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2026

BANCO DE ESPAÑA
Eurosistema

Documentos de Trabajo
N.º 2623

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(*) We thank Daria Finocchiaro, David Martínez-Miera, Erlend Nier, Carlos Pérez, Mara Pirovano, Chiara Punzo, Livio Stracca, Javier Suárez, Carlos Thomas and conference participants in the Czech National Bank Workshop on Financial Stability and Macroprudential Policy, the Symposium of the Spanish Economic Association and ECB and Banco de España seminar series for their useful comments and discussions. The opinions expressed herein are those of the authors and do not necessarily reflect those of the European Central Bank, the Banco de España or the Eurosystem. All errors are our own.
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Documentos de Trabajo. N.º 2623

July 2026

https://doi.org/10.53479/44147

ISSN: 1579-8666 (online edition)

Abstract

This paper studies the financial stability risks and distributional effects of monetary policy tightening and the role of macroprudential policy in shaping these outcomes. We develop a macro-banking model with leveraged borrowers, banks subject to balance-sheet constraints and endogenous default. Higher policy rates increase borrower default risk and generate bank losses, amplifying the contraction in credit and disproportionately affecting financially constrained households. Structural macroprudential policies, including higher capital requirements and tighter loan-to-value caps, attenuate these effects by reducing leverage *ex ante*. The impact of countercyclical interventions is state-dependent: borrower-based measures mitigate the contraction in credit faced by constrained households, while releasing capital buffers supports lending when banks are well capitalized but can amplify credit contraction when balance sheets are weak.

Keywords: monetary policy, financial stability, macroprudential policy.

JEL classification: E44, E52, E58.

Resumen

En este documento se estudian los riesgos para la estabilidad financiera y los efectos distributivos del endurecimiento de la política monetaria, así como el papel de la política macroprudencial en la configuración de estos resultados. Desarrollamos un modelo macro bancario con prestatarios apalancados, bancos sujetos a restricciones de balance y riesgo de impago endógeno. Unos tipos de interés oficiales más altos aumentan el riesgo de impago de los prestatarios y generan pérdidas bancarias, lo que amplifica la contracción del crédito y afecta de manera desproporcionada a los hogares con restricciones financieras. Las políticas macroprudenciales estructurales, entre ellas unos mayores requisitos de capital y límites más estrictos a la relación préstamo-valor, atenúan estos efectos al reducir el apalancamiento *ex ante*. El impacto de las intervenciones contracíclicas depende del estado de la economía: las medidas dirigidas a los prestatarios mitigan la contracción del crédito a la que se enfrentan los hogares con restricciones, mientras que la liberación de colchones de capital respalda la concesión de crédito cuando los bancos están bien capitalizados, pero puede amplificar la contracción crediticia cuando los balances son débiles.

Palabras clave: política monetaria, estabilidad financiera, política macroprudencial.

Códigos JEL: E44, E52, E58.

1 Introduction

Periods of monetary tightening aimed at restoring price stability are often associated with financial stability risks (Jiménez et al., forthcoming; Boissay et al., 2026). By increasing debt-servicing costs and compressing asset valuations, higher interest rates weaken the balance sheets of leveraged households and financial intermediaries, thereby amplifying the contractionary effects of monetary policy through credit and default channels.

The extent to which these amplification effects materialize crucially depends on the macroprudential policy framework. Following the Global Financial Crisis, macroprudential instruments have been increasingly used to contain systemic risk and enhance the resilience of both banks and borrowers. Capital-based measures strengthen banks' loss-absorbing capacity and affect the transmission of shocks through the financial sector, while borrower-based tools limit excessive leverage and bolster household balance sheets. Although these instruments are now widely deployed across advanced economies, much less is known about how they interact with monetary policy during tightening cycles and whether borrower- and capital-based instruments differ in their ability to attenuate the amplification of monetary tightening.

This paper addresses two closely related questions. First, how does monetary policy tightening affect financial stability in an economy with leveraged borrowers and banks, and how are the associated costs distributed between financially constrained and unconstrained agents? Second, to what extent can macroprudential policies mitigate these side effects and reduce the uneven burden imposed by higher interest rates?

To answer these questions, we build a macro-banking model that extends the standard New Keynesian framework by incorporating borrower and bank balance-sheet constraints and endogenous default. In the model, an increase in the policy rate raises debt-servicing costs for leveraged borrowers, leading to higher household default rates. Higher borrower distress, together with rising funding costs, generate losses for banks, weakening their balance sheets and increasing the likelihood of bank default. The strength of these channels depends on initial financial conditions: when leverage is high and balance sheets are fragile, monetary tightening generates pronounced financial stability side effects; when balance sheets are strong, these effects are substantially muted. This emphasis on bank balance-sheet conditions and solvency constraints as key determinants of monetary transmission is consistent with recent quantitative work (Abad et al., 2026).

The quantitative model calibrated for the euro area shows that a monetary policy tightening raises default probabilities of both borrowers and banks. The resulting increase in default rates and the associated contraction in credit supply translate into a disproportionately large adjustment for financially constrained households. As borrowing costs rise and collateral values fall, these households are forced to cut consumption and housing demand sharply, leading to sizable welfare losses. By contrast, unconstrained saver households are largely insulated from these financial channels and experience much smaller welfare losses, driven mainly by standard intertemporal substitution. As a result, financial frictions amplify not only the aggregate contraction induced by monetary tightening, but also its distributional effects, shifting a disproportionate share of the adjustment onto borrowers.

We show that, in this context, macroprudential policies play an important role in shaping both financial stability and welfare outcomes during monetary tightening episodes. Structural macroprudential measures increase the resilience of both borrowers and banks. Higher bank capital requirements raise the loss-absorbing capacity of the banking sector, while tighter borrower-based measures, such as loan-to-value caps, limit leverage ex ante and improve household balance sheets. As a result, increases in policy rates lead to smaller rises in default probabilities, a more muted contraction in credit supply, and lower welfare losses for financially constrained households. Borrower-based measures are particularly effective in stabilizing consumption and housing demand among leveraged households, thereby reducing the uneven welfare costs induced by monetary tightening.

We also analyze the role of countercyclical macroprudential policies during monetary tightening episodes.[1] Their effects depend crucially on the initial condition of bank balance sheets. When banks enter the tightening phase with strong capital positions, releasing the Countercyclical Capital Buffer supports lending and dampens the contractionary effects of higher interest rates, mitigating welfare losses for borrowers with negligible effects on savers' welfare. When bank capitalization is weak, however, a risk channel dominates. In this case, lowering capital requirements raises bank default risk and weakens bank balance sheets, offsetting or even reversing the intended stabilizing effects of a CCyB release. Under these conditions, borrower-based countercyclical measures are relatively more effective. Policies that prevent an unintended tightening of borrower constraints, such as maintaining the effective stringency of loan-to-value caps, support credit access for financially constrained households and reduce the uneven welfare costs of monetary tightening without increasing bank fragility.

Our results contribute to a growing literature on the interaction between monetary and macroprudential policy (e.g. Alpanda and Zubairy, 2017; Angelini, Neri, and Panetta, 2014;

[1] We abstract from the accumulation phase of macroprudential capital buffers and instead focus on the effects of deploying existing buffers during the tightening phase.

Carrillo et al., 2021; Chen et al., 2023; Collard et al., 2017; Ferrero, Harrison, and Nelson, 2024; Jensen, Ravn, and Santoro, 2018; Paoli and Paustian, 2017; Van der Ghote, 2021; Mendicino et al., 2020). Relative to this literature, our contribution is threefold. First, we characterize the financial stability side effects of monetary tightening in an economy with endogenous default and balance-sheet constraints. Second, we show that financial frictions amplify the economic and welfare costs of monetary tightening in an asymmetric manner, with financially constrained households bearing a disproportionate share of the adjustment. Third, we jointly study borrower-based and capital-based macroprudential instruments, considering both their structural (ex ante) and countercyclical (ex post) dimensions, and assess their effectiveness in mitigating these costs.

Our results are also closely related to recent empirical evidence on financial stability effects of monetary policy. Using cross-country bank-level data, Bouis, Mirza, and Nier (2025) show that higher interest rates increase loan loss provisions, while tight borrower-based measures in place ex ante significantly attenuate this effect. They also document state-dependent bank profitability, with interest margin gains more likely to be offset when banks enter tightening cycles with vulnerable balance sheets. Similarly, Jiménez et al. (forthcoming) show that monetary tightening can generate financial stability risks when it follows prolonged periods of low interest rates that foster credit booms and financial vulnerabilities. These findings are echoed by Boissay et al. (2026), who show theoretically that extended monetary accommodation can induce risk-taking and credit expansion, while subsequent tightening may trigger sharp reversals through the materialization of credit risk. Our framework complements this evidence by providing a structural interpretation of these mechanisms and by studying how macroprudential instruments can mitigate both financial instability and uneven adjustment costs.

The remainder of the paper is organized as follows: Section 2 presents the model. Section 3 describes the calibration. Section 4 studies the effects of monetary policy shocks and their implications for financial stability. Section 5 analyses the role of alternative macroprudential policies during monetary tightening. Section 6 concludes.

2 The model

We consider an economy populated by two dynasties that provide full consumption insurance to their members. These dynasties differ in their intertemporal preferences and are labeled as patient and impatient. The patient dynasty includes both workers and bankers.

Workers supply labor to the production sector and transfer their wage income to the dynasty's household. Bankers manage financial intermediaries and use their limited net worth to provide equity to banks, transferring their terminal wealth back to the dynasty in the form of dividends. Patient households derive utility from consumption, leisure, and housing, and save through bank deposits and long-term government bonds.

The impatient dynasty, by contrast, is characterized by a lower discount factor, which induces a desire to borrow rather than save. These households have the same utility structure as patient ones, consuming both goods and housing, but they finance their housing purchases through mortgages. Borrowers internalize that higher leverage implies a higher lending rate due to increasing default risk, which leads to an interior solution for optimal leverage when the borrowing constraint is not binding. In particular, in the absence of a binding LTV constraint, borrowers choose their debt level by equating the marginal benefit of additional borrowing to its marginal cost, which includes the endogenous increase in borrowing rates induced by higher default risk. Whether the LTV constraint binds depends on its level and on economic conditions: it can bind or not in both the steady state and in response to shocks.[2] Borrowers may default on their mortgages when the value of their housing collateral falls below their outstanding debt. In such cases, banks repossess the collateral, but incur verification costs that create deadweight losses. Imposing an LTV limit reduces borrowers' exposure to asset price fluctuations and helps to contain default probabilities.

Bankers provide equity financing to banks using their net worth and return their terminal wealth to the patient dynasty. Banks use this equity, together with non-contingent deposits from patient households, to finance mortgage loans to impatient households and to purchase long-term government bonds. Banks operate under limited liability and default whenever their net worth becomes negative. Bank failures trigger costly asset repossessions, which represent further losses to the economy.

A fraction κ of bank deposits is insured through a government-backed deposit insurance scheme (DIS), funded by lump-sum taxes. The remaining uninsured deposits are priced by depositors based on the expected average losses across the banking sector. Crucially, individual banks' leverage and risk profiles are assumed to be unobservable to small, dispersed depositors. As a result, the risk of default is not priced at the margin, and banks face no direct funding penalty for taking excessive risks. This friction creates incentives for excessive

[2] In the benchmark calibration, the LTV constraint binds in steady state and becomes more binding following contractionary monetary policy shocks. This feature is consistent with our focus on financial amplification during tightening episodes. While the model allows for the possibility that the constraint becomes slack, all policy experiments considered in the paper are conducted in regions of the state space where monetary tightening increases the tightness of the borrowing constraint.

leverage and underpricing of credit risk, providing a clear rationale for imposing regulatory capital requirements.

The following subsections describe each of these model components in more detail.

2.1 Default risk

The debt issued by banks and the mortgage loans taken by impatient households are subject to idiosyncratic risk, captured by shocks $\omega_{j,t+1}$ for each borrower class $j \in \{b, m\}$, where b denotes banks and m denotes mortgage borrowers. These shocks affect the gross return on the corresponding assets multiplicatively, and are assumed to be independently distributed and log-normally distributed with mean one and standard deviation σ. For each borrower type j, let $F_j(\omega_{j,t+1})$ denote the cumulative distribution function of the shock $\omega_{j,t+1}$.

A borrower of type j defaults if the realized shock falls below a threshold $\bar{\omega}_{j,t+1}$, which defines the cutoff value below which the asset return is insufficient to meet debt obligations. The probability of default is thus given by $F_j(\bar{\omega}_{j,t+1})$. Following Bernanke, Gertler, and Gilchrist (1999), the fraction of total assets held by borrowers of type j that end up in default is defined as

$$G_j(\bar{\omega}_{j,t+1}) = \int_0^{\bar{\omega}_{j,t+1}} \omega_{j,t+1}\, dF_j(\omega_{j,t+1}),$$

and the expected gross share of asset value that goes to the lender as

$$\Gamma_j(\overline{\omega}_{j,t+1}) = \mathbb{E}_t[min\{\omega_{j,t+1}, \overline{\omega}_{j,t+1}\}] = G_j\left(\overline{\omega}_{j,t+1}\right) + \overline{\omega}_{j,t+1}[1 - F_j\left(\overline{\omega}_{j,t+1}\right)].$$

In the presence of a proportional asset repossession cost μ_j, the net share of assets that goes to the lender can be expressed as $\Gamma_j(\overline{\omega}_{j,t+1}) - \mu_j G_j\left(\overline{\omega}_{j,t+1}\right)$. The share of assets eventually accrued to the borrowers of class j is $\mathbb{E}_t[max\{\omega_{j,t+1} - \overline{\omega}_{j,t+1}, 0\}] = 1 - \Gamma_j(\overline{\omega}_{j,t+1})$.

2.2 Patient households

The dynasty of patient households solves

$$\max_{\substack{\{C_{s,t+\tau}, L_{s,t+\tau,p}, H_{s,t+\tau,p},\\ K_{t+\tau}, D_{t+\tau}, B_{t+\tau}, B^g_{t+\tau}\}_{\tau=0,1,2,\dots}}} \mathbb{E}\left(\sum_{\tau=0}^{\infty} \beta^{t+\tau} \log(C_{s,t+\tau}) - \frac{\varphi}{1+\eta}(L_{s,t+\tau})^{1+\eta} + \varphi_h \log(H_{s,t+\tau})\right)$$

subject to,

$$P_tC_{s,t} + Q_t(K_t - (1-\delta)K_{t-1}) + D_t + B_t + B_t^g + n_t^{add} + c(n_t^{add}) \leq$$
$$P_t r_{k,t}K_{t-1} + W_tL_{s,t} + R_{d,t}D_{t-1} + R_{t-1}B_{t-1} + R_{g,t-1}B_{t-1}^g + P_tT_{s,t} + P_t\tau_t + P_t\pi_t$$

where φ measures the disutility of labor, η is the inverse of the Frisch elasticity of labor supply, and φ_h is the weight of housing goods in utility. Here, $C_{t,p}$ denotes consumption, $L_{t,p}$ represents hours worked, $H_{t,p}$ is housing goods, P_t is the nominal price of the consumption good, and W_t is the nominal wage rate. Households invest in physical capital K_t with nominal price Q_t, depreciation rate δ, and rental rate $r_{k,t}$. Furthermore, they can transfer an additional amount of equity directly to new bankers, n_t^{add}, subject to a quadratic cost, $c\left(n_t^{add}\right) = \psi_0 n_t^{add} + \frac{\psi_1}{2}\left(n_t^{add}\right)^2$. Holdings B_{t-1} of the risk free asset (which is in zero net supply) pay the gross short-term nominal interest rate R_{t-1} at t. The gross return obtained on the deposit portfolio D_{t-1} is $R_{d,t} = R_{d,t-1} - (1-\kappa)\tau_t$, where $R_{d,t-1}$ is the promised gross deposit rate (that the fraction κ of insured deposits always pay) and τ_t is the average per unit loss rate (relative to the promised repayment) experienced on the fraction of uninsured deposits. For $\kappa < 1$, making the bundle of insured and uninsured bank debt attractive to savers requires a contractual gross interest rate $R_{d,t-1}$ higher than the free rate R_{t-1}.

