Should banks' regulatory capital reflect unrealized capital gains and losses? A quantitative assessment*

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Abstract

We develop a quantitative general equilibrium model of risky banks with a bond portfolio subject to interest rate risk and consider the implications of having the unrealized capital gains or losses of such a portfolio excluded from the (amortized-cost accounting) or included in the (fair-value accounting) definition of regulatory capital. We show that unrealized gains or losses affect bank lending despite the deposit franchise. Banks are relatively insulated from short-term volatility in securities returns under the amortized-cost accounting treatment, resulting in a smoother credit supply. This comes at the cost of higher bank failure probabilities during prolonged periods of intense monetary policy tightening. Under our calibration, fair-value accounting treatment is superior in welfare terms.

Keywords: Interest rate risk, credit risk, regulatory capital, accounting rules, financial stability

JEL Classification: G21, G28, G32, G33, E44, E51

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1 Introduction

Banks invest a considerable fraction of their asset holdings in long-term fixed-income securities which are highly liquid and nearly free of default risk. These securities allow the bank to meet any unexpected withdrawals of its predominantly short-term funding, while simultaneously earning a term premium. But they also pose a risk to the bank because the market value of long-term securities declines when the yield curve shifts upwards, producing accounting losses that deplete their equity capital. Should such accounting losses (or gains) related to the impact of interest rate risk on debt securities also affect banks' regulatory capital base? Basel III contains proposals in favor of it. Yet, some bank managers, regulators and academics have argued that doing so would result in greater volatility in banks' regulatory capital levels (see e.g. Barth, Landsman, and Wahlen, 1995; Basel Committee on Banking Supervision, 2017).[1] Indeed if banks are constrained in their ability to raise equity, then shielding their regulatory capital from some of the valuation implications of temporary fluctuations in interest rates can allow them to maintain a more steady provision of credit. However, during a prolonged period of unexpectedly high interest rates, neglecting unrealized losses in the portfolio of debt securities may allow severely under-capitalized banks to operate, posing a financial stability risk (see e.g. Flannery and Sorescu, 2023). Arguments supporting this view are reflected in the Review of the Federal Reserve's Supervision and Regulation of Silicon Valley Bank (Barr, 2023).

This article studies this trade-off in a quantitative macro-banking model that jointly accounts for banks' exposure to credit and interest rate risk, and in which financial stability risks from unexpectedly high interest rates are most severe when accompanied by high default rates in banks' loan portfolio. In the model, banks use insured deposits and equity to extend one-period risky loans to entrepreneurial firms and invest in a portfolio of default-free long-term government bonds. Firm defaults cause losses for banks, depleting their equity capital. The market price of long-term bonds is sensitive to changes in interest rate. Resulting unrealized (accounting) gains or losses are excluded for calculating the value of bank equity relevant for regulatory requirements – which as in reality applies a positive risk weight to the risky loans and a zero weight on the long-term government bonds. Banks' regulatory capital base therefore overstates their true net worth during periods of increasing interest rates.

[1] The differences in accounting and regulatory treatment of unrealized gains and losses on banks' securities portfolio have historically evolved through the use of prudential filters by regional regulators. See Argimón, Dietsch, and Estrada (2018) for a discussion on the pre-crisis heterogeneity across Euro Area countries in their use of the prudential filters. Kim, Kim, and Ryan (2019) provide a concise background on the accounting and capital requirements for securities held by U.S. banks.

Distortions due to limited liability combined with safety net guarantees imply that banks operate with particularly high effective leverage during such periods, so that the impact of credit losses on their solvency and the macro-economy are much larger.

The calibrated macro-banking model of credit and interest rate risk reproduces many relevant features of the data related to the financial markets, macro-economic quantities and prices. We also validate the model in its ability to capture the differences coming from the regulatory treatment of accounting losses by comparing it with the empirical literature on the effects that realized and unrealized capital losses have on loan pricing by banks. Consistent with available evidence, the model implies that banks charge a higher lending rate in response to unrealized balance sheet losses, and that this response is weaker than the one associated with realized changes in regulatory capital.

We then study a regulatory regime that includes unrealized gains and losses on the bonds portfolio in calculating the value of bank equity relevant for capital requirements. Not surprisingly, regulatory bank capital is more sensitive to changes in the interest rate. This translates to a greater volatility in credit. At the same time, the terms of the financial contract between banks and firms are better aligned with macro-economic conditions and bank balance sheet fundamentals. The better pricing of risk makes both banks and firms safer on average, freeing up resources otherwise spent on deadweight losses from bankruptcies. The reduction in twin default probabilities results in lower macro-economic volatility. Overall, this regulatory regime is welfare-improving, lending support to the Basel III proposals for removing prudential filters which insulate banks' regulatory capital from accounting gains or losses on debt securities portfolio.

Our modeling of the credit-risk framework builds on Mendicino et al. (forthcoming) which adds banks in a setup following the Bernanke, Gertler, and Gilchrist (1999) financial-accelerator tradition and taking explicitly into account the structure of asset returns implied by holding of risky loans whose risk of default is not fully diversifiable at the bank level. As a result, bank solvency problems arise endogenously from high default rates among bank borrowers. We embed this framework in a standard New-Keynesian model with investment and augment the bank's portfolio choice problem to include default-free long-term bonds issued by the government. The maturity mismatch resulting from holding these bonds exposes them to interest rate risk.

