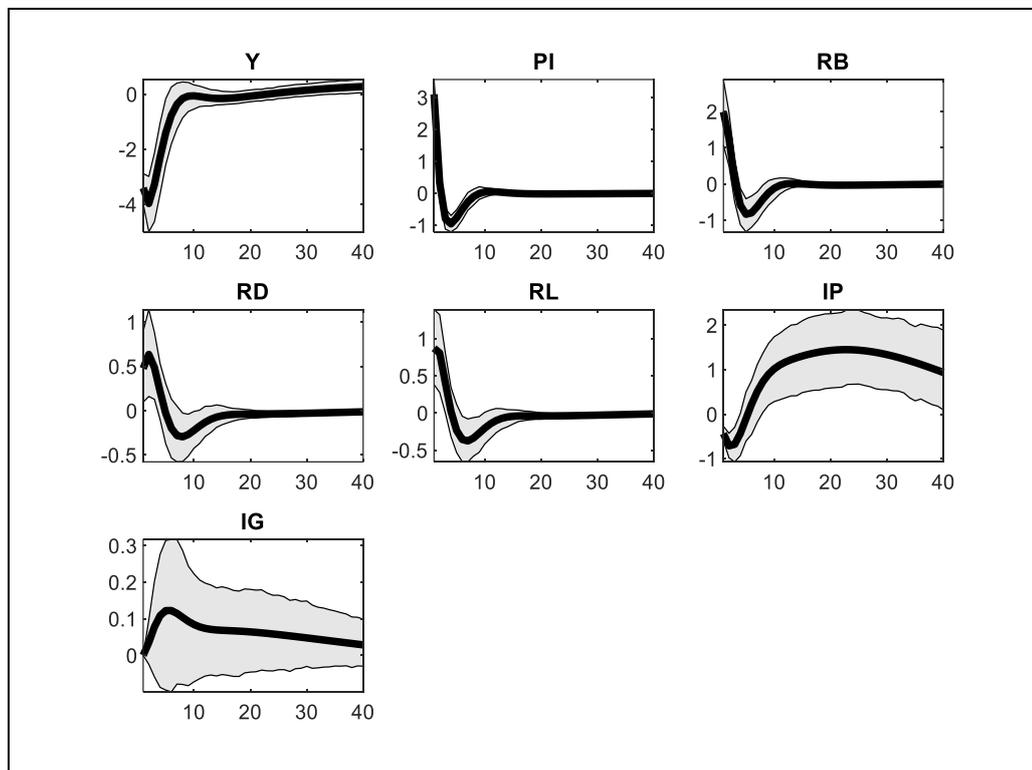


Figure 6 – Impulse-response functions to a price markup shock
Source: Authors' estimates (Dynare 6.4).

5.3.6 Impulse-response function – technological shock

According to the figure, a positive shock to total factor productivity (A) reduces marginal cost and shifts the hybrid New Keynesian Phillips Curve downward, producing disinflation (PI) upon impact. The monetary authority responds according to the Taylor rule with easing: the policy rate (RB) falls immediately, with a gradual pass-through to the deposit

rate (RD) and the lending rate (RL); subsequently, a slight positive overshooting is observed in rates, as output expansion (Y) dominates inflation stabilization.

The efficiency gain increases Y sharply in the short run, and the trajectory slowly converges to the steady state. Despite the financial relief, private investment (IP) shows a persistent decline: the supply shock reduces the marginal value of capital (via Tobin's q and capital utilization), so that the investment accelerator weakens and output expansion is met primarily by current productivity, not capital accumulation. Public investment (IG) is declining moderately and temporarily, consistent with the estimated fiscal rule.

Overall, the technological shock generates real expansion with disinflation, initial interest rate cuts, and partial pass-through to the cost of credit, while private capital formation contracts over the relevant horizon.