Finally, $T_{s,t}$ is a lump-sum tax used by the DIS to ex-post balance its budget, τ_t represents aggregate net transfers from entrepreneurs and bankers to the household, and π_t denotes the profits from capital management firms.

2.3 Impatient households

The objective function of the impatient households has the same form and parameters as that of patient households, except for the discount factor, which for them is $\beta_m < \beta_s$ and will induce the members of this dynasty to borrow rather than save in equilibrium. Their budget constraint reads as follows:

$$P_tC_{m,t} + Q_{h,t}H_{m,t} - B_{m,t} \leq W_tL_{m,t} + (1 - \Gamma_{m,t}(\overline{\omega}_{m,t}))R_t^{H,nom}Q_{h,t-1}H_{m,t-1} - P_tT_{m,t}.$$

where $R_t^{H,nom} = (1-\delta_{m,t})\frac{Q_{h,t}}{Q_{h,t-1}}$ is the ex-post nominal gross unlevered return on housing, $B_{m,t}$ is the dynasty's aggregate borrowing from the banking system. Each impatient household experiences at the beginning of each period t an idiosyncratic shock $\omega_{m,t}$ to the efficiency units of housing owned from the previous period and has the option to (strategically) default on the non-recourse housing loans associated with those units. This shock makes the effective resale value of the housing units acquired in the previous period $Q_{h,t}H_{m,t} = \omega_{m,t}Q_{h,t}H_{m,t}(1-\delta_{m,t})$ and, given that default is costless for households, it makes default on the underlying loan ex-post optimal for the household whenever $\omega_{m,t}Q_{h,t}H_{m,t}(1-\delta_{m,t}) < R_{m,t-1}B_{m,t-1}$. Therefore, the actual return on mortgage loans that banks get is:[3]

$$\widetilde{R}^b_{b,t+1} \quad = \left[\Gamma_m(\overline{\omega}_{m,t+1}) - \mu_m G_m(\overline{\omega}_{m,t+1})\right]\frac{R_{m,t+1}Q_{h,t}H_{m,t}}{B_{M,t+1}}.$$

Borrower-based macroprudential policies are introduced as a borrowing limit for impatient households. More precisely, macroprudential authorities establish a Loan-to-Value cap,[4]

$$R_{m,t}B_{m,t} \leq \mathrm{LTV}_t Q_{h,t}H_{m,t}.$$

This LTV cap reduces households' leverage by limiting borrowing to a fraction of the value of their housing assets, making it less likely that the collateral value will fall below the outstanding debt and thus reducing the likelihood of default. By lowering the default probability, the LTV cap also reduces the risk premium banks require, which in turn decreases households' funding costs.

2.4 Bankers

In each period, after receiving the returns on their previous investments, a fraction $1-\theta_b$ of bankers exits and becomes workers, while an equal fraction of workers enters and becomes bankers. This turnover ensures that the population of each class of agents remains constant

[3] The model consider adjustable lending rates. While mortgage markets in several euro area countries are characterized by a high share of fixed-rate contracts at origination, the fixation period of these mortgages is typically limited and does not coincide with the full maturity of the loan. In practice, many contracts feature rate fixation periods of a few years after which rates are reset. As a result, even in many countries with a high prevalence of fixed-rate mortgages at origination, households remain exposed to interest rate changes over the life of the loan. In this sense, modelling short-term debt with variable rates captures, in reduced form, the exposure of borrowers to interest rate risk over relevant horizons. For example, De Stefani and Mano (2025) document that mortgages classified as fixed-rate at origination may still feature relatively short fixation periods, and that loans expected to reset within a few years can be treated as fixed-rate in the data.

[4] We focus on LTV caps as they are among the most widely used borrower-based macroprudential instruments in practice and in the quantitative macro-finance literature. Other borrower-based measures, such as debt-service-to-income (DSTI) or debt-to-income (DTI) limits also restrain household leverage, and would be expected to have qualitatively similar effects on financial stability in our framework.

at size χ, preventing the aggregate net worth of bankers from growing without bound. New bankers receive an endowment of total net worth ι_t from the household. Both surviving and new bankers use their net worth n_t to provide equity financing eq_t to banks and transfer their terminal wealth to the household in the form of dividends.

The individual banker's problem is given by:

$$V_{b,t} = \max_{\{\text{eq}_t, \text{div}_t\}} \left\{ \text{div}_t + \mathbb{E}_t \Big[\Lambda_{s,t+1} \big((1-\theta_b)\, n_{b,t+1} + \theta_b V_{b,t+1} \big) \Big] \right\}$$

subject to:

$$\text{eq}_t + \text{div}_t = n_t$$
$$n_{t+1} = \rho_{t+1}^{nom}\, \text{eq}_t$$
$$\text{div}_t \geq 0$$

where $\Lambda_{s,t+1} = \beta_s \lambda_{s,t+1}^{nom} / \lambda_{s,t}^{nom}$ is the stochastic discount factor of the patient household and div_t is the dividend that the banker pays to the household dynasty. Guessing that the value function is linear in net worth, as in Gertler and Kiyotaki (2010),

$$v_{b,t} n_t = \max_{\{\text{eq}_t, \text{div}_t\}} \left\{ \text{div}_t + \mathbb{E}_t \Big[\Lambda_{s,t+1} \left(1 - \theta_b + \theta_b v_{b,t+1}\right) n_{t+1} \Big] \right\},$$

where $\Lambda_{b,t+1} = \Lambda_{t+1}\left[1 - \theta_b + \theta_b v_{b,t+1}\right]$. Insofar as the shadow value of one unit of bankers equity satisfies $v_{b,t} > 1$ (which we verify to hold true), bankers only pay dividends when they retire.

Taking into account effects of retirement and the entry of new bankers, as well as households' equity injections into banks, the evolution of active bankers' *aggregate* net worth can be described as:

$$n_t = \theta_b(\rho_t eq_{t-1}) + \iota_{b,t} + n_t^{add}$$

where ρ_t is return on equity, that will be defined in the banks' problem below, and $\iota_{b,t}$ is new bankers' nominal net worth endowment (received from saving households), which we assume to be a proportion χ_b of the net worth of retiring bankers:

$$\iota_{b,t} = \chi_b(1-\theta_b)(\rho_t eq_{t-1}).$$

2.5 Banks

The representative bank issues equity eq_t among bankers and nominal deposits D_t that promise a gross interest rate $R_{d,t}$ among households. The bank uses these funds to purchase long-term government bonds $B_{g,t}$ and to provide a continuum of identical mortgage loans of total size $B_{m,t}$. The presence of government bonds allows banks to adjust their portfolio composition in response to changes in the risk-return trade-off induced by monetary policy shocks. This portfolio is subject to a bank-idiosyncratic asset return shock $\omega_{b,t+1}$. The bank operates across two consecutive dates and gives back its terminal net worth, if positive, to the bankers. If a bank's terminal net worth is negative, it defaults. The DIS then takes the returns $(1-\mu_b)\omega_{b,t+1}\left(\widetilde{R}_{b,t+1}B_{m,t}+R_{g,t+1}B_{g,t}\right)$ where μ_b is a proportional repossession cost, pays the fraction κ of insured deposits in full, and pays a fraction $1-\kappa$ of the repossessed returns to the holders of uninsured deposits.

The representative bank maximizes the net present value of bankers' equity stake

$$NPV_{b,t}=\mathbb{E}\left(\frac{\Lambda_{b,t+1}}{\pi_{t+1}}\max\left\{\omega_{b,t+1}\left(\widetilde{R}_{b,t+1}B_{m,t}+R_{g,t+1}B_{g,t}\right)-R_t^dD_t,0\right\}\right)-v_{b,t}eq_t, \tag{1}$$

where the equity eq_t is valued at its equilibrium opportunity cost $v_{b,t}$, and the max operator reflects shareholders' limited liability as explained above. The bank is subject to the balance sheet constraint, $B_{m,t}+Q_{g,t}B_{g,t}=eq_t+D_t$, and the regulatory capital constraint $eq_t\geq\phi_t\left(B_{m,t}+B_{g,t}\right)$, where ϕ_t is the capital requirement. If the capital requirement is binding, the above expression must hold with equality.[5] The threshold value of ω^b_{t+1} below which the bank fails is:

$$\bar{\omega}_{b,t+1}=\frac{R_{d,t}\big(\left(1-\phi\right)B_{m,t}+\left(1-\phi\Delta_g\right)B_{g,t}\big)}{\left(\widetilde{R}_{b,t+1}B_{m,t}+R_{g,t+1}B_{g,t}\right)}$$

Prior definitions, allows us to rewrite the bank's objective function as

$$\max_{B_{m,t},B_{g,t}}\left\{\mathbb{E}_t\left[\frac{\Lambda^b_{t+1}}{\Pi_{t+1}}\left(1-\Gamma^b_{t+1}(\overline{\omega}^b_{t+1})\right)\left(\widetilde{R}_{b,t+1}B_{m,t}+R_{g,t+1}B_{g,t}\right)\right]-v^b_t\phi\left(B_{m,t}+B_{g,t}\right)\right\};$$

The optimization problem implies that the bank is willing to invest in mortgage loans insofar as

[5] As it turns out to be in equilibrium because partially insured deposits are always less costly than equity financing.

$$\mathbb{E}_t\left(\frac{\Lambda^b_{t+1}}{\Pi_{t+1}}R_{m,t+1}\left[\left(1-\Gamma^b_{t+1}(\overline{\omega}_{b,t+1})\right)-\Gamma'_{b,t+1}(\overline{\omega}_{b,t+1})\frac{\partial\overline{\omega}_{b,t+1}}{\partial B_{m,t}}B_{m,t}\right]\right)\geq v^b_t\phi,$$

This constraint will hold with equality since it is not in the banks' interest to pay more for their loans than strictly needed.[6] Finally, we can write the banks' aggregate return on equity as $\rho_{t+1}=\left[\left(1-\Gamma^b_{t+1}(\overline{\omega}_{b,t+1})\right)-\Gamma'_{b,t+1}(\overline{\omega}_{b,t+1})\frac{\partial\overline{\omega}_{b,t+1}}{\partial B_{m,t}}B_{m,t}\right]\frac{R_{m,t+1}}{\phi_t}$.

2.6 Consumption goods production sector

We assume a continuum $i\in[0,1]$ of monopolistically competitive firms that produce a differentiated intermediate good $y_t(i)$ by combining labor $l_t(i)$ and capital $k_t(i)$ using a constant-returns-to-scale technology:

$$y_t(i)=l_t(i)^{1-\alpha}k_{t-1}(i)^{\alpha}, \tag{2}$$

where α is the share of capital in production. Intermediate good firms are owned by the household dynasty and distribute profits or losses back to it. The intermediate output is then purchased by the perfectly competitive firms that produce the final consumption good Y_t according to a CES technology.

We assume sticky prices at the intermediate production sector according to the standard Calvo setup. Prices are set for contractual periods of random length. Each contract expires with probability $1-\xi$ per period. When the contract expires, the intermediate producer i sets the new price $\widetilde{p}_t(i)$ to maximize the present discounted value of future real profits over the validity of the contract.

2.7 Capital and housing goods production

The optimization problems of capital producers and housing producers are symmetric. Let $I_{\Phi,t}$ with $\Phi=\{K,H\}$ represent capital investment and housing investment, respectively. Both producers combine investment, $I_{\Phi,t}$, with the previous stock of capital or housing, Φ_{t-1}, in order to produce new capital or housing which can be sold at nominal price $Q_{\Phi,t}$. Producers face adjustment costs as in Jermann (1998), $S\left(\frac{I_{\Phi,t}}{\Phi_{t-1}}\right)=\frac{a_1}{1-\frac{1}{\psi_\Phi}}\left(\frac{I_{\Phi,t}}{\Phi_{t-1}}\right)^{1-\frac{1}{\psi_\Phi}}+a_2$, where a_1 and a_2 are chosen to guarantee that, in the steady state, the investment-to-capital

[6] In our setup, the regulatory capital constraint is binding in equilibrium, reflecting the relatively lower cost of deposits compared to equity financing. As a result, banks always operate at the regulatory minimum, and variations in capital requirements directly affect their lending capacity and risk exposure.

and investment-to-housing ratio is equal to the depreciation rate and $S'\left(I_{\Phi,t}/\Phi_{t-1}\right)$ equals one. The law of motion of the capital and housing stock can be written as

$$\Phi_t = \left(1-\delta_\Phi\right)\Phi_{t-1} + S\left(\frac{I_{\Phi,t}}{\Phi_{t-1}}\right)\Phi_{t-1}, \tag{3}$$

where δ_Φ is the depreciation rate.

2.8 Monetary authority

The monetary authority sets the one-period short-term nominal interest rate R_t according to a Taylor-type policy rule:

$$R_t = R_{t-1}^{\rho_R}\left[\bar{R}\left(\frac{\pi_t}{\bar{\pi}}\right)^{\alpha_\pi}\left(\frac{GDP_t}{GDP_{t-1}}\right)^{\alpha_{GDP}}\right]^{1-\rho_R} \tag{4}$$

where ρ_R is the interest rate smoothing parameter, α_π and α_{GDP} determine the responses of the interest rate to GDP growth and inflation deviations from the target $\bar{\pi}$, respectively. $\bar{R}$ denotes the steady state level of the nominal interest rate.

2.9 Macroprudential authority

Macroprudential authorities set structural values for borrower LTV caps, $\bar{\text{LTV}}$, and bank capital requirements, $\bar{\phi}$. In addition to these ex-ante levels, authorities may adjust macroprudential instruments dynamically in response to financial conditions.[7] When ex-post macroprudential policies are considered in the simulation exercises, both the LTV cap and the capital buffer follow simple countercyclical feedback rules. Formally:

$$\begin{aligned} \text{LTV}_t &= \bar{\text{LTV}} + \Phi_{\text{ltv}}\left(\mu_{m,t} - \bar{\mu}_m\right) \\ \phi_t &= \bar{\phi} + \Phi_\phi\left(B_{m,t} - \bar{B}_m\right) \end{aligned}$$

where $\mu_{m,t}$ is the multiplier associated with the LTV constraint on mortgage borrowers, and $B_{m,t}$ denotes the aggregate volume of mortgage lending. The parameters Φ_{ltv} and Φ_ϕ capture the sensitivity of each instrument to deviations from their respective steady-state values.

[7] Importantly, our framework does not explicitly model the endogenous accumulation of capital buffers over the financial cycle. Instead, we assume that macroprudential authorities can adjust capital requirements in response to economic conditions, capturing the use of previously accumulated buffers. Therefore, changes in ϕ_t should be interpreted as temporary relaxations or tightenings of effective capital requirements, rather than a full representation of the institutional CCyB mechanism, which involves a gradual build-up and subsequent release of buffers.