Banks run a deposit franchise, setting net deposit rates that are a fixed fraction of the policy rate. Their deposit spreads are therefore increasing in the policy rate (see Drechsler, Savov, and Schnabl, 2021). This partially hedges interest rate risk. In our model, the deposit franchise has an additional effect which is that it makes the bank's objective function convex in lending. This is because payoffs from the deposit franchise are riskless while lending is risky. Hence, banks are safe when they supply loan volumes up to the level at which the highest possible loss in their loan portfolio equals the profits from the deposit franchise. For higher levels of lending, banks have a non-zero default probability that is increasing in size of their loan portfolio. Limited liability and safety net guarantees imply that once banks are risky, their marginal profit from lending must change (since at that point, any increase in lending affects the bank's default probability). For a given loan rate, banks then either prefer to lend the maximum amount that respects the regulatory capital requirement, or zero. Modeling-wise this is a non-trivial difficulty that does not arise in setups abstracting from either risky lending or banks' deposit franchise.[2] One contribution of our work is to set up and solve such a model.

We estimate the model parameters using the simulated method of moments, targeting a large set of unconditional moments in macro, banking, and financial euro area (EA) data from the OECD Quarterly National Accounts and the ECB Statistical Data Warehouse for 1995-2016. Over this period, banks' loans-to-bonds ratio averaged 3.6 and the maturity of their bond holdings corresponded to about 3.4 years. Our baseline calibration replicates these features of the data, which are crucial for capturing the exposure to interest rate risk coming from these assets. The capital requirement on the risky loans is set at 8%, matching the standards set by the Basel agreements.

Our main quantitative exercises compare a regime in which the value of bank equity relevant for regulation reflects the value of the long-term bonds at amortized-cost (or "book value") with a regime in which the value of equity reflects the fair value (or "market value") of the bonds. We validate the model's ability to allow this comparison by assessing it against the empirical literature on loan pricing implications of realized and unrealized bank losses. Consistent with available evidence, our model implies that banks charge a higher lending rate in response to unrealized losses on balance sheet (Volk, 2024), and that this response is weaker than the one associated with realized changes in regulatory capital (Dagher, Dell'Ariccia, Laeven, Ratnovski, and Tong, 2016).

The validated model is used to study the optimal prudential measure of regulatory bank capital. When unrealized losses on the long-term bonds are excluded, banks operate with accumulated losses on balance sheet during periods of monetary policy tightening. For any

[2] Drechsler, Savov, Schnabl, and Wang (2023) develop a banking model with deposit franchise and run-risk. They consider the effect of a reduced-form adverse credit shock on the likelihood of a run, without explicitly solving for the bank's portfolio-choice problem.

level of borrower defaults, the risk of bank insolvencies during such periods is larger. But the presence of safety net guarantees gives banks with limited liability an incentive to underprice borrower risk, as they do not internalize the effects of their individual choices on the social costs of their failures. Banks extend loans up to the point that the capital requirement is binding – which in this case is less restrictive than if it were to be based on their true loss-absorbing capacity. While this dampens the decline in credit, investment and output, any adverse shock that increases default risk among bank borrowers causes a large increase in bank defaults.

Instead, when unrealized gains or losses on the long-term bonds are included, regulatory bank capital is more sensitive to changes in interest rates. As a result, credit is more volatile. However, firm and bank default probabilities are *less* volatile. This is because this regulatory treatment limits banks' effective leverage (and hence riskiness) in times when it would otherwise be elevated due to unrealized losses and thus makes the banking sector more resilient to credit losses in times when it would be particularly vulnerable to them. Hence, it reduces the mean and variance of bank and firm failures. The reduction in probability of twin defaults results in lower volatility of output, consumption and inflation, overall translating to higher welfare. Our results thus lend support to the Basel III proposal of recognizing unrealized gains and losses for regulatory purposes (i.e., removing prudential filters).

Related literature This paper belongs to the literature on quantitative models of bank regulation. Following the formalization of welfare trade-offs associated with capital regulation in Van den Heuvel (2008), a big strand of the literature has studied the optimal level of capital requirement (Begenau, 2020; Elenev, Landvoigt, and Van Nieuwerburgh, 2021; Abad, Martinez-Miera, and Suarez, 2024; Mendicino et al., forthcoming), the interaction of capital regulation and monetary policy (Angeloni and Faia, 2013; Collard, Dellas, Diba, and Loisel, 2017), the interaction of capital regulation and banking market structure (Corbae and D'Erasmo, 2021; Begenau and Landvoigt, 2022), and the rationale behind dynamic capital requirements (Davydiuk, 2017; Malherbe, 2020). In the models considered in this literature, banks' assets and liabilities are typically assumed to last only one period, thus rendering the discussion on interest rate risk and the capital treatment of unrealized gains or losses irrelevant. We extend the analysis adding long-term bonds to banks' assets and complement the existing literature by focusing on the implications of the prudential treatment of unrealized gains and losses for credit supply and banks' solvency.