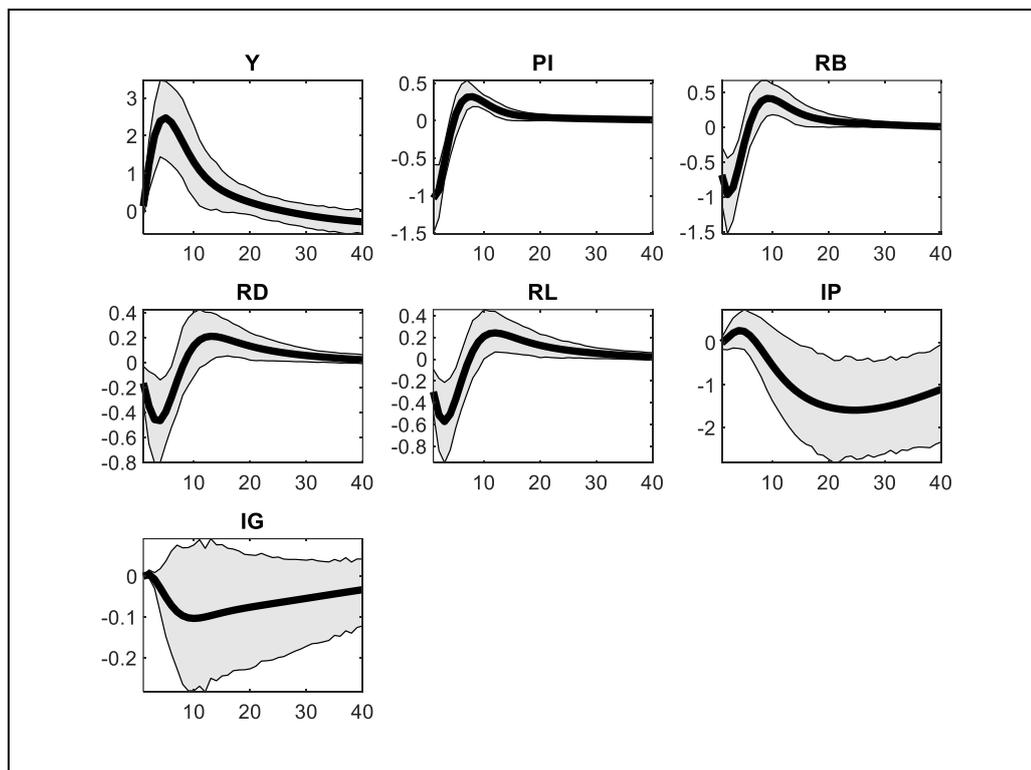


Figure 7 – Impulse-response functions to a technological shock
Source: Authors' estimates (Dynare 6.4).

Final considerations

This article proposed and estimated a New Keynesian DSGE with explicit government and banking sector to structurally decompose the determinants of the spread and quantify the monetary and fiscal transmission channels for bank rates and activity. In line with the objectives

outlined in the introduction – to decompose the spread, measure pass-throughs, evaluate policy counterfactuals, and offer a framework adapted to Brazilian specificities – the empirical results advance the literature by isolating, with Bayesian identification, the relative roles of credit risk (default), market risk/idiosyncrasy/power, and regulatory funding costs.

First, the responses to monetary tightening reveal incomplete and asymmetric pass-through: the Selic (base rate) rises immediately, the deposit rate adjusts gradually and partially, and the lending rate reacts more and more quickly, so that the spread widens in the short term and closes only when the pass-through to the passive margin consolidates. This stable pattern of "incomplete pass-through with inertia in the passive margin" is exactly what Section 3 systematizes for Brazil, given competitive frictions, adjustment costs, and risk perception on both sides of the bank balance sheet.

Second, the variance decomposition of the spread forecast error indicates dominance of default and risk/idiosyncrasy/market power shocks, with a small contribution from the reserve requirement/liquidity block. The historical decomposition corroborates this finding: episodes of spread stress are led by defaults, with reinforcement (or dampening) of the risk/market power component. This evidence is consistent with the empirical studies highlighted in Section 3 on the central role of the credit cycle and risk in bank pricing, and with the indication that changes in reserve requirements explain little of the spread volatility in the sample analyzed.

Third, the real channel operates conventionally: an increase in the cost of using capital reduces capital utilization and Tobin's q , compressing private investment and, with a lag, output and inflation. This mechanism – a credit-mediated financial accelerator – is in line with Section 3, according to which contractionary monetary policy shocks shrink credit (especially free-resource credit). The incorporation of the banking sector amplifies and adds persistence to transmission, especially via funding costs and credit risk; in the fiscal case, such amplification can occur when measures affect these same channels. Fourth, when comparing the results with Section 3 on efficiency and competition, we observe consistency: (i) higher defaults reduce efficiency and tend to increase spreads – which is reflected in the weight of the *npl* shock in the model; and (ii) recent advances in efficiency and competition (digitalization, fintechs, and open banking) are associated with reduced spreads – a movement captured by the risk/idiosyncrasy/market power component.

The policy implications are straightforward. Monetary policy affects the cost of credit, but the level and volatility of the spread depend primarily on microprudential factors (risk management and pricing, creditor protection, collateral recovery) and competitive/technological factors that affect market power and operational efficiency. Thus,

reforms that reduce structural defaults and strengthen competition tend to produce lasting gains in spreads, in line with recent evidence of greater banking efficiency in Brazil. In contrast, reserve requirement changes play a secondary role in the spread variation in the sample analyzed, which recommends parsimony when using liquidity instruments to "manage" spreads.