The LTV rule implies that the cap responds to changes in the tightness of the borrowing constraint, as reflected by movements in the LTV multiplier. For sufficiently large values of (Φ_{ltv}), this rule approximates a policy stance where the LTV cap is actively adjusted to keep the bindingness of the constraint roughly constant over the cycle. This type of intervention, where the LTV cap is relaxed during a monetary policy tightening to prevent further tightening of borrowing conditions, has been implemented in several euro area jurisdictions. The rationale is to avoid the amplification of monetary tightening through unintended macroprudential procyclicality, whereby falling collateral values and higher rates would otherwise make the regulatory constraint more binding and restrict credit access just when the economy is already weakening [see][for a discussion of recent policy changes across European countries]hempell2024implications.

The policy experiments presented in the following sections are designed to isolate the effects of macroprudential policy. Specifically, we compare a baseline scenario in which only the structural (ex-ante) values of LTV and capital requirements are enforced, against alternative scenarios where: (i) the structural values are set at tighter levels to improve resilience, and (ii) the countercyclical adjustments described above are activated to mitigate the impact of monetary tightening on credit dynamics.

3 Calibration

The model is calibrated using micro and macro quarterly Euro Area data for the 2001 Q1-2019 Q4 period. We divide parameters into two groups. A first group is externally set to standard values in the literature. A second group is chosen to match a set of key euro area moments. Table 1 reports all the parameter values resulting from our calibration.

Pre-set parameters. These parameters mainly govern preferences, technology, and nominal rigidities and are set to standard values used in the DSGE literature. We set the Frisch elasticity of labor supply, η, equal to one, the capital-share parameter of the production function, α, equal to 0.30, the discount rate of patient households is 0.9975. The depreciation rate of physical capital, δ, equal to 0.03. The labor disutility parameter, φ, which only affects the scale of the economy, is normalized to one. The average net markup of intermediate firms θ is 20% and the Calvo parameter, ξ 0.9. The bankruptcy cost parameters are set equal to a common value of 0.30 for both banks and households. Regarding the Taylor rule, we assume standard coefficients for the response to activity and inflation and the smoothing parameter (see e.g. Coenen et al. 2008).

Calibrated parameters. A second set of parameters are set jointly by minimizing the sum of the square distances between the observed moments and the steady state values. However, some parameters can be linked to specific targets. The steady state inflation parameter, $\overline{\pi}$ and the discount factor, β, directly pin down the inflation target and the risk free rate which match the real interest rate observed over the sample period. The share of insured deposits in bank debt κ is set to 0.54 in line with the evidence by Demirgüç-Kunt, Kane, and Laeven (2015) for EA countries.

We calibrate the share of borrowers in the economy to match the proportion of indebted households in the Euro Area of about 43%.[8] The weight on housing in the utility of borrowers matches the share of housing held by the indebted and non-indebted households in the Euro Area.

The borrowers' discount factor β_m, helps to match the ratios of household mortgages to GDP. The housing depreciation rate is calibrated to match the ratio of residential investment to GDP. The new bankers' endowment parameter, χ_b, is used to make the steady state bank expected return on equity, ρ_b, equal to the average cost of equity of EA banks. In addition, the survival rate of bankers, θ_b, is used so that the shadow value of bank equity, υ_b, matches the average price-to-book ratio of banks over the calibration period.

The bank capital requirement parameter, ϕ, is calibrated to match the average capital ratio of euro area banks, which we set at 13.3% based on aggregate data.[9] Since this measure is defined in terms of risk-weighted assets, we adjust it to make it consistent with the structure of the model, where bank assets consist primarily of mortgage loans. In line with Basel regulatory standards, we assume a representative risk weight of 50% for mortgage exposures. Accordingly, the model-consistent capital requirement is given by $\phi = 0.5 \times 13.3\% = 6.64\%$.

The variances of the two idiosyncratic shocks are mainly used to match the remaining targets. As shown in Table 2, we match very closely the targeted moments selected for the calibration.

While mortgage default rates are not direct targets of our calibration, their levels are consistent with the low empirical magnitudes in most euro area countries. In particular, default probabilities are disciplined by matching observed mortgage spreads, which embed compensation for credit risk. For example, euro area data show that non-performing loans remain below 2% of total loans in recent years. At the same time, the mechanism linking monetary policy to default risk is well established: higher interest rates increase borrowersâ debt servicing burden and raise the probability of default, [see][]bouis2025high.

[8] See 2017 ECB Household Finance and Consumption Survey (HFCS)

[9] The calculation is based on data collected from the consolidated banking dataset of the ECB - CBD2.

Table 1: Model parameters

A) Preset parameters					
Disutility of labor for savers	φ_s	1	Banks bankruptcy cost	μ_M	0.3
Disutility of labor for borrowers	φ_m	1	Households bankruptcy cost	μ_m	0.3
Habits formation	ϑ	0.5	Capital adjustment cost parameter	ψ_k	4.57
Housing weight in savers' utility	υ_s	1	Housing adjustment cost parameter	ψ_h	2.42
Frisch elasticity of labor	η	1	Calvo probability	ξ	0.9
Capital share in production	α	0.3	Smoothing parameter (Taylor rule)	ρ_R	0.86
Depreciation rate of capital	δ_k	0.03	Inflation response (Taylor rule)	α_π	1.9
Population of bankers	x_b	1	Output growth response (Taylor rule)	$\alpha_{\Delta Y}$	0.18
Population of savers	x_s	1	Output gap response	α_Y	0.05
Equity issuance cost parameter	ψ_0	1.5	Net markup of intermediate firms	θ	0.2
B) Calibrated parameters					
Share of insured deposits	κ	0.54	Capital ratio	ϕ	6.64
Steady-state inflation	$\overline{\pi}$	1.005	Population of impatient households	x_m	0.90
Discount factor of borrowers	β_m	0.95	STD iid risk for banks	σ_M	0.024
Housing depreciation	δ_h	0.012	STD iid risk for borrowers	σ_m	0.0523
Housing weight in borrowers' utility	υ_m	0.4274	Transfer from HH to bankers	χ_b	0.60
Discount factor for savers	β_s	0.9955	Survival rate of bankers	θ_b	0.951

Table 2: Model fit

Targets	**Definition**	**Data**	**Model**
Fraction of borrowers	$x_m/(x_m+x_s)$	0.43	0.42
Inflation	$(\overline{\pi}-1)\times 400$	1.59	1.50
Capital ratio (risk-weighted)	ϕ	6.64	6.64
Share of insured deposits	κ	0.56	0.54
HH loans to GDP	B_M/GDP	2.07	2.06
Spread HH loans	$(R^M-R^d)\times 400$	1.08	0.71
Banks' default	$F_b(\overline{\omega}_b)\times 400$	0.78	0.77
Real equity return of banks	$(\rho_F-1)\times 400$	8.14	8.08
Banks' price to book ratio	v_b	1.20	1.74
Housing Investment to GDP	I_H/GDP	0.06	0.06
Borrowers' housing wealth share of GDP	$(B_M\times x_m)/GDP$	0.52	0.56

Note: Data sample: Euro Area 2001:Q1-19:Q4; Interest rates, equity returns, default rates, and spreads are reported in annualized percentage points.

3.1 Solution method

The model features nonlinearities arising from occasionally binding constraints and state-dependent default. We solve the model using a piecewise-linear approach based on the OccBin method, which allows us to account for regime changes associated with the bindingness of the LTV constraint. However, in our simulations of monetary policy tightening increase the tightness of the borrowing constraint and capital requirement is binding in all simulations, so no regime switching arises.

4 The implications of monetary policy for financial stability

First, we examine how monetary policy tightening impacts the financial stability of borrowers, banks, and the broader economy. Figure 1 shows the impulse response functions of a set of endogenous variables to a monetary policy tightening of 100 basis points. The tightening induces a contraction in economic activity, with output and inflation declining as consumption and investment fall.

Beyond these standard channels, monetary tightening can lead to side effects on financial stability, by constraining credit and activating balance sheet mechanisms that affect both borrowers and banks. Higher interest rates erode borrowers' net worth and reduce housing prices, increasing households' default probabilities, as collateral values fall relative to outstanding debt. At the same time, higher funding costs and weaker credit demand reduce bank profitability and increase banks' default probabilities. Through these channels, monetary tightening increases financial vulnerabilities among excessively leveraged borrowers and banks, contracting credit supply and posing risks to broader financial stability.

Figure 2 illustrates the impulse responses of consumption and housing demand across household types. Financially-constrained borrowers experience a sharp contraction in consumption reflecting higher debt servicing costs and tighter borrowing constraints. By contrast, savers adjust consumption mainly through intertemporal substitution in response to the higher returns on savings, resulting in a comparatively muted response.

Housing demand exhibits similar heterogeneity. Higher mortgage rates induce borrowers to reduce housing investments, contributing to a decline in house prices. Savers partially offset this decline increasing their own housing purchases, generating a reallocation of housing assets from constrained borrowers to savers, as shown in Figure 2. These dynamics highlight the distributional and financial stability effects through which monetary policy shocks propagate through the housing market and the financial sector.

Figure 1: Monetary policy shock

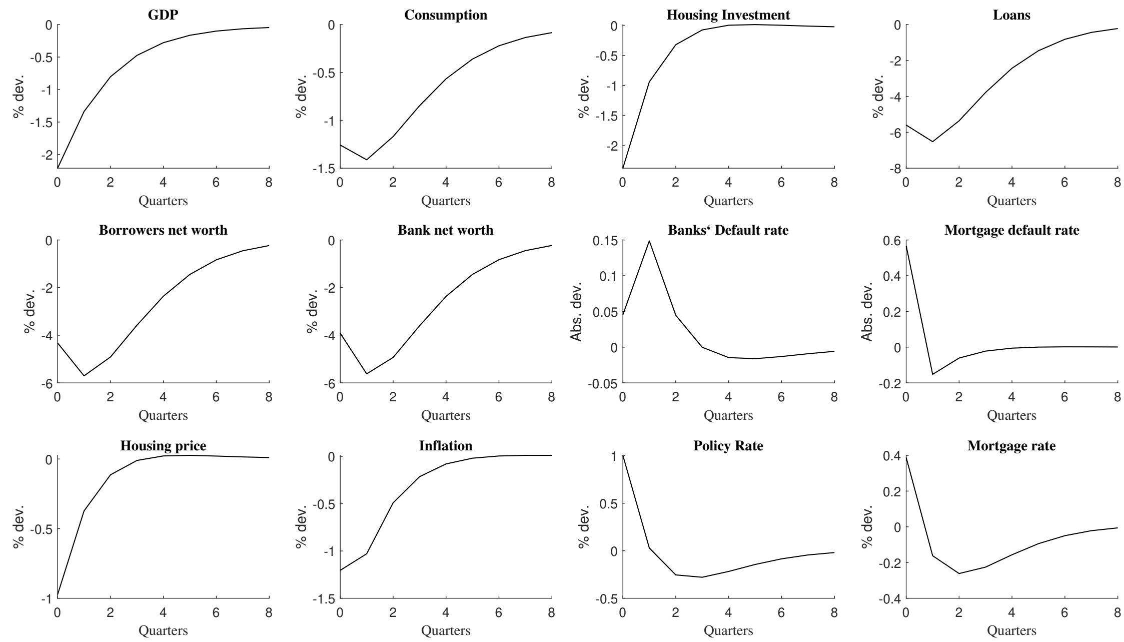
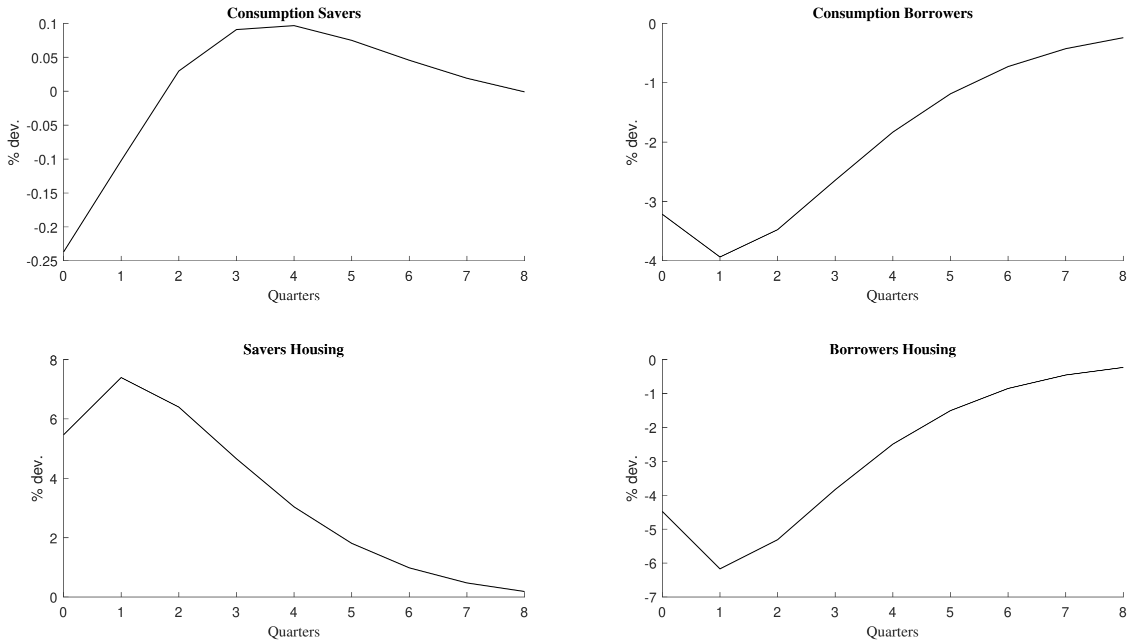


Figure 2: Monetary policy shock



5 The role of macroprudential policies

Our model generates financial stability effects of monetary policy that are absent in a standard New Keynesian framework. In the baseline economy without additional macroprudential policies, an increase in interest rates not only reduces consumption through intertemporal substitution but also erodes the net worth of borrowers and banks. This reduction in net worth leads to a large contraction in housing demand and consumption among credit-constrained households, and it raises default rates for both borrowers and banks, generating costly deadweight losses. In essence, the model's bank lending channel amplifies monetary policy effectiveness, but also leads to financial stability side effects. This section studies how macroprudential policies affect these amplification mechanisms.[10] We consider two classes of macroprudential instruments: structural (ex ante) measures implemented before the shock, such as higher bank capital requirements and tighter loan-to-value (LTV) caps on borrowers, and countercyclical (ex-post) measures adjusted in reaction to the shock, such as releasing or building up the countercyclical capital buffer (CCyB) and adjustment of borrower-based limits to keep their bindingness constant. We evaluate their effectiveness in limiting financial stability risks and moderating the distributional costs for borrowers of a monetary tightening.

5.1 Ex-ante macroprudential policies

We first consider structural macroprudential policies that are in place before the monetary tightening: a tighter bank capital requirement and a tighter LTV cap on mortgages. To assess their effectiveness, we compare three model environments: the baseline economy with standard regulatory settings, an economy with a permanently tighter LTV cap, and an economy with a higher minimum capital ratio for banks. Figures 3 and 4 illustrate the responses of an unanticipated monetary tightening under each regime. In the baseline economy, the monetary policy shock produced the financial amplification described above, with a disproportionate contraction in economic activity and increase financial stability risks, reflected in higher default probabilities. By contrast, when a tighter LTV cap is imposed ex ante, borrowers enter the tightening phase with lower leverage. As a result, the decline in house prices translates into a smaller deterioration of net worth and a lower increase in mortgage default risk. Consumption and housing demand of borrowers are therefore more stable, and

[10] Our analysis is focused on the role of borrower-based macroprudential measures (BBMs) in shaping the transmission of monetary policy tightening. We do not aim to characterize the optimal level of macroprudential regulation or to provide a full welfare analysis. In particular, while tighter BBMs can reduce leverage and financial volatility, they may also entail costs in terms of lower credit access, lower equilibrium output, and potentially adverse distributional effects. Evaluating these trade-offs is beyond the scope of this paper.

the contraction in output and house prices is attenuated (Figure 3). As shown in Figure 4 borrowers suffer a much smaller reduction in consumption when the LTV cap is in place. The reduction in borrower default risk also improves bank balance sheets by preserving loan quality, leading to a smaller increase in bank default probability relative to the baseline.