In this sense, our work is more closely related to Begenau, Bigio, Majerovitz, and Vieyra

(2025). In their model, differences in banks' book equity (relevant for regulation) and market equity arise from accounting rules which allow a delayed recognition of loan losses. As a result, regulation requiring instantaneous recognition of loan losses effectively tightens capital requirements. In contrast, the regulatory requirement to recognize revaluations of the long-term bonds portfolio in our model results in tighter capital requirements during monetary policy tightening and weaker requirements during monetary policy expansions. Therefore, our models differ in their normative implications of the regulatory accounting framework.

Our work is related to the literature on "accounting" (or capital measurement) issues in banking.[3] Several classical studies in this literature share a common theme that fair value accounting may lead to fire-sale spirals triggered by forced selling of illiquid or credit-risky assets by financial institutions subject to capital or alternative balance sheet constraints.[4] In wake of the 2023 U.S. regional banking crisis involving the failure of Silicon Valley Bank, these accounting discussions have focused on the prudential treatment of unrealized gains or losses on liquid debt securities that are relatively free of default risk. Greenwald, Krainer, and Paul (2024) and Orame, Ramcharan, and Robatto (2025) study how the regulatory accounting framework influences the transmission of monetary policy onto bank lending. The implications produced by our model regarding the same are consistent with these and other empirical findings (see e.g. Beutler, Bichsel, Bruhin, and Danton (2020); Marsh and Laliberte (2023)). We complement these studies by underscoring the financial stability consequences of the regulatory accounting framework. Our work therefore bridges this literature with the renewed discussions on the importance and implications of banks' interest rate risk exposure (Drechsler et al., 2021; Drechsler et al., 2023; Haddad, Hartman-Glaser, and Muir, 2023; Jiang, Matvos, Piskorski, and Seru, 2024; DeMarzo, Krishnamurthy, and Nagel, 2024; Begenau, Landvoigt, and Elenev, 2024; Varraso, 2024).

Outline The rest of the paper is organized as follows. Section 2 describes our macro-banking model. Section 3 contains the solution method and calibration strategy, presents the baseline parameterization, and discusses the quantitative performance of the model. In

[3]See Freixas and Tsomocos (2004) for an early theoretical contribution.

[4]For example, Allen and Carletti (2008) show that when financial markets are illiquid, such as during a financial crisis, the use of fair value accounting to assess solvency may lead to undesirable liquidation of banks' assets. See also Plantin, Sapra, and Shin (2008). Ellul, Jotikasthira, Lundblad, and Wang (2015) argue that when regulatory capital reflects fair value of risky assets, it creates incentives for financial institutions to sell risky assets during a financial crisis since it improves their risk-weighted capital ratios. However, the evidence presented in Laux and Leuz (2010) suggests it is unlikely that fair value accounting contributed to the severity of the 2008 financial crisis in a sizable way.

Section 4 we analyze the performance of the economy under alternative regulatory accounting frameworks, identifying the approach that maximizes social welfare. The Appendix contains a complete list of equilibrium conditions and full description of the data sources, solution method, and several complementary materials referred throughout the main text.

2 The model

We consider a discrete-time, infinite-horizon economy in which dates are indexed by t. The baseline framework is a standard New Keynesian model with investment.[5] In contrast to the conventional model, each household consists of workers, entrepreneurs, and bankers. Workers supply labor to the production sector and transfer their wage income back to the family. Entrepreneurs and bankers provide equity to entrepreneurial firms and banks, respectively.

There exist a continuum of measure one of islands. In each island there is a continuum of measure one of entrepreneurial firms and a representative bank. Entrepreneurial firms and banks live for one period, issue equities among entrepreneurs and bankers, respectively, and obtain external financing by issuing non-contingent debt in the form of bank loans and deposits, respectively. Entrepreneurial firms use equity and loans to buy physical capital, which some intermediate good producers rent in the next period. Their terminal net worth is subject to both idiosyncratic and island-specific shocks. The latter is non-diversifiable from the banks' perspective. In addition to providing loans, banks invest in a portfolio of long-term bonds. Both entrepreneurial firms and banks operate under limited liability and default when their terminal asset value is lower than their debt obligations. Non-defaulted entrepreneurial firms and banks pay their terminal net worth to entrepreneurs and bankers, respectively.

In the rest of this section, we present the model ingredients in more detail.

2.1 Households

There is a unit continuum of households indexed by h, that provide consumption insurance to three types of members: workers, bankers and entrepreneurs.

Households derive utility from consumption C_t and disutility from labor H_t. To improve the quantitative performance of the model, consumption is subject to internal habit forma-

[5] See e.g., Smets and Wouters (2007) and Christiano, Eichenbaum, and Evans (2005).

tion governed by the parameter b.[6] Households provide differentiated labor hours H_{ht} to intermediate goods-producing firms, remunerated at a nominal wage W_{ht}. The disutility derived from labor is governed by the inverse Frisch elasticity φ_H and a scaling parameter ξ_H.

Households can save in fully insured bank deposits D_t remunerated at gross interest rate R_{Dt}. To account for non-bank funding, households can also invest in physical capital K_t^H at real price Q_t, subject to a management cost ς_t, and rent it to intermediate good producers at rate z_t.[7] Physical capital depreciates at rate δ. The nominal price of the single consumption good is denoted by P_t, and inflation is defined as $\Pi_t = P_t/P_{t-1}$ with steady state $\bar{\Pi}$.