Finally, as in much of the literature, our exercise adopts simplifications that open up natural areas for extension. Linearization around the steady state can mitigate nonlinearities in stress episodes; representing the banking sector in a small number of states adds heterogeneity (size, funding profile, and governance) that can be explored in versions with different bank types; and we do not explore very recent institutional changes (e.g., regulatory and payments innovations), whose incorporation is a direct extension. These caveats do not alter the central message: incomplete pass-through with inertia in the passive margin, preponderance of credit risk and market power in spread formation, and real effects consistent with the financial accelerator. The framework, therefore, proves useful for evaluating, in an integrated manner, combinations of monetary policy and micro/macroprudential measures aimed at the structural drivers of the spread.

References

- AREOSA, W.; MEDEIROS, M. Inflation Dynamics in Brazil: The Case of a Small Open Economy. *Brazilian Review of Econometrics*, v. 27, n. 1, 2007.
- BANCO CENTRAL DO BRASIL. *Estatísticas Fiscais do Governo Geral – Dívida Bruta*. Brasília, [s.d.]. Available at: <https://www.bcb.gov.br/estatisticas/>. Accessed on August 8, 2025
- BANCO CENTRAL DO BRASIL. *Relatório de Economia Bancária*. Brasília, [s.d.]. Available at: <https://www.bcb.gov.br/publicacoes/relatorioeconomiabancaria>. Accessed on August 8, 2025
- BANCO CENTRAL DO BRASIL. *Sistema Gerenciador de Séries Temporais (SGS)*. Brasília, [s.d.]. Available at: <https://www3.bcb.gov.br/sgspub/>. Accessed on August 8, 2025.
- BERNANKE, B. S.; GERTLER, M. Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *Journal of Economic Perspectives*, v. 9, n. 4, p. 27–48, 1995.
- BERNANKE, B. S.; GERTLER, M.; GILCHRIST, S. The Financial Accelerator in a Quantitative Business Cycle Framework. In: TAYLOR, J. B.; WOODFORD, M. (org.). *Handbook of Macroeconomics*. v. 1C. Amsterdam: Elsevier, 1999.
- BONELLI, R.; VELOSO, F. *Crescimento econômico e mudança estrutural*. Rio de Janeiro: Editora FGV, 2012.
- BRASIL. SECRETARIA DO TESOUREIRO NACIONAL. *Despesas primárias do Governo Central (séries históricas)*. Brasília, [s.d.]. Available at: <https://www.tesourotransparente.gov.br/>. Accessed on August 8, 2025.
- CALVO, G. A. *Staggered Prices in a Utility-Maximizing Framework*. *Journal of Monetary Economics*, v. 12, n. 3, p. 383–398, 1983.
- CASTRO, M. R.; GOUVEA, S.; MINELLA, A.; SANTOS, R. C.; SOUZA-SOBRINHO, N. F. *SAMBA: Stochastic Analytical Model with a Bayesian Approach for the Brazilian Economy*. Working Paper n. 422. Brasília: Banco Central do Brasil, 2015.
- CHRISTIANO, L. J.; EICHENBAUM, M.; EVANS, C. L. Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, v. 113, n. 1, p. 1–45, 2005.
- CHRISTIANO, L. J.; MOTTO, R.; ROSTAGNO, M. Risk Shocks. *American Economic Review*, v. 104, n. 1, p. 27–65, 2014.
- CHU, Victorio Yi Tson. Principais fatores macroeconômicos da inadimplência bancária no Brasil. In: BANCO CENTRAL DO BRASIL. *Juros e Spread Bancário no Brasil – Avaliação de 2 Anos do Projeto*. Brasília: Banco Central do Brasil, p. 40–47, 2001
- CUNHA, André M.; LÉLIS, Marcos T. C.; SILVA, Pedro P.; LOPES, Lucas U. *Ciclos financeiros e o comportamento do crédito no Brasil nos anos 2000*. *Economia e Sociedade*, v. 28, n. 1, p. 201–226, 2019.

CÚRDIA, V.; WOODFORD, M. Credit Spreads and Monetary Policy. *Journal of Money, Credit and Banking*, v. 42, n. s1, p. 3–35, 2010.

FRISCHTAK, Claudio; MOURÃO, João; NORONHA, Júlia. *Oportunidades para a privatização da infraestrutura: o que fazer, como fazer*. Brasília: Confederação Nacional da Indústria (CNI), 2017.

GERALI, A.; NERI, S.; SESSA, L.; SIGNORETTI, F. M. Credit and Banking in a DSGE Model of the Euro Area. *Journal of Money, Credit and Banking*, v. 42, n. s1, p. 107–141, 2010.

GERTLER, M.; KARADI, P. A Model of Unconventional Monetary Policy. *Journal of Monetary Economics*, v. 58, n. 1, p. 17–34, 2011.