Higher bank capital requirements generate a complementary form of resilience. Entering the tightening episode with a stronger capital base, banks are better equipped to absorb the increase in their funding costs and any loan losses associated with the tightening. Figure 3 illustrates that, under a higher capital ratio, credit and output contract less than in the baseline economy. Borrower households benefit from this stabilization of credit supply, experiencing a smaller reduction in consumption (Figure 4). The effects on savers are largely unchanged across the economies, as macroprudential tools are mainly affecting the segments of the economy that are prone to financial frictions. As expected, the higher capital requirement directly reduces the probability of bank default following the shock.

Overall, both types of ex-ante macroprudential policy substantially improve the economy's resilience to monetary tightening by operating on different sides of the economy. Tighter LTV caps stabilize borrower balance sheets, while the capital requirement improves bank resilience and limit contractions in credit supply. These results indicate that borrower-based instruments are particularly effective in curbing housing-price-driven amplification, whereas capital-based instruments become more important when banking sector vulnerability is a concern.

Figure 5 reports the distributional welfare effects of the 100 basis point monetary tightening under alternative ex ante macroprudential configurations. The figure reports consumption equivalent welfare changes for savers and borrowers and decomposing them into the contributions of consumption utility, disutility from labor, and housing services. Each stacked bar represents the post shock value of the dynasty's value function. Under baseline regulatory settings, the tightening entails a net welfare loss for borrowers of almost 1.4 percent in consumption equivalent terms, reflecting lower consumption, higher labor supply (as credit constrained households work more to smooth expenditures when borrowing tightens) and reduced housing services. By contrast, welfare effects on savers are much smaller, driven mainly by intertemporal substitution. Introducing ex ante macroprudential tightening mitigates the amplification generated by financial frictions and reduces the welfare cost for borrowers. The LTV cap delivers the largest improvement by directly limiting leverage and stabilizing net worth when interest rates rise. Higher capital requirements provide additional gains by reducing bank default risk and dampening contractions in credit supply, although their effect on borrower welfare is smaller when banking sector vulnerability is moderate. Welfare outcomes for savers remain largely unchanged, consistent with their limited exposure to financial frictions.

Figure 3: Monetary policy shock with ex-ante macroprudential policies

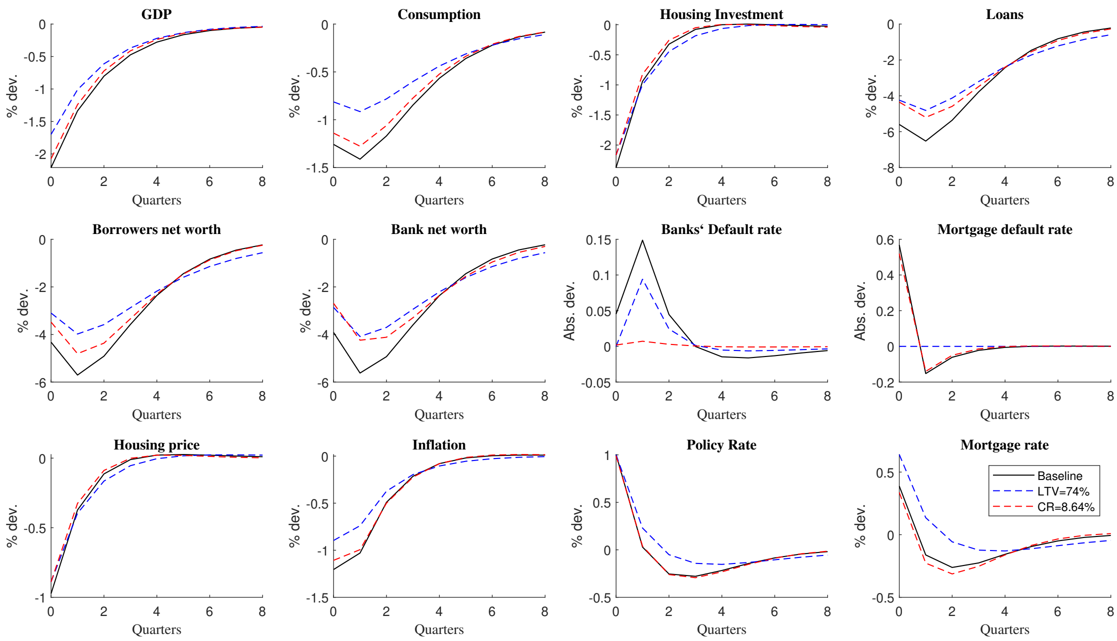


Figure 4: Monetary policy shock with ex-ante macroprudential policies

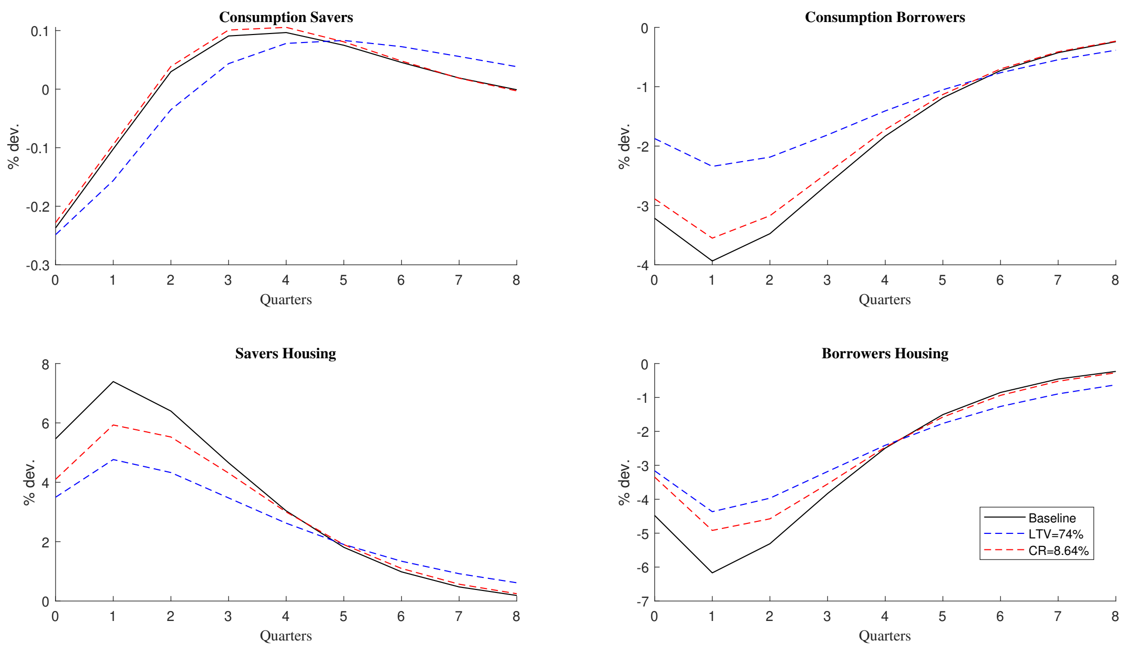
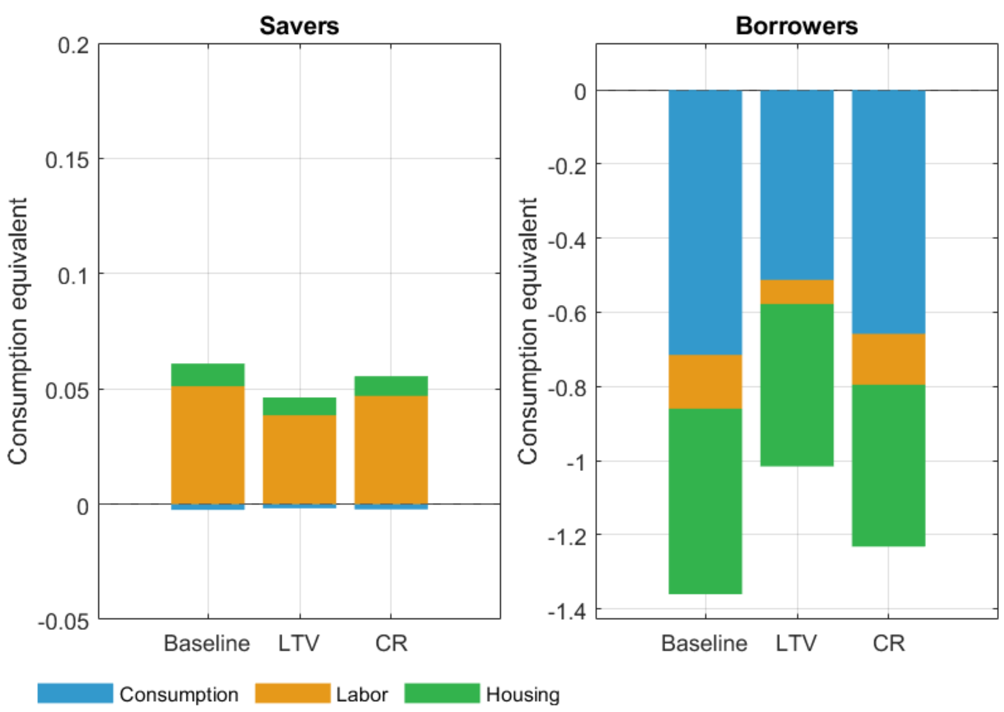


Figure 5: Monetary policy shock with ex-ante macroprudential policies - welfare implications



5.2 The impact of ex-post macroprudential policies

We next study countercyclical macroprudential interventions that can be deployed during monetary tightening to counteract its adverse side effects. Unlike the structural tools, these ex-post measures allow regulators to adjust buffers and constraints as the shock unfolds. We consider three policy responses: (1) a temporary relaxation of the LTV cap, aimed at keeping the bindingness of borrowing constraints roughly constant during the monetary tightening, a practice already implemented in several euro-area jurisdictions in the latest monetary tightening episode; (2) a temporary relaxation of capital requirements (which we interpret as the use of previously accumulated capital buffers, in line with CCyB-type policies), allowing banks to operate temporarily with lower capital requirements; and (3) a build-up of the CCyB, involving a tightening of capital requirements intended to quickly reinforce banks' capital positions if they are perceived as excessively vulnerable at the onset of monetary tightening.

It is important to clarify the interpretation of countercyclical capital policy in our framework. Unlike institutional CCyB frameworks, which involve the gradual accumulation of capital buffers in good times and their subsequent release in periods of stress, our model abstracts from the buildup phase and focuses on the effects of relaxing (increasing) capital requirements during a monetary tightening episode, conditional on the availability of releasable buffers. As a result, our experiments should be interpreted as capturing the short-run use of capital buffers rather than the full CCyB cycle.

The LTV adjustment directly targets borrower balance sheets, whereas CCyB adjustments operate through bank balance sheets. The effects of these measures depends on the state of the banking system . Accordingly, we analyze two scenarios: one in which banks enter the tightening in which they are well-capitalized, and one in which they enter with weak capital positions.

Figures 6 and 7 report the impulse response under low bank exante capitalization. Figures 9 and 10 correspond to the high capitalization case. Each figure compares the baseline monetary tightening with the outcomes under an LTV relaxation, a CCyB release, and a CCyB build-up.

The LTV relaxation maintains the bindingness of the constraint roughly constant throughout the monetary tightening. This policy avoids a procyclical interaction between falling house prices and regulatory borrowing limits. In both capitalization scenarios, the LTV relaxation stabilizes borrower balance sheets by preserving borrowing capacity when net worth falls. As a result, the contraction in borrower consumption and housing demand is substantially attenuated relative to the baseline. This mechanism is largely independent of banks' initial capitalization because it primarily affects borrower-side constraints rather than bank solvency.

By contrast, the consequences of a temporary relaxation of capital requirements, in contrast, are state-dependent. A CCyB release activates two competing mechanisms: the countercyclical lending channel and a risk channel. The countercyclical lending channel operates by relaxing regulatory constraints on banks, supporting credit supply. The risk channel arises because lower ex-post capitalization increases default risk and funding costs. Which channel dominates depends on banks' initial capital position.

When banks begin the tightening with strong balance sheets (Figure 9), the countercyclical lending channel dominates. Credit supply contracts by less than in the baseline, and the decline in borrower consumption is attenuated. Borrowers thus benefit from stronger credit access and can better smooth the impact of higher interest costs. Although bank risk increases, default probabilities rise only modestly given the initially high capital buffers. In this case, the CCyB release smooths the transmission of monetary tightening without materially compromising financial stability.

When banks enter the tightening with weak capital positions, the risk channel dominates (Figure 7). Lowering capital requirements further increases default risk and tightens funding conditions. Banks respond by contracting lending more sharply, amplifying the decline in aggregate demand. With limited capital to start with, allowing banks to operate with even lower buffers magnifies concerns about their solvency. As borrowers become riskier due to the monetary tightening, banks quickly find themselves unable to absorb the resulting losses. Consequently, their default probabilities surge even above the baseline scenario. Anticipating higher risks, banks reduce lending more aggressively, exacerbating the contraction in credit supply and aggregate demand. In this case, a CCyB release becomes destabilizing rather than countercyclical.

We therefore also consider a CCyB build-up as an alternative response when banks are initially fragile. Although it tightens lending conditions on impact, a CCyB build-up reduces bank default risk and stabilizes credit dynamics over time. In the low-capital scenario, our simulations indicate that the CCyB build-up significantly lowers banks' default risk relative to the well capitalized case (Figure 10), ultimately increasing resilience in the banking sector and stabilizing credit conditions over time.

In summary, each ex-post macroprudential policy serves a distinct purpose, and its effect depends on the condition of the banking sector. LTV caps relaxations consistently support borrower demand by alleviating credit constraints without significantly depending on bank capitalization. CCyB release effectively mitigate the downturn when banks are well-capitalized, but destabilize credit when capitalization is weak. CCyB build-ups are instead effective when banks are initially weakly-capitalized, by containing default risk.

Figures 8 and 11 show consumption equivalent welfare costs for savers and borrowers, Figure 8 corresponds to the case where banks enter the tightening with lower capitalization, while Figure 11 reports the same analysis when banks are well capitalized at the onset of the shock. A relaxation of the LTV cap to keep its bindingness roughly constant during the tightening delivers a clear welfare improvement for borrowers, unconditional on bank capitalization, by preserving collateral based borrowing capacity as house prices and net worth fall. In contrast, a CCyB release in the fragile state (Figure 8) severely worsens the welfare implications of the monetary policy shock. The reduction in capital buffers raises bank default risk and amplifies borrowers' welfare losses. This deterioration is especially visible for borrowers, but it also reduces savers' welfare through the consumption component. When banks are well capitalized, a CCyB release becomes not only welfare improving but also even more beneficial than the LTV relaxation in accommodating the effects of the monetary tightening. Across both figures, savers' welfare effects remain concentrated on borrowers.