With all these ingredients, the maximization problem of household h is stated as:

$$\max_{\{C_{ht},D_{ht},K_{ht}^H,H_{ht}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{ht} - bC_{ht-1})^{1-\sigma}}{1-\sigma} - \frac{\xi_H H_{ht}^{1+\varphi_H}}{1+\varphi_H} \right], \tag{1}$$

subject to the budget constraint:

$$\begin{aligned} P_t C_{ht} + P_t D_{ht} + P_t(Q_t + \varsigma_t)K_{ht}^H &= W_{ht}H_{ht} \\ &+ R_{Dt-1}P_{t-1}D_{ht-1} + P_t(z_t + (1-\delta)Q_t)K_{ht-1}^H + \Sigma_{ht}, \end{aligned} \tag{2}$$

where Σ_{ht} summarizes other cash flows that the household receives, but which are irrelevant for its optimization problem. We assume that the household invests its deposits symmetrically in all the (symmetric) banks in the economy. Appendix A.1 provides the FOCs for this problem.

2.1.1 Nominal Wage Setting

The model features sticky wages.[8] A labor union collects all household-differentiated varieties of labor H_{ht}, which are sold to a competitive labor packer after setting nominal wages W_{ht}. The elasticity of substitution between varieties is ϵ_W. Wage setting is subject to Rotemberg (1982) adjustment costs governed by parameter θ_W which the union finances by charging

[6] See, for example, Smets and Wouters (2007), Christiano et al. (2005), and Christiano, Motto, and Rostagno (2014).

[7] Capturing the non-bank-dependent part of the economy prevents our model from overstating the macroeconomic consequences of changes in credit supply.

[8] As discussed in, e.g., Galí (2015) and Smets and Wouters (2007), sticky wages contribute to dampen the rise in inflation after, e.g., an expansionary monetary policy shock, consistent with data. In our setup this adds realism to the impact of debt deflation on financial sector defaults.

households a lump-sum fee. Since these elements are standard in New Keynesian models, further details are relegated to Appendix A.2.

2.1.2 Bankers & Entrepreneurs

Bankers and entrepreneurs are modeled in a symmetric manner, and are therefore discussed together in this section.

At date t, bankers and entrepreneurs invest symmetrically in an all-islands portfolio of one-period banks and entrepreneurial firms, respectively. Bankers and entrepreneurs receive the terminal net worth of their banks and firms at the beginning of $t+1$. At that point, bankers are also charged a lump sum tax by the government to finance the deposit insurance agency (DIA).

To make bankers and entrepreneurs net worth scarce, we assume that in every period a fraction $(1-\theta_\chi), \chi \in \{B, E\}$ of bankers and entrepreneurs retire and become workers, while the same measure of workers becomes bankers and entrepreneurs. When they retire, they pay out their wealth to households. New bankers and entrepreneurs in period t on the other hand receive a fraction ξ_χ of the net worth of the bankers and entrepreneurs that have retired in period t. Calibration of the parameters will ensure equity is scarce enough for banks and entrepreneurs never to finance all their investments without debt.

In every period, continuing and new bankers and entrepreneurs decide how much (real) dividends ν_t^χ to pay out to their households and how much (real) equity χ_t (with $\chi_t = B_t$ for bankers, and $\chi_t = E_t$ for entrepreneurs) to invest in the equity portfolio. Bankers and entrepreneurs take the nominal return on their equity ρ_t^χ as given. Stating the maximization problem in real terms, the value function of a representative banker or entrepreneur i is

$$V_t^\chi(\chi_{it}) = \max_{\nu_{it}^\chi \geq 0, \chi_{it} \geq 0} \mathbb{E}_t \left[\nu_{it}^\chi + \mathbb{E}_t \Lambda_{t,t+1} \left((1-\theta_\chi)\chi_{t+1} + \theta_\chi V_{t+1}^\chi(\chi_{it+1}) \right) \right], \quad (3)$$

with

$$\chi_{it+1} = \frac{\rho_{t+1}^\chi}{\Pi_{t+1}} (\chi_{it} - \nu_{it}^\chi). \quad (4)$$

Following the established approach in the literature, we guess and verify that the value function is linear in the net worth of banker or entrepreneur i: $V_t^\chi(\chi_{it}) = s_t^\chi \chi_{it}$.[9] Further

[9]See, for example, Gertler and Kiyotaki (2010).

guessing (and later verifying) that in the vicinity of the steady state we have $s_t^\chi > 1$, which implies $\nu_t^\chi = 0$ by the Envelope Theorem.[10] It then follows that

$$s_t^\chi = \mathbb{E}_t \underbrace{\Lambda_{t,t+1}\left(1-\theta_\chi+\theta_\chi s_{t+1}^\chi\right)}_{=\Lambda_{t,t+1}^\chi} \frac{\rho_{t+1}^\chi}{\Pi_{t+1}}. \tag{5}$$

Equation (5) defines the bankers' or entrepreneurs' stochastic discount factor for later use as $\Lambda_{t,t+1}^\chi = \Lambda_{t,t+1}(1-\theta_\chi+\theta_\chi s_{t+1}^\chi)$, where $\Lambda_{t,t+1}$ is the household's stochastic discount factor. Finally, the aggregate law of motion of equity of bankers or entrepreneurs is

$$\chi_{t+1} = (\theta_\chi + \xi_\chi(1-\theta_\chi))\frac{\rho_{t+1}^\chi}{\Pi_{t+1}}\chi_t - \frac{T_{t+1}}{P_{t+1}}, \tag{6}$$

where T_{t+1} are nominal lump-sum taxes imposed by the deposit insurance agency, described below in detail.