GERTLER, M.; KIYOTAKI, N. Financial Intermediation and Credit Policy in Business Cycle Analysis. In: FRIEDMAN, B. M.; WOODFORD, M. (org.). *Handbook of Monetary Economics*. v. 3A. Amsterdam: Elsevier, 2010.

IBGE. *Contas Nacionais Trimestrais*. Rio de Janeiro, [s.d.]. Available at: <https://www.ibge.gov.br/>. Accessed on August 8, 2025.

IBGE. *Índice Nacional de Preços ao Consumidor Amplo (IPCA)*. Rio de Janeiro, [s.d.]. Available at: <https://www.ibge.gov.br/>. Accessed on August 8, 2025.

KAVA, Lucas Eduardo. *Estimação Bayesiana em Modelo DSGE com Canal de Crédito: um estudo preliminar dos impactos da política monetária no Brasil*. 2019. Monografia (Graduação em Ciências Econômicas) – Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto, Universidade de São Paulo (FEA-RP/USP), Ribeirão Preto, 2019.

MARINS, Jaqueline Terra Moura; NEVES, Myrian Beatriz Eiras das. *Inadimplência de crédito e ciclo econômico: um exame da relação no mercado brasileiro de crédito corporativo*. Brasília: Banco Central do Brasil (Trabalhos para Discussão, n. 304). 2013.

MEH, C. T.; MORAN, K. The Role of Bank Capital in the Propagation of Shocks. *Journal of Economic Dynamics and Control*, v. 34, n. 3, p. 555–576, 2010.

MINELLA, André; SOUZA-SOBRINHO, Nelson F. Monetary policy channels in Brazil through the lens of a semi-structural model. *Economic Modelling*, v. 30, p. 405–419, 2013.

MINELLA, André; FREITAS, Paulo Springer de; GOLDFAJN, Ilan; MUINHOS, Marcelo Kfoury. Inflation targeting in Brazil: constructing credibility under exchange rate volatility. *Journal of International Money and Finance*, v. 22, n. 7, p. 1015–1040, 2003.

NUNES, André Francisco Nunes de; PORTUGAL, Marcelo Savino. Choques no spread de crédito bancário e suas implicações para a condução da política monetária no Brasil. *Economia Aplicada*, v. 22, n. 2, p. 273–306, 2018.

PERES, Marco Aurélio Ferreira; ELLERY JUNIOR, Roberto de Góes. Efeitos dinâmicos dos choques fiscais do governo central no PIB do Brasil. *Pesquisa e Planejamento Econômico*, v. 39, n. 2, p. 159–206, 2009.

SMETS, F.; WOUTERS, R. Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. *American Economic Review*, v. 97, n. 3, p. 586–606, 2007.

SOUZA, Gustavo José de Guimarães e; FEIJÓ, Carmem Aparecida do Valle Costa. O processo interativo entre a dinâmica macroeconômica e os bancos: uma perspectiva acerca do risco de crédito além do spread. *Anais do XXXV Encontro Nacional de Economia (ANPEC)*, Recife, 2007.

SMANIOTTO, Emanuelle N.; ALVES, Tiago W.; LÉLIS, Marcos T. C. Atividade econômica e crédito: uma aplicação VAR/VEC sobre recursos livres e direcionados. *Perspectiva Econômica*, v. 15, n. 1, p. 51–66, 2019.

STAUB, Roberta B.; SOUZA, Geraldo da Silva e; TABAK, Benjamin M. Evolution of bank efficiency in Brazil: a DEA approach. *European Journal of Operational Research*, v. 202, n. 1, p. 204–213, 2010.

TAKAHASHI, Fábio Lucas; VASCONCELOS, Marcos Roberto. Eficiência bancária no Brasil (2010–2019): uma análise de dois estágios. *Revista de Economia Mackenzie*, v. 19, n. 2, p. 165–187, 2022.

TAYLOR, John B. Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy* 39, 1993.

TIRYAKI, Gisele Ferreira; GAVAZZA, Ive de Oliveira; ANDRADE, Cláudia Malbouisson; MOTA, André Luís. Ciclos de crédito, inadimplência e as flutuações econômicas no Brasil. *Revista de Economia Contemporânea*, v. 21, n. 1, p. 1–33, 2017.

TOBIN, J. A General Equilibrium Approach to Monetary Theory. *Journal of Money, Credit and Banking*, v. 1, n. 1, p. 15–29, 1969.

VINHADO, Fernando da Silva; DIVINO, José Angelo. Política monetária, macroprudencial e bancos: evidências empíricas usando VAR em painel. *Revista Brasileira de Finanças*, v. 13, n. 4, p. 691–731, 2015.

WANKE, Peter; BARROS, Carlos Pestana. Two-stage DEA: an application to major Brazilian banks. *Expert Systems with Applications*, v. 41, n. 5, p. 2337–2344, 2014.

Appendix – Priors and Posteriors