These findings confirm that macroprudential measures focused on bank capitalization are generally the most efficient means of managing the side effects of monetary tightening, given their central role in ensuring financial stability. Nonetheless, borrower-based tools like LTV caps play an indispensable complementary role, particularly in scenarios where vulnerabilities are concentrated in the household sector or when the banking system itself faces significant stress. A joint use of these ex-ante and ex-post tools allows the economy to go through the monetary tightening with fewer unintended economic and financial costs.

Figure 6: Monetary policy shock - Ex-post policies from low capitalized banks

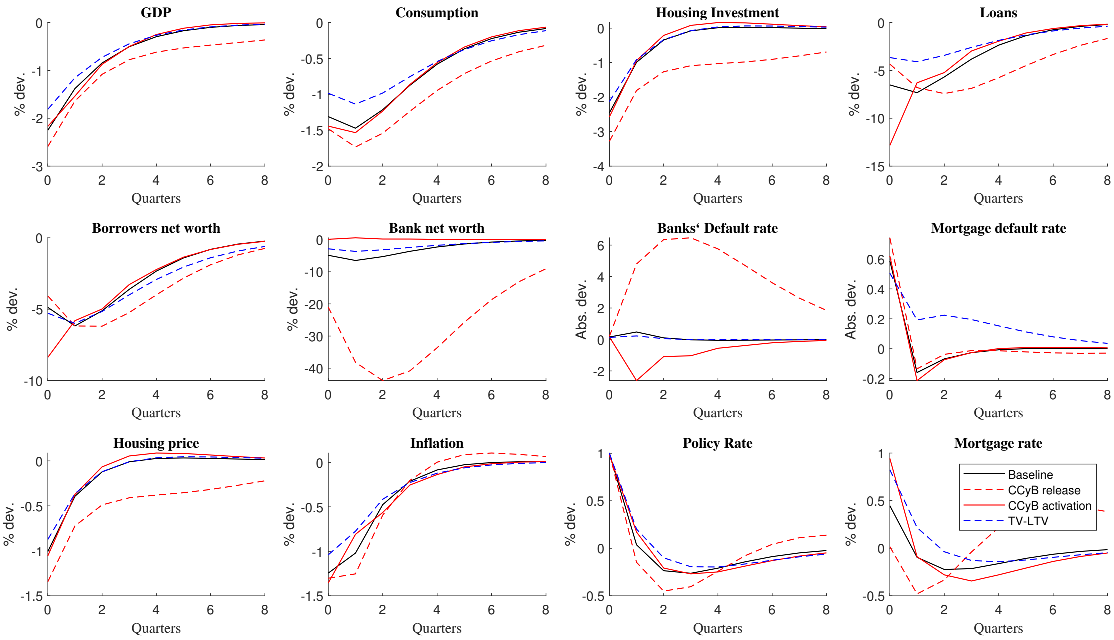


Figure 7: Monetary policy shock - Ex-post policies from low capitalized banks

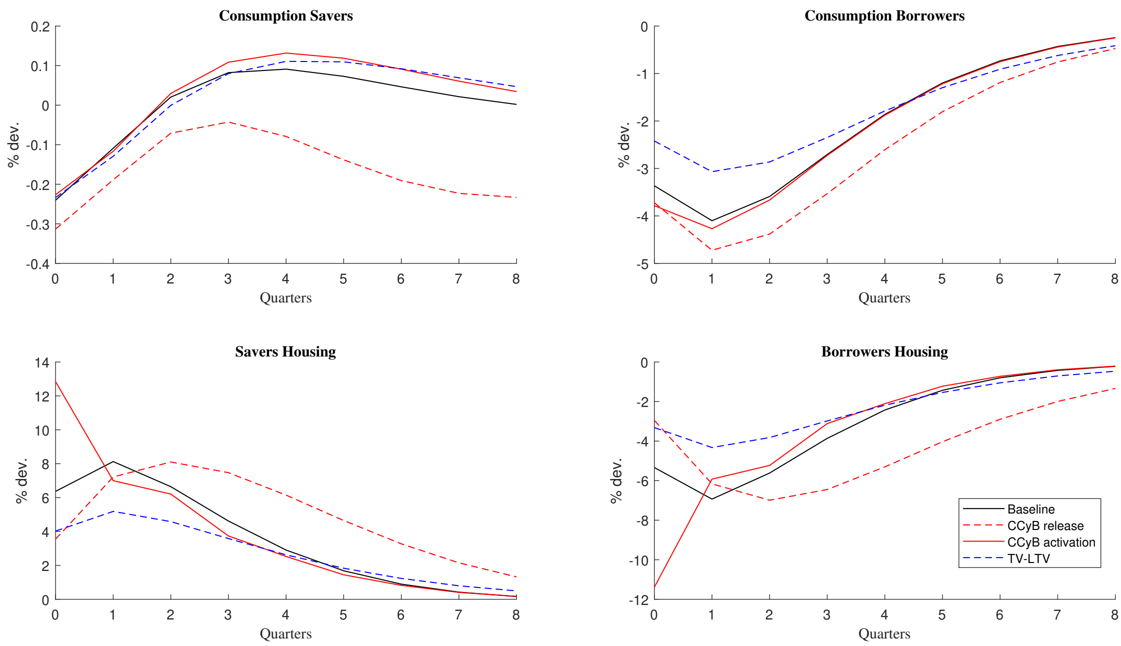


Figure 8: Monetary policy shock - Ex-post policies from low capitalized banks - welfare implications

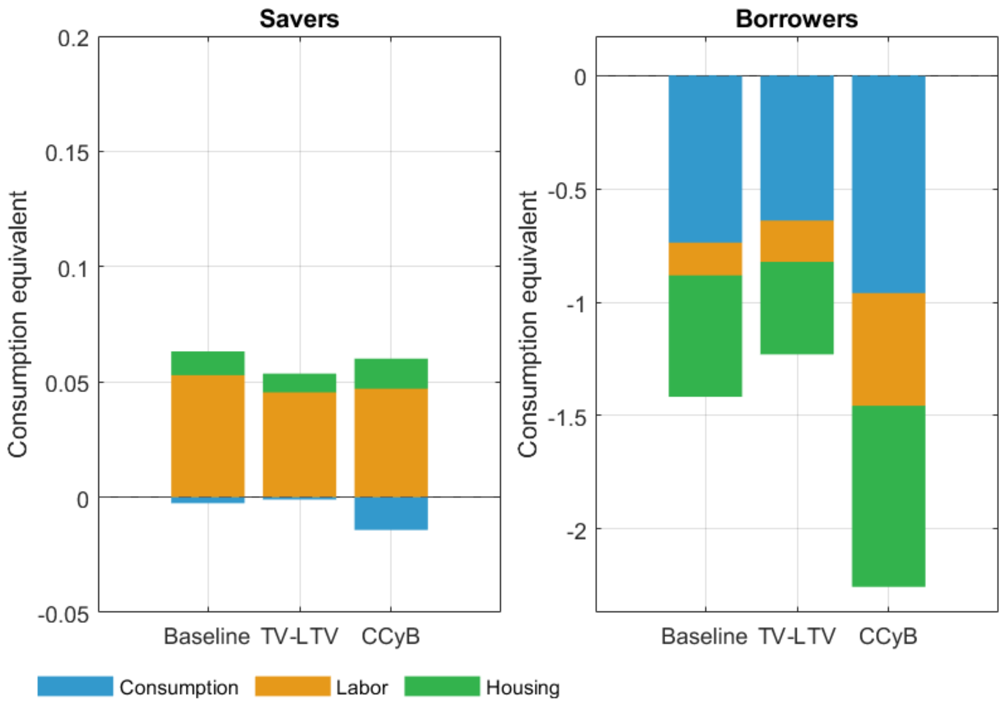


Figure 9: Monetary policy shock - Ex-post policies from well capitalized banks

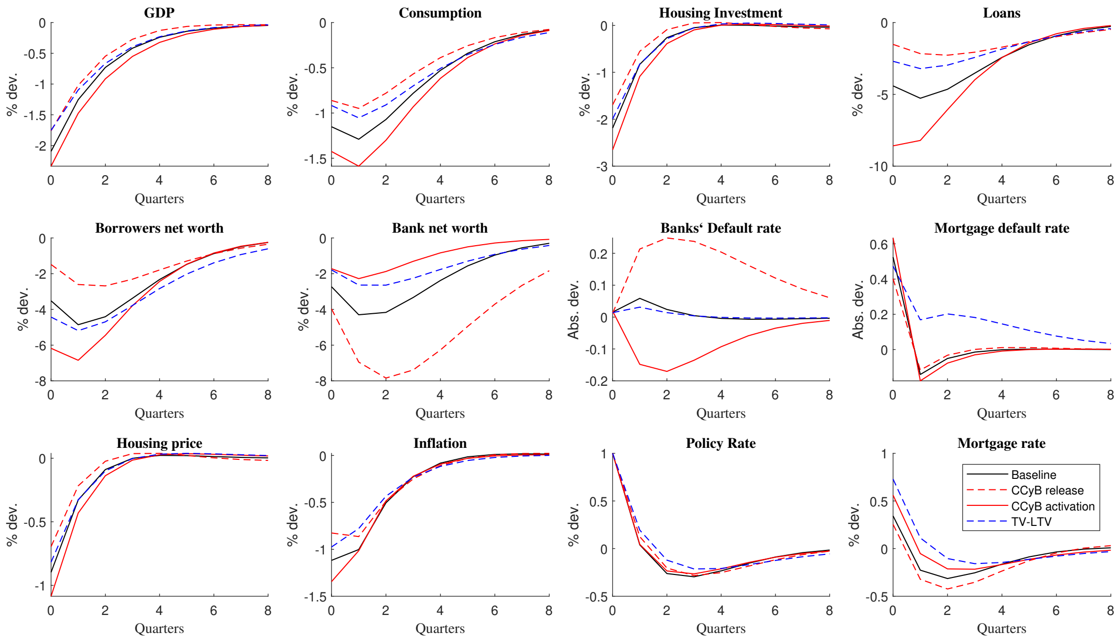


Figure 10: Monetary policy shock - Ex-post policies from well capitalized banks

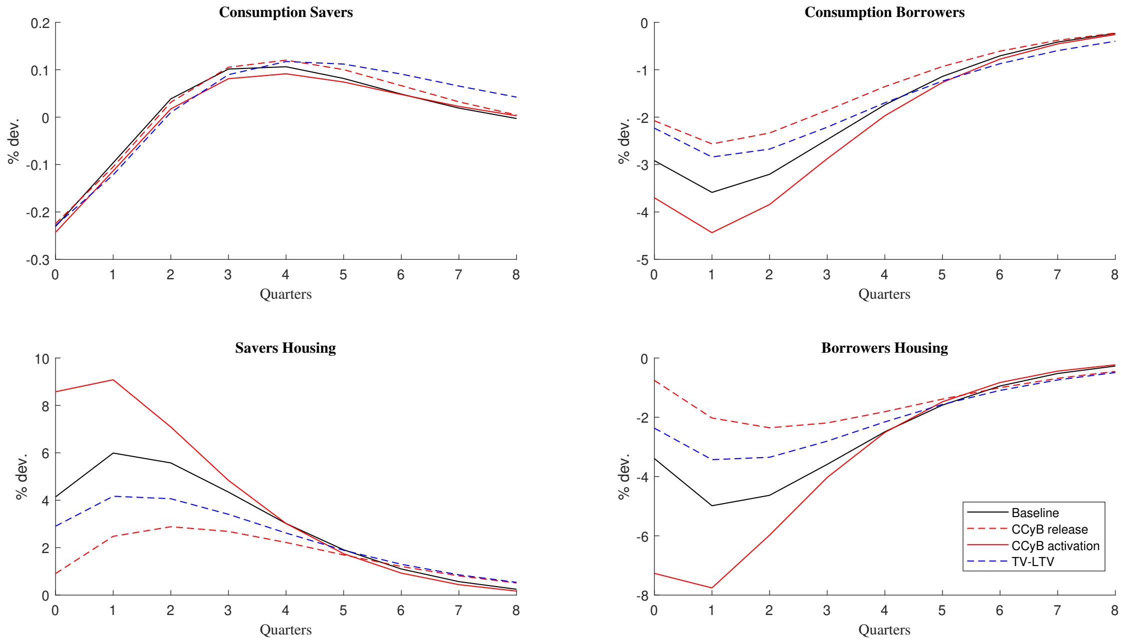
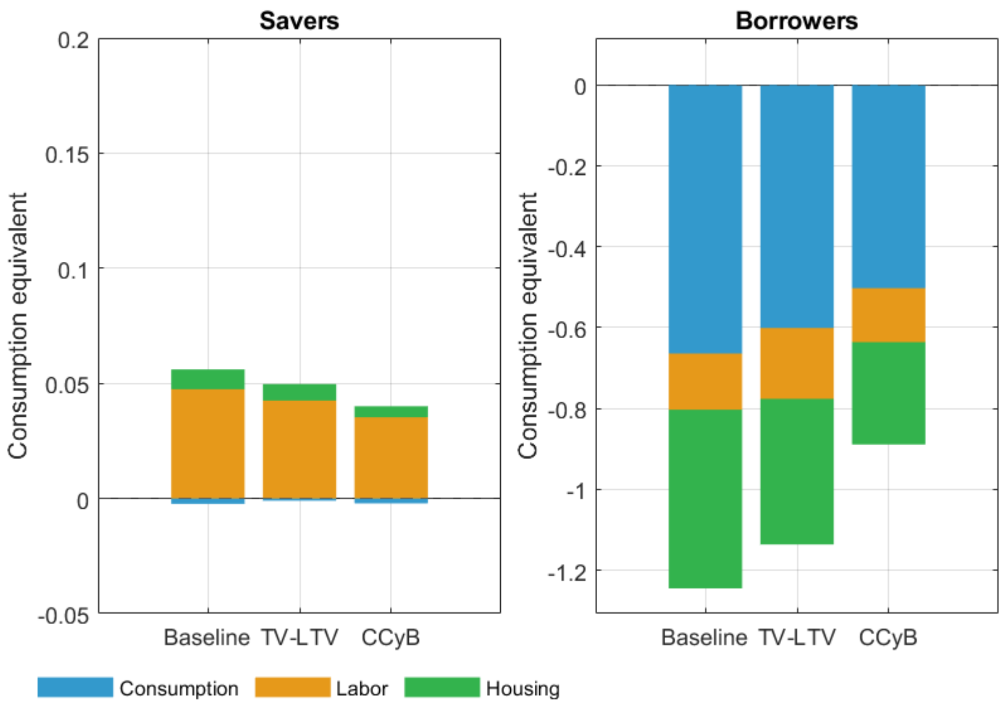


Figure 11: Monetary policy shock - Ex-post policies from well capitalized banks - welfare implications



6 Conclusion

This paper studies how macroprudential policies affect financial resilience during episodes of monetary tightening. Relative to a standard New Keynesian framework - where monetary policy operates mainly through intertemporal substitution and investment - our model features borrower and bank balance-sheet constraints and endogenous default. These frictions generate financial amplification effects: monetary tightening weakens borrower and bank net worth and induces a disproportionate contraction in consumption and housing demand among financially constrained households. At the same time, higher default rates generate deadweight losses that further depress economic activity and financial stability.

We first show that ex-ante structural macroprudential policies, mitigate these adverse amplification mechanisms. Higher bank capital requirements directly increase bank resilience, while tighter LTV caps enhance borrower resilience by stabilizing household net worth and expenditure. Notably, when bank default probabilities are relatively low, tighter LTV regulations play a particularly influential role by directly curbing the destabilizing feedback between declining collateral values and household solvency.