2.2 Entrepreneurial Firms

Entrepreneurial firms provide the key connection between the financial sector and the real economy: they rely on bank loans to invest in physical capital used in the production sector. They hence transmit conditions in the financial sector to the real economy through their (physical) capital supply, and in turn transmit conditions in the real economy to the financial sector through the impact of the real return on (physical) capital on the loan default probability.

Each island is populated by a unit continuum of entrepreneurial firms indexed by j. These are one-period institutions owned by entrepreneurs. Entrepreneurial firms purchase physical capital K_{jt} from capital producers at real price Q_t. To finance their investment, they use loans L_{jt} from the bank on their island and equity E_{jt}:

$$E_{jt} + L_{jt} = Q_t K_{jt}. \tag{7}$$

At date $t+1$, entrepreneurial firms rent capital acquired at the end of t to intermediate good producers against a rental price z_{t+1}, and sell undepreciated capital $(1-\delta)K_{jt}$ back

[10] We make sure that under our calibration of the model parameters $s_t^\chi = 1$ with a probability close to 0 and thus directly impose $\nu_t^\chi = 0$.

to capital producers at real price Q_{t+1}.[11] Following Mendicino et al. (forthcoming) , the final asset value of every entrepreneurial firm is subject to an idiosyncratic shock ω_j and an island specific shock ω_k, engendering loan default risk which is only partly diversifiable at the island-specific banks. By limited liability, the nominal terminal net worth of entrepreneurial firm j on island k at time $t+1$ is

$$P_{t+1}\Omega^{Firm}_{jkt+1}(\omega_j, \omega_k) = max\{\omega_j\omega_k[P_{t+1}Q_{t+1}(1-\delta)K_{jt} + P_{t+1}z_{t+1}K_{jt}] - R_{Ljt}P_tL_{jt}, 0\}. \quad (8)$$

According to Equation (8), entrepreneurial firm j defaults at $t+1$ if its idiosyncratic shock is below the threshold $\bar{\omega}_{t+1}(\omega_k)$:

$$\bar{\omega}_{t+1}(\omega_k) = \frac{R_{Ljt}L_{jt}}{\omega_k\Pi_{t+1}\left[Q_{t+1}(1-\delta)K_{jt} + z_{t+1}K_{jt}\right]}. \quad (9)$$

To capture the impact of uncertainty on the fluctuation of default risk, we introduce Christiano et al. (2014) risk shocks in the same way as Mendicino et al. (forthcoming) . Specifically, we assume the shocks ω_j and ω_k are independent and log-normal distributed, with time-varying mean and variance:

$$log(\omega_\Xi) \sim N\left(-\frac{\sigma^2_{\omega_{\Xi t}}}{2}, \sigma_{\omega^2_{\Xi t}}\right),\ \Xi \in \{j,k\}, \quad (10)$$

where the standard deviation $\sigma_{\omega_{\Xi t}}$ follows the following AR(1) process:

$$log(\sigma_{\omega_{\Xi t}}) = (1-\rho_{\omega_\Xi})log(\bar{\sigma}_{\omega_\Xi}) + \rho_{\omega_\Xi}log(\sigma_{\omega_{\Xi t-1}}) + \sigma_{\sigma_\Xi}\epsilon_{\sigma_\Xi},\ \epsilon_{\sigma_\Xi} \sim N(0,1). \quad (11)$$

While the risk shocks ϵ_{σ_Ξ} are mean preserving ($\mathbb{E}(\omega_{\Xi t}) = 1\ \forall t$), a higher value of $\sigma_{\omega^2_{\Xi t}}$ implies that the distribution of ω's has fatter tails, leading to higher default risk.

At the end of each period, all terminal net worth of entrepreneurial firms is paid out to entrepreneurs. The nominal return on entrepreneurial equity is:

$$\rho^E_{t+1} = \frac{\Pi_{t+1}\int_0^\infty\int_0^\infty \Omega^{Firm}_{jkt+1}(\omega_j,\omega_k)dF_{jt+1}(\omega_j)dF_{kt+1}(\omega_k)}{E_t}. \quad (12)$$

[11]In contrast to models in which all production factors are pre-financed with loans (e.g., Mendicino et al, forthcoming and Hristov and Hülsewig, 2017), our setup with only pre-financed capital allows output at t to respond to contemporaneous demand conditions (Mendicino, Nikolov, Suarez, and Supera, 2020). As an implication, monetary policy transmission is as in the canonical New Keynesian model.