We then study ex-post countercyclical macroprudential measures. The effectiveness of these measures depend on banks' initial capitalization. A CCyB release is highly effective in sustaining credit supply and moderating economic contraction when banks enter the tightening well-capitalized. However, under weak bank capitalization, the risk channel dominates, and releasing the CCyB intensifies financial stability risks. By contrast, relaxing the LTV constraint to maintain its bindingness constant during downturns, consistently mitigates the economic contraction independently of banks' initial capital strength.

Overall, our results support the use of bank capital-based macroprudential measures, given their role in managing monetary policy's negative side effects. Borrower-based measures play a complementary role, particularly when systemic vulnerabilities exist in household balance sheets or when the macroprudential toolkit targeting banks is compromised. An effective macroprudential framework allows monetary policy to pursue price stability with smaller financial and distributional costs.

This analysis should be interpreted as focusing on the interaction between monetary policy and macroprudential tools, rather than prescribing an active response of macroprudential policy to short-term monetary shocks. In practice, macroprudential policy is typically designed with a longer-term perspective, aiming to limit the build-up of systemic risk and ensure resilience over the financial cycle. In this sense, our results highlight how existing macroprudential settings can shape the transmission of monetary policy tightening, rather than implying that such policies should be adjusted in a short-term or reactive manner. This interpretation is consistent with recent policy discussions emphasizing the complementary roles of monetary and macroprudential policy, where the latter focuses on the ex-ante build-up of resilience and the former on price stability (see Detken, Hempell, and Pirovano, 2025).

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A The extended model

This appendix presents an extended version of the baseline model, aimed at assessing the robustness of our main results. The extension introduces additional features that relax some simplifying assumptions of the benchmark framework, while preserving its core mechanisms. Repeating the quantitative analysis within this richer environment yields results that are qualitatively and quantitatively similar to those obtained in the baseline model.

A.1 Model Economy

We consider an economy populated by two dynasties: patient households (denoted by$s$) and impatient households (denoted by m). Households that belong to each dynasty differ in terms of their subjective discount factor, $\beta_s \leqslant \beta_m$. The mass of savers' households x_s is normalized to one and x_s is the mass of impatient households x_m.

The patient dynasty provides risk sharing to three different classes of members: workers (w), entrepreneurs (e), and bankers (b), of constant measure each x_ϱ for $\varrho = w, e, b$ respectively. Workers supply labor to the production sector and transfer their wage income to the household. In addition, they also provide deposits to banks, invest in productive capital and in banks' equity. Entrepreneurs and bankers manage entrepreneurial firms (denoted by f) and banks, respectively.

The impatient dynasty instead consists only of workers which in equilibrium borrow from banks using their housing as collateral. Banks (which come in two types, denoted by $j = \{M, F\}$) use equity provided by bankers and deposits supplied by patient workers to grant loans to entrepreneurial firms and borrowing households. Entrepreneurs, borrowing households and banks operate under limited liability and default when the value of their assets fall below their debt obligations. Defaults entail repossession costs and represent deadweight losses for the economy. A fraction κ of deposits is insured by a deposite insurance scheme (DIS) funded by a lump sum tax, while a fraction $1 - \kappa$ of deposits is uninsured. Depositors price the deposit rate for each bank based on the riskiness of the average bank. This is the key friction of the model since banis do not fully internalise the negative effects of excessive leverage, providing a rationale for capital requirements.

The production sector features final and intermediate good producers and producers of physical capital and housing. Intermediate good producers face sticky prices. Finally, the macroprudential authority sets the level of capital requirement on both types of loans, while the monetary policy authority sets the level of the nominal risk free rate following a Taylor type rule.

A.2 Default risk

Default in the model can occur for both aggregate and idiosyncratic reasons. All borrowers in the economy are subject to idiosyncratic shocks, $\omega_{i,t+1}$ (with $i = \{m, f, M, F\}$), which are independently distributed and follow a log-normal distribution with mean one and standard deviation σ_i, where density and cumulative distribution functions are denoted by $f_i(\omega_{i,t+1})$ and $F_i(\omega_{i,t+1})$, respectively. These shocks affect the ability of firms and households to repay their loans and of banks to repay their deposits.

For each class of borrowers, there is a threshold realisation of $\omega_{i,t+1}$ below which a borrower of class i defaults, $\bar{\omega}_{i,t+1}$. Therefore, the probability of default of such borrower is $F_i(\bar{\omega}_{i,t+1})$. Importantly, the default thresholds are also affected by fluctuations in aggregate variables.

Following Bernanke, Gertler and Gilchrist (1999) (henceforth, BGG), the share of total assets owned by borrowers of class i which end up in default is defined as

$$G_i\left(\overline{\omega}_{i,t+1}\right) = \int_0^{\overline{\omega}_{i,t+1}} \omega_{i,t+1} f_i\left(\omega_{i,t+1}\right) d\omega_{i,t+1},$$

and the expected share of asset value of such class of borrowers that goes to the lender as

$$\Gamma_i(\overline{\omega}_{i,t+1}) = \mathbb{E}_t[min\{\omega_{i,t+1}, \overline{\omega}_{i,t+1}\}] = G_i\left(\overline{\omega}_{i,t+1}\right) + \overline{\omega}_{i,t+1}[1 - F_i\left(\overline{\omega}_{i,t+1}\right)].$$

In the presence of a proportional asset repossession cost μ_i, as we assume, the net share of assets that goes to the lender can be expressed as $\Gamma_i(\overline{\omega}_{i,t+1}) - \mu_i G_i\left(\overline{\omega}_{i,t+1}\right)$. The share of assets eventually accrued to the borrowers of class i is $\mathbb{E}_t[max\{\omega_{i,t+1} - \overline{\omega}_{i,t+1}, 0\}] = 1 - \Gamma_i(\overline{\omega}_{i,t+1})$.

A.3 Households

Both patient s and impatient dynasties m maximize their own expected discounted future utility. Households that belong to each dynasty differ in terms of their subjective discount factor, $\beta_s \leqslant \beta_m$. The utility function takes the following functional form:

$$U_{\varkappa,t} = \log(C_{\varkappa,t} - \vartheta C_{\varkappa,t-1}) + \upsilon_{\varkappa} log(H_{\varkappa,t}) - \frac{\varphi_{\varkappa}}{1+\eta}(L_{\varkappa,t})^{1+\eta} \tag{5}$$

for $\varkappa = \{s, m\}$. Households derive utility from the consumption of nondurable goods ($C_{\varkappa,t}$, with one-period habits) and of housing services provided by their own stock of housing, $H_{\varkappa,t}$. They work $L_{\varkappa,t}$ hours in the consumption good producing sector.

A.4 Patient households

The dynamic budget constraint of the patient households, in nominal terms, is as follows:

$$P_t C_{s,t} + Q_{h,t} H_{s,t} + D_t + (Q_{k,t} + P_t s_t) K_{s,t} + A_t + N_{b,t}^{add} \leq W_t L_{s,t} + (P_t r_{k,t} + (1 - \delta_{k,t}) Q_{k,t}) K_{s,t-1} + \tag{6}$$

$$+(1 - \delta_{h,t}) Q_{h,t} H_{s,t-1} + \widetilde{R}_t^{d,nom} D_{t-1} + \widetilde{R}_{t-1}^{rf,nom} A_{t-1} + P_t \Pi_{s,t} + P_t \Xi_{s,t} - P_t T_{s,t} - c(N_{b,t}^{add}) \tag{7}$$

Patient households buy housing units outright, priced at $Q_{h,t}$ and physical capital, $K_{s,t}$, priced at $Q_{k,t}$. While both stocks are subject to depreciation (at rates $\delta_{h,t}$ and $\delta_{k,t}$, respectively), the latter is also subject to a capital management cost, s_t, which is taken as given by the household.

They can also invest in a risk-free asset (A_t), which is zero in net supply and in a perfectly diversified portfolio of nominal bank debt, D_t. Holdings of the former pay the gross short-term nominal interest rate $\widetilde{R}_t^{rf,nom}$, while the latter yields a gross nominal return of $\widetilde{R}_t^{d,nom}$. The return on portfolio of bank debt held at $t-1$ has two components:

$$\widetilde{R}_t^{d,nom} = R_{t-1}^{d,nom} - (1 - \kappa)\Omega_t$$

where κ denotes the fraction of deposits that always pays back the promised gross deposit rate $R_{t-1}^{d,nom}$ and can be interpreted as the fraction of bank debt that will benefit from a bailout in case of default. The remaining fraction $1 - \kappa$ is instead uninsured and pays back the promised rate $R_{t-1}^{d,nom}$ if the issuing bank is solvent but absorbs some default losses if the bank fails, where Ω_t is the average default loss per unit of bank debt realized at period t. For $\kappa < 1$, making deposits attractive to savers requires setting a contractual gross deposit rate $R_{t-1}^{d,nom}$ higher than the free rate $R_{t-1}^{rf,nom}$.

$\Xi_{s,t}$ denotes the aggregate net transfers from entrepreneurs and bankers to the households. In addition to an initial endowment households can also transfer an additional amount of equity directly to new bankers, $N_{b,t}^{add}$, subject to a quadratic cost: [11]

$$c\left(N_{b,t}^{add}\right) = \psi_0 N_{b,t}^{add} + \frac{\psi_1}{2}\left(N_{b,t}^{add}\right)^2.$$

Finally, we denote by $\Pi_{s,t}$ the real profits that households receive from firms that manage the capital stock held by the households as well as the intermediate good producers (physical capital, housing good, differentiated intermediate good). $T_{s,t}$ is a lump-sum tax used by the Deposit Insurance Agency (DIA) to ex-post balance its budget.

A.4.1 Impatient Households

The dynamic budget constraint for the impatient households is given by:

$$P_t C_{m,t} + Q_{h,t} H_{m,t} - B_{M,t} \leq W_t L_{m,t} + (1 - \Gamma_{m,t}(\overline{\omega}_{m,t})) R_t^{H,nom} Q_{h,t-1} H_{m,t-1} - P_t T_{m,t}.$$

The impatient dynasty consists of workers only which in equilibrium borrow from banks. Household debt (in aggregate terms denoted by $B_{M,t}$) is contracted at a gross nominal rate of $R_t^{M,nom}$ to the individual members of the dynasty against their individual housing units, on a limited liability non-recourse basis. $T_{m,t}$ denotes the impatient dynasty contribution to the DIA.

Each borrower's stock of housing units bought the previous period suffers an idiosyncratic shock, $\omega_{m,t}$, at the beginning of each new period. Each individual household then decides whether to default on the individual loan attached to the housing held from the previous period and the residual net worth is passed on to the dynasty, which is not liable for any unpaid debt. Thus, fluctuations in the dynasty's net worth are driven by both loan-repaying households (who keep their housing net worth) and defaulting households (whose net worth vanishes).

Default occurs when the value of housing units acquired in the previous period, $\omega_{m,t} Q_{h,t-1} H_{m,t-1}$ is lower than the outstanding mortgage debt, $R_{t-1}^{M,nom} B_{M,t-1}$. This occurs when $\omega_{m,t} \leq \bar{\omega}_{m,t} = \frac{x_{h,t-1}}{R_t^{H,nom}}$, where $\bar{\omega}_{m,t}$ is the default threshold, $R_t^{H,nom} = (1 - \delta_{m,t}) \frac{Q_{h,t}}{Q_{h,t-1}}$ is the ex-post nominal gross unlevered return on housing and $x_{h,t-1} = \frac{R_{t-1}^{M,nom} B_{M,t-1}}{Q_{h,t-1} H_{m,t-1}}$ measures household leverage in $t-1$.

Importantly, the impatient households problem includes a second constraint: the partic-

[11] The parameters of the quadratic cost are calibrated such that the additional amount of equity is zero in steady state. This additional model feature however allows the household to increase funds allocated to banks when bank equity is particularly scarce.

ipation constraint of the bank. This reflects the competitive pricing of the loans that banks are willing to offer for different choices of leverage by the household:

$$\mathbb{E}_t\left[\Lambda_{b,t+1}\left(\left(1-\Gamma_M(\overline{\omega}_{M,t+1})\right)\left(\Gamma_m(\overline{\omega}_{m,t+1})-\mu_m G_m(\overline{\omega}_{m,t+1})\right)\right)R^{H,nom}_{t+1}\right]Q_{h,t}H_{m,t}=\upsilon_{b,t}\phi_{M,t}B_{M,t}$$

Given that $\mathbb{E}_t(\bar{\omega}_{m,t+1}) = \mathbb{E}_t\left(\frac{R_t^{M,nom}B_{M,t}}{R_{t+1}^{H,nom}Q_{h,t}H_{m,t}}\right)$, it becomes clear that the borrowing rate associated with the housing loan contract, $R_t^{M,nom}$, is part of the decision variables of the impatient dynasty at t. Therefore, intuitively, this constraint imposes that $R_t^{M,nom}$ is such that the expected, properly discounted payoffs that the loans provide to bankers - who contribute equity $\phi_{M,t}B_{M,t}$ to the type-M bank - are large enough to compensate them for the opportunity cost of such equity, with each unit of bankers' wealth priced at its shadow value, $\upsilon_{b,t}$. The (binding) capital requirement on housing loans is denoted by $\phi_{M,t}$. Finally, in case of default, the repossession of collateral by the banks involves verification costs similar to those considered in BGG, denoted by μ_m.

A.5 Entrepreneurs

The size of the entrepreneur population, x_e, is constant throughout. However, at the beginning of each period, a mass $(1-\theta_e)x_e$ of workers becomes new entrepreneurs and a mass $\theta_e x_e$ of entrepreneurs retires, becoming workers. The former benefits from an endowment ι_e provided by the patient dynasty (for simplicity, amounting to an exogenous fraction χ_e of the wealth of retiring entrepreneurs), while the latter transfers their net worth to the patient dynasty. Active entrepreneurs cannot raise additional equities from households over time and need to rely exclusively on their accumulated net worth in order to provide (inside) equity to entrepreneurial firms.

A.5.1 Individual Entrepreneurs

Each entrepreneur invests her net worth, n_e, into entrepreneurial firms, with her set of choice variables comprising $\mathrm{eq}_{e,t}$, the part of net worth symmetrically invested in the measure/one continuum of entrepreneurial firms, and $\mathrm{div}_{e,t}$, which are the dividends that the entrepreneur can pay to the saving dynasty prior to retirement.[12]

[12]For clarity, we resort to lower-case letters to denote the individual counterpart of aggregate variables.