2.3 Banks

Each island is populated by a representative bank k. As entrepreneurial firms, banks are active between two consecutive periods t and $t+1$. In period t banks combine equity B_{kt} from bankers and insured deposits D_{kt} from households in order to extend loans L_{kt} to entrepreneurial firms operating in their island. The bank can also invest in both one-period government bonds S_{kt}, remunerated at the deposit facility rate R_t set by the central bank, and long-term zero-coupon bonds S^L_{kt}, trading at market price Q^S_t. The latter are purchased by banks from a *bond management company* in period t and, if not maturing, resold to it in period $t+1$. The role of this company is discussed below in detail. For tractability, as in Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012), these bonds are assumed to reach maturity in an independent random manner with probability $1/m$ per period so that in each period a fraction $\frac{1}{m}$ of them mature. This implies that the average maturity of the bonds is m periods. In market value terms, banks face the following balance-sheet constraint

$$L_{kt} + S_{kt} + Q^S_t S^L_{kt} = B_{kt} + D_{kt}. \tag{13}$$

Banks extend loans in a perfectly competitive manner. It is assumed that in addition to the loan rate R_{Lt}, banks reap a non-pecuniary benefit c_R per unit of lending. It is thus costly for the bank to reduce lending beyond the bank's lending capacity implied by capital requirements (to be discussed below), reflecting a weakening in lending relationships.[12] The role of this assumption will be discussed below, alongside the bank's profit maximization problem.

Banks raise insured deposits D_{kt} in a monopolistic manner at rate R_{Dkt}. The demand for deposits of bank k is:

$$D(R_{Dkt}, R_{Dt}) = \left(\frac{R_{Dkt}}{R_{Dt}}\right)^{-\epsilon_D} D_t. \tag{14}$$

Banks take the aggregate deposit rate $R_{Dt} = (\int_0^1 R_{Dkt}^{1-\epsilon_D} dk)^{\frac{1}{1-\epsilon_D}}$ as given. As shall be seen, this allows our model to feature a sensitivity of deposit rates to the policy rate of the same form as in Drechsler et al. (2023), with deposit spreads increasing in the policy rate. Further, in keeping with the Drechsler et al. (2023) deposit franchise setup, the bank has to pay a

[12] While each bank is a one-period institution, the bank's shareholders continue to profit from the banking relationship in the future. While we do not model such dynamics, this can for example be thought of as relationships embodied in the employees of the bank k, not in the institution per se, with a constant set of employees employed by the succession of banks on island k. Each bank is managed in the interest of shareholders, and internalized the benefits of the lending relationship in this manner, but cannot use it to avoid default due to its non-pecuniary nature.

fixed cost (in real terms) c_f per period to operate. This feature has two roles. First, as discussed in Drechsler et al. (2023), it allows to think of the deposit franchise as an interest rate swap, with a fixed leg c_f and a floating leg corresponding to the profits in deposit taking. Second, it allows the model to reproduce a realistic return on equity for banks.

Lastly, at the beginning of period t, every bank k is endowed with an identical amount of equity $\bar{B}_t$ by bankers, such that $B_{kt} = \bar{B}_t$.

Intertemporal trade of the long-term bonds. The banking industry operates a long-term bond management company which centralizes the trade of bonds between the subsequent cohort of banks. The main role of this company is to keep track of the amortized-cost value of the loans to replicate the situation in which bonds were held by banks operating over multiple periods. At date t, this company buys the bonds at (real) market price Q_t^S from surviving banks that bought them at $t-1$ and from the Deposit Insurance Agency (DIA), which repossesses the bonds from failing banks that bought them at $t-1$. Then, the company sells the bonds at market price to the new cohort of banks that buy them (together with the newly issued long-term bonds) at t.

Importantly, this company provides a "certificate of amortized-cost value" to the bonds, which allows banks to write their balance sheet for regulatory purposes (in real terms) as follows:

$$L_{kt} + S_{kt} + Q_t^{AC} S_{kt}^L = \bar{B}_t + D_{kt} + (Q_t^{AC} - Q_t^S) S_{kt}^L, \tag{15}$$

where Q_t^{AC} is the real average amortized-cost value of bonds according to the certificate, and $(Q_t^{AC} - Q_t^S) S_{kt}^L$ measures what would be regarded as unrealized capital losses (if $Q_t^{AC} > Q_t^S$) or gains (if $Q_t^{AC} < Q_t^S$) if the bank were measuring the value of its bonds at their certified amortized cost. Given the permanent inventory dynamics of the stock of long-term bonds, the law of motion of Q_t^{AC} is given by:

$$Q_t^{AC} S_{kt}^L = \frac{Q_{t-1}^{AC}}{\Pi_t} \left(1 - \frac{1}{m}\right) S_{kt-1}^L + Q_t^S \left(S_{kt}^L - \left(1 - \frac{1}{m}\right) S_{kt-1}^L\right), \tag{16}$$

where the first term in the right hand side represents the continuation amortized-cost value of the non-matured bonds, and the second term is the market value of the newly issued bonds acquired by the bond management company in the primary bond market.[13]

[13]Note that the amortized-cost value of the newly issued bonds coincides with the market value.