Letting $\lambda_{s,t}^{nom}$ denote the Lagrange multiplier of the budget constraint of the representative household in period t, the problem of the representative entrepreneur can be written as

$$V_{e,t} = \max_{\{\text{eq}_{e,t}, \text{div}_{e,t}\}} \left\{ \text{div}_{e,t} + \mathbb{E}_t \Big[\Lambda_{s,t+1} \left((1-\theta_e)\, n_{e,t+1} + \theta_e V_{e,t+1} \right) \Big] \right\}$$

subject to:

$$\text{eq}_{e,t} + \text{div}_{e,t} = n_{e,t}$$
$$n_{e,t+1} = \int_0^{\infty} \rho_{f,t+1}^{nom}\,(\omega_{f,t+1}) dF_f\,(\omega_{f,t+1})\, eq_{e,t}$$
$$\text{div}_{e,t} \geq 0$$

where $\Lambda_{s,t+1} = \beta_s \lambda_{s,t+1}^{nom} / \lambda_{s,t}^{nom}$ is the stochastic discount factor of the patient household; and $\rho_{f,t}^{nom}(\omega_{f,t})$ is the rate of return on the entrepreneurial equity invested in a firm that experiences a return shock $\omega_{f,t}$. As in Gertler and Kiyotaki (2010), we guess that the value function is linear in net worth $V_{e,t} = v_{e,t} n_{e,t}$, where $v_{e,t}$ is the shadow value of one unit of entrepreneurial equity. Then, we can write the Bellman equation as:

$$v_{e,t} n_{e,t} = \max_{eq_{e,t}, \text{div}_{e,t}} \left\{ \text{div}_{e,t} + \mathbb{E}_t \Big(\Lambda_{s,t+1} \left[1 - \theta_e + \theta_e v_{e,t+1} \right] n_{e,t+1} \Big) \right\}.$$

Insofar as $v_{e,t} > 1$ (which we verify to hold true under our parameterizations), entrepreneurs will find optimal not to pay dividends prior to retirement (that is, $\text{div}_{e,t}$ is only positive and equal to $n_{e,t}$ when the entrepreneur retires). Finally, it is useful to define entrepreneurs' stochastic discount factor as

$$\Lambda_{e,t+1} = \Lambda_{s,t+1} \left[1 - \theta_e + \theta_e v_{e,t+1} \right].$$

A.5.2 Entrepreneurial Firms

The representative entrepreneurial firm operates across two consecutive dates. At the beginning of the period, it takes $EQ_{e,t} = \int_0^{x_e} \text{eq}_{e,t}\, de$ equity units from the mass x_e of individual entrepreneurs, each priced at their shadow value $v_{e,t}$, and borrows $B_{F,t}$ from banks at nominal interest rate R_t^b to buy physical capital $K_{f,t}$ from capital producers at t . In the following period, the firm rents the available effective units of capital, $\omega_{f,t+1} K_{f,t}$ (where $\omega_{f,t+1}$ is the firm-idiosyncratic return shock) to capital users, sells back the depreciated capital to capital producers, and pays out its terminal net worth to entrepreneurs. Thus, the representative entrepreneurial firm maximizes the net present value of the equity taken from entrepreneurs, i.e.:

$$\mathbb{E}_t\left[\Lambda_{e,t+1}\left(1-\Gamma_f(\bar{\omega}_{f,t+1})\right)R^{K,nom}_{t+1}Q_{k,t}K_{f,t}\right]-\upsilon_{e,t}EQ_{e,t}$$

where $R^{K,nom}_{t+1}=\frac{P_{t+1}r_{k,t+1}+(1-\delta_{k,t+1})Q_{k,t+1}}{Q_{k,t}}$ is the gross nominal return on capital and $\Lambda_{e,t+1}$ is the stochastic discount factor following from the definition in the individual entrepreneur's problem.

In a similar fashion to borrowing households, each entrepreneurial firm also faces the participation constraint of its bank, capturing the competitive pricing of type-F banks' loans for different leverage choices by the firm:

$$\mathbb{E}_t\left[\Lambda_{b,t+1}\left(1-\Gamma_F(\overline{\omega}_{F,t+1})\right)\widetilde{R}^{F,nom}_{t}B_{F,t}\right]\ \geq \upsilon_{b,t}\phi_{F,t}B_{F,t}$$

where $\widetilde{R}^{F,nom}_{t}B_{F,t}=\left(\Gamma_f(\bar{\omega}_{f,t+1})-\mu_f G_f(\bar{\omega}_{f,t+1})\right)R^{K,nom}_{t+1}Q_{k,t}K_{f,t}$ is the gross return that the representative bank of class F obtains from a diversified portfolio of corporate loans (thus reflecting the shocks affecting each of the f firms). Furthermore, the loan taken from the F-type bank is $B_{F,t}=Q_{k,t}K_{f,t}-EQ_{e,t}$. In case of default, the repossession of collateral by the banks involves verification costs similar to those considered in BGG, denoted by μ_f.

A firm's default occurs when its asset value given the idiosyncratic shock, $\omega_{f,t}R^{K,nom}_{t+1}Q_{k,t}K_{f,t}$, is insufficient to pay its debt obligations, $R^{F,nom}_{t}B_{F,t}$, where $R^{F,nom}_{t}$ denotes the contractual gross nominal rate on the corporate loan. Therefore, we have:

$$\mathbb{E}_t(\bar{\omega}_{f,t+1})=\mathbb{E}_t\left(\frac{R^{F,nom}_{t}B_{F,t}}{R^{K,nom}_{t+1}Q_{f,t}K_{f,t}}\right)=\mathbb{E}_t\left(\frac{R^{F,nom}_{t}B_{F,t}}{(P_{t+1}r_{k,t+1}+(1-\delta_{k,t+1})Q_{k,t+1})K_{f,t}}\right)$$

Taking into account effects of retirement and the entry of new entrepreneurs, the evolution of active entrepreneurs' aggregate nominal net worth can be described as:

$$N_{e,t}=\theta_e\rho^{nom}_{f,t}EQ_{e,t-1}+\iota_{e,t},$$

where $\rho^{nom}_{f,t}=\int_0^\infty \rho_{f,t}\left(\omega_{f,t}\right)dF_f\left(\omega\right)$ is the return on a well-diversified unit portfolio of equity investments in entrepreneurial firms and $\iota_{e,t}$ is new entrepreneurs' net worth endowment, which we assume to be a proportion χ_e of the net worth of the retiring entrepreneurs:

$$\iota_{e,t}=\chi_e(1-\theta_e)\rho^{nom}_{f,t}EQ_{e,t-1}.$$

A.6 Bankers

The size of the banker population, x_b, is constant throughout. However, at each period, a mass $(1-\theta_b)x_b$ of workers become new bankers and a mass $\theta_b x_b$ of bankers retires, becoming workers. The former benefits from an endowment $\iota_{b,t}$ provided by the patient dynasty (for simplicity, amounting to an exogenous fraction χ_b of the wealth of retiring bankers), while the latter transfer their net worth to the patient dynasty. Differently from entrepreneurs, bankers can also receive additional equity from households in each period subject to a cost. This difference is justified by the fact that banks tend to be much larger than non-financial firms and have easier access to capital markets.

A.6.1 Individual Bankers

The problem of the representative banker is similar to the problem of the entrepreneurs with the only difference that bankers can invest their individual net worth, $n_{b,t}$, into equity of two classes j of competitive banks that extend loans $B_{j,t}$ to either impatient households ($j = M$) or firms ($j = F$). For the two classes of banks to receive positive equity from bankers ($\mathrm{eq}_{j,t} > 0$), the following no-arbitrage (or indifference) condition must hold:

$$\mathbb{E}_t\left[\Lambda_{b,t+1}\rho^{nom}_{M,t+1}\right] = \mathbb{E}_t\left[\Lambda_{b,t+1}\rho^{nom}_{F,t+1}\right] = \upsilon_{b,t}$$

where $\Lambda_{b,t+1}$ is the bankersâ stochastic discount factor, $\rho^{nom}_{j,t+1} = \int_0^{\infty}\rho^{nom}_{j,t+1}\left(\omega_{j,t+1}\right)dF_j\left(\omega_{j,t+1}\right)$ is the return of a diversified portfolio consisting of the equity of banks of type j, and $\upsilon_{b,t}$ is the shadow value of bankersâ net worth.

The problem of the individual banker is as follows:

$$V_{b,t} = \max_{\{\mathrm{eq}_{M,t},\mathrm{eq}_{F,t},\mathrm{div}_{b,t}\}}\left\{\mathrm{div}_{b,t} + \mathbb{E}_t\Big[\Lambda_{s,t+1}\big((1-\theta_b)\,n_{b,t+1} + \theta_b V_{b,t+1}\big)\Big]\right\}$$

subject to:

$$\mathrm{eq}_{M,t} + \mathrm{eq}_{F,t} + \mathrm{div}_{b,t} = n_{b,t}$$
$$n_{b,t+1} = \rho^{nom}_{M,t+1}\,\mathrm{eq}_{M,t} + \rho^{nom}_{F,t+1}\,\mathrm{eq}_{F,t}$$
$$\mathrm{div}_{b,t} \geq 0$$

where $\Lambda_{s,t+1} = \beta_s\lambda^{nom}_{s,t+1}/\lambda^{nom}_{s,t}$ is the stochastic discount factor of the patient household and $\mathrm{div}_{b,t}$ is the dividend that the banker pays to the household dynasty.

As in the case of entrepreneurs, we guess that bankers' value function is linear in net worth, i.e. $V_{b,t} = v_{b,t} n_{b,t}$, where $v_{b,t}$ is the shadow value of a unit of banker wealth. The Bellman equation becomes

$$v_{b,t} n_{b,t} = \max_{\{\mathrm{eq}_{M,t}, \mathrm{eq}_{F,t}, \mathrm{Div}_{b,t}\}} \left\{ \mathrm{div}_{b,t} + \mathbb{E}_t \left[\Lambda_{s,t+1} \left(1 - \theta_b + \theta_b v_{b,t+1}\right) n_{b,t+1} \right] \right\},$$

and, insofar as $v_{b,t} > 1$ (which we will verify to hold under our parameterizations), bankers will find it optimal not to pay dividends prior to retirement (so $\mathrm{div}_{b,t}$ will only be positive and equal to $n_{b,t}$ when the banker retires). Finally, the bankers' stochastic discount factor can be defined as follows:

$$\Lambda_{b,t+1} = \Lambda_{t+1} \left[1 - \theta_b + \theta_b v_{b,t+1}\right].$$

A.6.2 Banks

The representative bank of class $j = (F, M)$ issues equity from the mass x_b of individual bankers, each priced at their shadow value $v_{b,t}$, and deposit $D_{j,t}$ that promise a gross nominal interest rate $R_t^{d,nom}$ among patient households. These funds are then used by F and M banks to extend loans to the entrepreneurial firms (of total size $B_{F,t}$) and to impatient households (of total size $B_{M,t}$), respectively.

The return on a diversified loan portfolio of class j entails, for the representative bank j, a nominal gross return of $\omega_{j,t+1} \widetilde{R}_{t+1}^{j,nom}$, where $\omega_{j,t+1}$ denotes the bank-idiosyncratic shock to the returns of the loan portfolio. Banks operate across two consecutive dates and give back their terminal net worth, if positive, to the bankers. If a bank's terminal net worth is negative, it defaults. The DIA then takes the returns $(1 - \mu_j)\omega_{j,t+1} \widetilde{R}_{t+1}^{j,nom} B_{j,t}$ – where μ_j is a proportional repossession cost – pays the fraction κ of insured deposits in full, and pays a fraction $1 - \kappa$ of the repossessed returns to holders of the bank's uninsured deposits.

The objective function of the representative bank of class j is to maximize the net present value of their shareholders' stake at the bank

$$NPV_{j,t} = \mathbb{E}_t \left[\Lambda_{b,t+1} \Big(\max \left\{ \omega_{j,t+1} \widetilde{R}_{t+1}^{j,nom} B_{j,t} - R_t^{d,nom} D_{j,t}, 0 \right\} - v_{b,t} EQ_{j,t} \Big) \right],$$

subject to a balance sheet constraint $B_{j,t} = EQ_{j,t} + D_{j,t}$, and a regulatory constraint $EQ_{j,t} \geq \phi_{j,t} B_{j,t}$, where the equity investment $EQ_{j,t}$ is valued at its equilibrium opportunity cost $v_{b,t}$, $\phi_{j,t}$ is the capital requirement on the portfolio of j loans, and the max operator reflects shareholders' limited liability.

If the capital requirement is binding (as it turns out to be in equilibrium because partially insured deposits are always "cheaper" than equity financing), we can write the loans of the bank as $B_{j,t} = EQ_{j,t}/\phi_{j,t}$, its deposits as $D_{j,t} = (1-\phi_{j,t})EQ_{j,t}/\phi_{j,t}$. Since the bank fails when the realized return per unit of loans is lower than the associated debt repayment obligations, $(1-\phi_{j,t})R_t^{j,nom}$, the threshold value of $\omega_{j,t+1}$ below which the bank fails is:

$$\mathbb{E}_t(\overline{\omega}_{j,t+1}) = \mathbb{E}_t\big[\,(1-\phi_{j,t})\,R_t^{d,nom}/\widetilde{R}_{t+1}^{j,nom}\big].$$

Accordingly, the probability of failure of the bank of class j is $F_j(\overline{\omega}_{j,t+1})$, which will be driven by fluctuations in the aggregate return on loans, $\widetilde{R}_{t+1}^{j,nom}$, as well as shocks to the distribution of the bank return shock, $\omega_{j,t+1}$.

The bank's objective function can be written as:

$$NPV_{j,t} = \left\{\mathbb{E}_t\left[\Lambda_{b,t+1}\left[1-\Gamma_{j,t+1}(\overline{\omega}_{j,t+1})\right]\frac{\widetilde{R}_{t+1}^{j,nom}}{\phi_{j,t}} - v_{b,t}\right]\right\}EQ_{j,t},$$

which is linear in the bank's scale as measured by $EQ_{j,t}$. So, banks' willingness to invest in loans with gross returns described by $\widetilde{R}_{t+1}^{j,nom}$ and subject to a capital requirement $\phi_{j,t}$ requires having

$$\mathbb{E}_t\left[\Lambda_{b,t+1}\left[1-\Gamma_{j,t+1}(\overline{\omega}_{j,t+1})\right]\widetilde{R}_{t+1}^{j,nom}\right] \geq \phi_{j,t}v_{b,t},$$

which explains the expressions for the participation constraint introduced in the entrepreneurial firms' problem. This constraint will hold with equality since it is not in the firms' interest to pay more for their loans than strictly needed.[13] Finally, we can write the banks' aggregate return on equity as $\rho_{j,t+1}^{nom} = \left[1-\Gamma_{j,t+1}(\overline{\omega}_{j,t+1})\right]\frac{\widetilde{R}_{t+1}^{j,nom}}{\phi_{j,t}}$.

Taking into account effects of retirement and the entry of new bankers, as well as households' equity injections into banks, the evolution of active bankers' *aggregate* net worth can be described as:[14]

$$N_{b,t} = \theta_b(\rho_{M,t}^{nom}E_{M,t-1} + \rho_{F,t}^{nom}E_{F,t-1}) + \iota_{b,t} + N_{b,t}^{add}$$

where $\iota_{b,t}$ is new bankers' nominal net worth endowment (received from saving households),

[13] In fact, any pricing of bank loans leading to $NPV_{j,t} > 0$ would make banks wish to expand $EQ_{j,t}$ unboundedly, which is incompatible with equilibrium. So, the constraint could be written with equality, as a sort of zero (rather than non-negative) profit condition.

[14] To save on notation, we also use $N_{b,t+1}$ to denote the aggregate counterpart of what $n_{b,t+1}$ is an individual banker's net worth.

which we assume to be a proportion χ_b of the net worth of retiring bankers:

$$\iota_{b,t} = \chi_b(1-\theta_b)(\rho^{nom}_{M,t} E_{M,t-1} + \rho^{nom}_{F,t} E_{F,t-1}).$$

A.7 Consumption Goods Production Sector

We assume a continuum of monopolistically competitive firms that produce a differentiated intermediate good each. The output of each intermediate good producer $i \in [0,1]$ is then purchased by the perfectly competitive firms that produce the final consumption good.

A.8 Final good producers

Perfectly competitive final good producers combine the continuum of intermediate goods $y_t(i)$ into a single final good Y_t according to a CES technology:

$$Y_t = \left(\int_0^1 y_t(i)^{\frac{1}{1+\theta}} di \right)^{1+\theta}.$$

As a result of profit maximization and the zero profit condition, intermediate good firm i faces a downward-sloping demand curve given by

$$y_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\frac{1+\theta}{\theta}} Y_t.$$

The CES aggregate price index is defined as:

$$P_t = \left(\int_0^1 p_t(i)^{-\frac{1}{\theta}} di \right)^{-\theta}$$

where $p_t(i)$ is the price of each intermediate good. θ can simply be interpreted as the price elasticity of the demand for intermediate goods.

A.8.1 Intermediate good producers

Intermediate good producers combine labor $l_t(i)$ and capital $k_t(i)$ to produce $y_t(i)$ units of their intermediate good i using a constant-returns-to-scale technology:

$$y_t(i) = z_t l_t(i)^{1-\alpha} k_{t-1}(i)^{\alpha},$$

where α is the share of capital in production. Intermediate good firms are owned by the patient household dynasty and distribute profits or losses back to it.

Intermediate good producers set prices according to a typical Calvo setup. Prices are set for contractual periods of random length during which an indexation rule applies. As a result, firms do not maximize their profits period by period. Each contract expires with probability $1 - \xi$ per period. When the contract expires, the intermediate producer i sets the new price $\widetilde{p}_t(i)$ to maximize the present discounted value of future real profits over the validity of the contract:

$$\mathbb{E}_t \left[\sum_{\tau=0}^{\infty} \Lambda_{s,t,t+\tau} \xi^j \left(\frac{\widetilde{p}_{t,t+\tau}(i)}{P_{t+\tau}} y_{t+\tau}(i) - mc_{t+\tau}(i) y_{t+\tau}(i) \right) \right]$$

subject to:

$$\widetilde{p}_{t,t+\tau}(i) = X_{t,t+\tau} \widetilde{p}_t(i),$$

and

$$y_{t+\tau}(i) = \left(\frac{X_{t,t+\tau} \widetilde{p}_t(i)}{P_{t+\tau}} \right)^{-\frac{1+\theta}{\theta}} Y_{t+\tau},$$

where $\Lambda_{s,t,t+\tau}$ is the patient household's stochastic discount factor between periods t and $t+\tau$, $mc_t(i)$ is the marginal cost for firm i at time t and $X_{t,t+\tau}$ is the indexation factor for prices that remain sticky between periods t and $t+\tau$. When the price remains sticky, the intermediate good producer is still able to index his price to the steady state inflation rate in the economy, which is the (gross) inflation rate targeted by the monetary authority, $\overline{\pi}$, so that:

$$X_{t,t+\tau} = \overline{\pi}^{\tau}.$$

A.9 Physical Capital and Housing Production

Each form of capital - housing (H) and physical capital (K) - has a production sector in this economy. Thus, for $\Upsilon = \{H, K\}$, producers of Υ combine investment $I_{\Upsilon,t}$, with the previous stock of capital, Υ_{t-1}, in order to produce new capital which can be sold at nominal price $Q_{\Upsilon,t}$. The Υ representative producing firm maximizes the expected discounted value to the household dynasty of its profits:

$$\max_{\{I_{\Upsilon,t+j}\}} \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{s,t+j} \left\{ \frac{Q_{\Upsilon,t+j}}{P_{t+j}} \left[S_{\Upsilon} \left(\frac{I_{\Upsilon,t+j}}{\Upsilon_{t+j-1}} \right) \Upsilon_{t+j-1} \right] - I_{\Upsilon,t+j} \right\}$$

where $S_{\Upsilon}\left(\frac{I_{\Upsilon,t+j}}{\Upsilon_{t+j-1}}\right)\Upsilon_{t+j-1}$ gives the units of new capital produced by investing $I_{\Upsilon,t+j}$. $S_{\Upsilon}(\cdot)$ captures adjustment costs such that:

$$S_{\Upsilon}\left(\frac{I_{\Upsilon,t}}{\Upsilon_{t-1}}\right) = \left(1 - \frac{\psi_{\Upsilon}}{2}\left(\frac{I_{\Upsilon,t}}{\Upsilon_{t-1}} - 1\right)^2\right).$$

Finally, denoting by $\delta_{\Upsilon,t}$ the depreciation rate of Υ form of capital, the law of motion of the capital stock can be written as:

$$\Upsilon_t = (1 - \delta_{\Upsilon,t})\Upsilon_{t-1} + S_{\Upsilon}\left(\frac{I_{\Upsilon,t}}{\Upsilon_{t-1}}\right)\Upsilon_{t-1}.$$

A.9.1 Physical Capital Management Firms

The capital management cost s_t associated with patient households direct holdings of capital $K_{s,t}$ is a fee levied by a measure-one continuum of capital management firms operating with decreasing returns to scale. These firms have a convex cost function $z(K_{s,t})$ where $z(0) = 0$, $z'(K_{s,t}) > 0$, and $z''(K_{s,t}) > 0$. Under perfect competition, maximizing profits $\Xi_t = s_t K_{s,t} - z(K_{s,t})$ implies the first order condition

$$s_t = z'(K_{s,t}),$$

which determines the equilibrium fees for each $K_{s,t}$. We assume a quadratic cost function, $z(K_{s,t}) = \frac{\varsigma}{2}K_{s,t}^2$, with $\varsigma > 0$, so that the first order condition becomes $s_t = \varsigma K_{s,t}$.

A.10 Deposit Insurance Agency

The deposit insurance agency (DIA), balance its budget period-by-period. Thus, the lump-sum taxes have to cover the cost of guaranteeing deposits every period. The total costs to the DIA due to losses caused by M and F banks, and hence the total lump sum tax imposed on agents is given by

$$T_t = T_{H,t} + T_{F,t} = \kappa \Omega_t D_{t-1} \tag{8}$$

where Ω_t is average default loss per unit of bank debt, which is the properly weighted average of the losses realized at each class of bank:

$$\Omega_t = \frac{D_{M,t-1}}{D_{t-1}} \Omega_{M,t} + \frac{D_{F,t-1}}{D_{t-1}} \Omega_{F,t} \tag{9}$$

with

$$\Omega_{j,t} = \left[\overline{\omega}_{j,t} - \Gamma_{j,t}\left(\overline{\omega}_{j,t}\right) + \mu_j G_{j,t}\left(\overline{\omega}_{j,t}\right)\right] \frac{\widetilde{R}_{j,t}}{1-\phi_{j,t}} \tag{10}$$

for $j = M, F$.[15]

A.11 Policy Authorities

Macroprudential authority. Macroprudential authorities set structural values for borrower LTV caps, $\mathrm{L\bar{T}V}$, and bank capital requirements, $\bar{\phi}$. In addition to these ex-ante levels, authorities may adjust macroprudential instruments dynamically in response to financial conditions. When ex-post macroprudential policies are considered in the simulation exercises, both the LTV cap and the capital buffer follow simple countercyclical feedback rules. Formally:

$$\begin{aligned} \mathrm{LTV}_t &= \mathrm{L\bar{T}V} + \Phi_{\mathrm{ltv}}\left(\mu_{m,t} - \bar{\mu}_m\right) \\ \phi_t &= \bar{\phi} + \Phi_{\phi}\left(B_{m,t} - \bar{B}_m\right) \end{aligned}$$

where $\mu_{m,t}$ is the multiplier associated with the LTV constraint on mortgage borrowers, and $B_{m,t}$ denotes the aggregate volume of mortgage lending. The parameters Φ_{ltv} and Φ_{ϕ} capture the sensitivity of each instrument to deviations from their respective steady-state values.

Monetary authority. The monetary authority sets the one-period short-term nominal interest rate R_t^{rf} according to a Taylor-type policy rule:

[15] Note that the remaining fraction $1-\kappa$ of the default losses are directly incurred by the saving households.

$$R_t^{rf,nom} = \rho_R R_{t-1}^{rf,nom} + (1-\rho_R)\left[\bar{R}\left(\frac{\pi_t}{\bar{\pi}}\right)^{\alpha_\pi}\left(\frac{GDP_t}{GDP_{t-1}}\right)^{\alpha_{\Delta Y}}\left(\frac{GDP_t}{G\bar{D}P}\right)^{\alpha_Y}\right]$$

where ρ_R is the interest rate smoothing parameter, α_π, $\alpha_{\Delta Y}$ and α_Y determine the responses to deviations of inflation from its target level $\bar{\pi}$, to GDP growth and to GDP from its steady state level, respectively. The steady state level of the nominal interest rate is denoted by $\bar{R}$.[16]

B Calibration

The model is calibrated using quarterly Euro Area data for the 2001:1-2019:4 period. Both micro and macro data inform the model's calibration. The calibration proceeds in two steps. We first set a number of parameters to values commonly used in the literature. The remaining parameters are the calibrated simultaneously so as to match key data targets. Table 1 reports all the parameter values resulting from our calibration.

Table 3: Model parameters

A) Preset parameters					
Disutility of labor for savers	φ_s	1	F banks bankruptcy cost	μ_F	0.3
Disutility of labor for borrowers	φ_m	1	M banks bankruptcy cost	μ_M	0.3
Habits formation	ϑ	0.5	Entrepreneurs bankruptcy cost	μ_f	0.3
Housing weight in savers' utility	υ_s	1	Households bankruptcy cost	μ_m	0.3
Frisch elasticity of labor	η	1	Capital adjustment cost parameter	ψ_k	5
Capital share in production	α	0.3	Housing adjustment cost parameter	ψ_h	5
Depreciation rate of capital	δ_k	0.03	Calvo probability	ξ	0.95
Population of entrepreneurs	x_e	1	Smoothing parameter (Taylor rule)	ρ_R	0.86
Population of bankers	x_b	1	Inflation response (Taylor rule)	α_π	2
Population of savers	x_s	1	Output growth response (Taylor rule)	$\alpha_{\Delta Y}$	0.15
Capital management cost - denominator	ϕ_K	2	Output gap response	α_Y	0.05
Equity issuance cost parameter	ψ_0	1.5	Risk weight on M banks	rw	0.5
Net markup of intermediate firms	θ	0.2	Survival rate of entrepreneurs	θ_e	0.975
B) Calibrated parameters					
Share of insured deposits	κ	0.54	Capital ratio	ϕ	13.29
Steady-state inflation	$\overline{\pi}$	1.005	Population of impatient households	x_m	0.90
Discount factor of borrowers	β_m	0.9729	STD iid risk for M banks	σ_M	0.0130
Housing depreciation	δ_h	0.0118	STD iid risk for F banks	σ_F	0.0552
Housing weight in borrowers' utility	υ_m	0.4274	STD iid risk for borrowers	σ_m	0.1003
Capital management cost - numerator	ς	0.002	STD iid risk for entrepreneurs	σ_f	0.3500
Transfer from HH to entrepreneurs	χ_e	0.2	Survival rate of bankers	θ_b	0.951
Transfer from HH to bankers	χ_b	0.5974	Discount factor for savers	β_s	0.9955

[16] GDP_t is defined as the sum of aggregate consumption and capital investment in order to avoid the counterintuitive impact of the resource costs of default on the measurement of output.

Table 4: Model fit

Targets	**Definition**	**Data**	**Model**
Fraction of borrowers	$x_m/(x_m + x_s)$	0.43	0.47
Real interest rate	$(1/\beta_s - 1) \times 400$	1.80	1.80
Inflation	$(\overline{\pi} - 1) \times 400$	2	2
Share of insured deposits	κ	0.54	0.54
Capital ratio	ϕ_F	13.3	13.3
NFC loans to GDP	B_F/GDP	1.70	1.69
HH loans to GDP	B_M/GDP	2.07	2.17
Spread NFC loans	$(R^F - R^d) \times 400$	1.26	1.61
Spread HH loans	$(R^M - R^d) \times 400$	1.02	0.71
NFCs' default	$F_f(\overline{\omega}_f) \times 400$	2.63	2.16
Banks' default (average)	$F_b(\overline{\omega}_b) \times 400$	0.83	0.86
Real equity return of banks	$(\rho_F - 1) \times 400$	8.14	10.16
Banks' price to book ratio	v_b	1.20	1.70
Housing Investment to GDP	I_H/GDP	0.06	0.06
Borrowers' housing wealth share of GDP	$(B_M \times x_m)/GDP$	0.52	0.55
Capital share of savers	K_s/K	0.33	0.21

Table 5: *

Note: Data sample: euro area 2001:Q1-23:Q4; Interest rates, equity returns, default rates, and spreads are reported in annualized percentage points. The standard deviations (Std) of GDP growth, Investment (Inv), and Loan growth are reported in quarterly percentage points.

Pre-set parameters. We set the Frisch elasticity of labor supply, η, equal to one, the capital-share parameter of the production function, α, equal to 0.30, the discount rate of households and the depreciation rate of physical capital, δ, equal to 0.03. The labor disutility parameter, φ, which only affects the scale of the economy, is normalized to one. The average net markup of intermediate firms θ is 20% and the Calvo parameter, ξ 0.95 in line with Christoffel, Coenen and Warne (2008). The bankruptcy cost parameters are set equal to a common value of 0.30 for both banks, households and firms. Regarding the Taylor rule, we assume standard coefficients for the response to activity and inflation and the smoothing parameter (see e.g. Christoffel, Coenen and Warne, 2008, **coenen2018new**). The parameter in the adjustment cost function of capital (ψ_K) and housing (ψ_K) producing firms are set to 5, a value which is in the ballpark of other papers of the euro area.
Calibrated parameters. A second set of parameters are set jointly. However, some parameters can be linked to specific targets. The steady state inflation parameter, $\overline{\pi}$ and the discount factor, β, directly pin down the inflation target and the risk free rate which match the real interest rate observed over the sample period. The share of insured deposits in bank debt κ is set to 0.54 in line with the evidence by Demirgüç-Kunt, Kane, and Laeven (2015) for EA countries.

We calibrate the share of borrowers in the economy to match the proportion of indebted households in the Euro Area of about 43%.[17] The weight on housing in the utility of borrowers matches the share of housing held by the indebted and non indebted households in the Euro Area.

The new entrepreneurs' endowment parameter, χ_e, helps to match the ratio of bank loans to non-financial corporations (NFC loans) over GDP while the borrowersâ discount factor β_m, helps to match the ratios of household mortgages to GDP. The housing depreciation rate his calibrated to match the ratio of residential investment to GDP. The new bankers' endowment parameter, χ_b, is used to make the steady state bank expected return on equity, ρ_b, equal to the average cost of equity of EA banks. The parameter of the capital management cost function, ς, is set to match the share of physical capital directly held by savers in the model with an estimate, based on EA flow of funds data, of the proportion of assets of the NFC sector whose financing is not supported by banks. In addition, the survival rate of bankers, θ_b, is used so that the shadow value of bank equity, υ_b, matches the average price-to-book ratio of banks over the calibration period.

The bank capital requirement parameter, ϕ, is set to the reference capital requirement

[17] See 2017 ECB Household Finance and Consumption Survey (HFCS)

of 13% such that the bank total capital ratio is the model matched the total-asset-weighted capital ratio in the EA over the sample period.[18] We assume that while corporate loans carry a full weight, mortgage loans only carry a 50 percent risk weight, in line with their treatment in the Basel regulatory prescriptions.

The variance of the four idiosyncratic shocks as well as that of the aggregate shocks are mainly used to match the remaining targets. As shown in Table 2, we match very closely the eleven moments selected as targets for the calibration.

[18]The calculation in based on data collected from the consolidate banking dataset of the ECB - CBD2.

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