Capital requirement. Banks are subject to a minimum capital requirement, which imposes that banks must operate with *regulatory* equity capital greater than or equal to a fraction γ of their loans. The key novelty in our analysis is the comparison of capital requirements under two different definitions of regulatory capital. Under a fair-value definition, the capital requirement is of the following form:

$$\gamma L_{kt} \leq \bar{B}_t. \tag{17}$$

Under the amortized-cost definition, the requirement takes the following form:

$$\gamma L_{kt} \leq B_{kt}^{AC}, \tag{18}$$

where

$$B_{kt}^{AC} \equiv \bar{B}_t + (Q_t^{AC} - Q_t^S) S_{kt}^L \tag{19}$$

represents the amortized-cost value of bank equity, which is defined using Equation (15). Therefore, the difference between the two resulting capital requirements arises from the prudential treatment of *unrealized* gains and losses associated with banks' long-term bonds portfolio.

Terminal net worth of a bank. As derived in Equation (9), conditional on the island-idiosyncratic shock ω_k, an entrepreneurial firm pays back its loan in full when it experiences a firm-idiosyncratic shock no lower than $\bar{\omega}_{t+1}(\omega_k)$. In case of default of an entrepreneurial firm, the bank only recovers a fraction $(1-\delta_M)$ of the firm's terminal asset value in Equation (8), where δ_M is an asset repossession cost. Hence, the nominal ex-post gross rate of return on loans of the bank in island k is

$$\begin{aligned} \tilde{R}_{Lkt+1}(\omega_k) = & \frac{\omega_k (1-\delta_M)\Pi_{t+1}[Q_{t+1}(1-\delta) + z_{t+1}] K_t^E}{L_t} \int_0^{\bar{\omega}_{t+1}(\omega_k)} \omega_j dF_{jt+1}(\omega_j) \\ & + R_{Lkt} \int_{\bar{\omega}_{t+1}(\omega_k)}^{\infty} dF_{jt+1}(\omega_j), \end{aligned} \tag{20}$$

where K_t^E denotes the aggregate level of physical capital held by entrepreneurs. By definition of the entrepreneurial firm's default threshold in Equation (9), the first term is bounded by R_{Lkt}: when borrowers default, they repay less than the agreed loan rate, otherwise they repay fully. This naturally limits upside-risk for the bank and therefore leads to a negatively skewed distribution of $\tilde{R}_{Lkt+1}(\omega_k)$.[14]

Due to the stochastic maturity of the long-term bond portfolio, the nominal gross rate of this portfolio is:

$$R^S_{kt+1} = \frac{\frac{1}{m} + \left(1 - \frac{1}{m}\right) \Pi_{t+1} Q^S_{t+1}}{Q^S_t}. \tag{21}$$

The nominal terminal net worth of the bank on island k is then

$$P_{t+1}\Omega^B_{kt+1}(\omega_k) = P_t \left[\tilde{R}_{Lkt+1}(\omega_k) L_{kt} + R_t S_{kt} + R^S_{kt+1} Q^S_t S^L_{kt} - c_f - R_{Dkt} D_{kt}\right]. \tag{22}$$

Banks default on their deposits if their terminal net worth is negative. From Equation (22), it is useful to define a threshold value for the island-specific shock ω_k below which the bank in island k defaults. This is implicitly done in the next equation

$$\tilde{R}_{Lkt+1}(\bar{\omega}_{bkt+1}) L_{kt} + R_t S_{kt} + R^S_{kt+1} Q^S_t S^L_{kt} - R_{Dkt} D_{kt} - c_f = 0. \tag{23}$$

Equation (23) implies that banks' failure rate at the beginning of period t+1 is $F_{kt+1}(\bar{\omega}_{kt+1})$. Thus, the nominal gross rate of return on the portfolio of equity of a banker that symmetrically invests in all banks is

$$\rho^B_{t+1} = \frac{\Pi_{t+1} \int_{\bar{\omega}_{bkt+1}}^{\infty} \Omega^B_{kt+1}(\omega_k) dF_{kt+1}(\omega_k)}{\bar{B}_t}. \tag{24}$$

Bank's profit maximization problem. Banks are managed in the interest of bankers, and maximize:

$$\max_{L_{kt}, S_{kt}, S^L_{kt}, R_{Dkt}} \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \Big[c_R L_{kt} + \tag{25}$$

$$\int_0^{\infty} max(\tilde{R}_{Lkt+1}(\omega) L_{kt} - R_{Dkt} D_{kt} + R_t S_{kt} + R^S_{t+1} Q^S_t S^L_{kt} - c_f, 0) F_{kt+1}(\omega)\Big]$$

$$\text{subject to } L_{kt} + S_{kt} + Q^S_t S^L_{kt} = D_{kt} + \bar{B}_t \tag{26}$$

$$D_{kt} = \left(\frac{R_{Dkt}}{R_{Dt}}\right)^{-\epsilon_D} D_t \tag{27}$$

[14] Thus the model features a structural link between bank asset returns and borrower defaults, which is crucial to accurately capture the importance of the feedback loop between conditions in the real economy and the financial sector (see Mendicino et al., forthcoming).

and under fair-value capital requirements:

$$\gamma L_{kt} \leq \bar{B}_t, \tag{28}$$

while under amortized-cost requirements:

$$\gamma L_{kt} \leq B_t^{AC}. \tag{29}$$

The optimal deposit rate R_{Dt} is independent of all other choices, and is given by:

$$R_{Dkt} = \frac{\epsilon_D}{\epsilon_D - 1} R_t. \tag{30}$$

Hence, all banks offer the same deposit rate in every period. This implies $R_{Dt} = R_{Dkt}$, as well as $D_t = D_{kt}$. Since $\epsilon_D < -1$, the sensitivity of the deposit rate to the policy rate, $\frac{\epsilon_D}{\epsilon_D - 1}$ is below one, as in Drechsler et al. (2023). Hence, as in their model, the deposit rate is a fraction of the short-term rate R_t, such that the deposit spread is increasing with R_t.

Further, the problem implies the following arbitrage condition for the two bond types:

$$\mathbb{E}_t \frac{\Lambda_{t,t+1}^B}{\Pi_{t+1}} \left[\frac{\frac{1}{m} + \left(1 - \frac{1}{m}\right) \Pi_{t+1} Q_{t+1}^S}{Q_t^S} - R_t \right] (1 - F_{kt+1}(\bar{\omega}_{bkt+1})). \tag{31}$$

Furthermore, it can be proven that for any deposit rate (including the optimal deposit rate), the objective function is convex in the loan volume L_{kt} (but not necessarily strictly convex). Banks are indifferent between any $L_{kt} \in [0, \bar{L}_t]$ (where $\bar{L}_t = \frac{\bar{B}_t}{\gamma}$ under fair-value capital requirements or $\bar{L}_t = \frac{B_t^{AC}}{\gamma}$ under amortized-cost capital requirements) if two conditions are simultaneously satisfied: if (i) a bank makes profits on non-lending activities that are so high that the bank never fails for any feasible loan volume $L < \bar{L}_t$, and (ii) the loan rate fulfills:

$$\mathbb{E}_t \frac{\Lambda_{t,t+1}^B}{\Pi_{t+1}} \left[c_R + \int_{\bar{\omega}_{bkt+1}}^{\infty} \left[\tilde{R}_{Lt+1}(\omega) - R_t(1-\gamma) \right] dF_{kt+1}(\omega) \right] = 0. \tag{32}$$

Otherwise, there is a corner solution and either $L_{kt}^* = 0$ or the bank chooses the maximum loan volume it ca extend without violating the capital requirement, i.e. $L_{kt}^* = \frac{\bar{B}_t}{\gamma}$ under fair-value based capital requirements, and $L_{kt}^* = \frac{B_t^{AC}}{\gamma}$ under amortized-cost based requirements. Which corner is optimal for the bank depends on the loan rate R_{Lkt}, which the bank takes as given. The proof can be found in the Appendix.

In summary, banks strictly prefer extending loans if the expected ex-post return is such that:

$$\mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \int_{\bar{\omega}_{bkt+1}}^{\infty} \left[\tilde{R}_{Lkt+1}(\omega) - R_t(1-\gamma))\bar{L}_t + (R_t - R_{Dt})D_t + (R^S_{t+1} - R_t)Q^S_t S^L_{kt} - c_f \right] dF_{kt+1}(\omega)$$
$$> \mathbb{E}_t \Lambda^B_{t,t+1} \left[(R^S_{t+1} - R_t)Q^S_t S^L_{kt} + (R_t - R_{Dt})D_t - c_f + R_t \bar{B}_t - c_R \bar{L}_t \right]. \tag{33}$$

This condition is verified numerically under the calibration explained in the next section. The role of the non-pecuniary benefit c_R is to make sure that under that calibration banks don't switch between extending zero loans and operating at maximum lending capacity, a pattern not observed in the data.[15]

Assuming this is the case, all banks choose identical loan volumes, as they receive the same level of equity from bankers. The k index is therefore dropped in continuation.
In summary, bank payoffs at time t are a function of the maximum loan volume $\bar{L}_{t-1}$ the bank can extend at time $t-1$ to comply with capital requirements, and are given by:

$$\Omega^B_t(\bar{L}_{t-1}) =$$
$$\int_{\bar{\omega}_{bt}}^{\infty} \left[(\tilde{R}_{Lkt}(\omega) - R_{t-1}(1-\gamma))\bar{L}_{t-1} - (R_{Dt-1} - R_{t-1})D_{t-1} + (R^S_{t+1} - R_t)Q^S_t S^L_t - c_f \right] dF_{kt}(\omega). \tag{34}$$

Deposit insurance agency. The DIA supervises the liquidation process of failed-bank assets, which is subject to proportional repossession costs δ_B.[16] It imposes a nominal lump-sum tax T_{t+1} on bankers to (ex-post) balance its budget period-by-period. The total nominal lump sum tax T_{t+1} is

$$\frac{T_{t+1}}{P_t} = \left[R_{Dt}D_t + c_f - R^S_{t+1}Q^S_t S^L_t - R_t S_t \right] F_{kt+1}(\bar{\omega}_{kt+1})$$
$$- (1-\delta_B) \left[\int_0^{\bar{\omega}_{bt+1}} \tilde{R}_{Lt+1}(\omega) L_t \, dF_{kt+1}(\omega) \right]. \tag{35}$$

[15]If c_R were set to zero, equity would need to be made artificially scarce for (33) to hold in every period, implying counterfactually large loan spreads.

[16]The model follows Bernanke et al. (1999) in adopting a "costly state verification" setup, by which the DIA must incur a cost that is proportional to the assets of the bank in order to observe the realization of the idiosyncratic shocks.

2.4 Contracting Problem Between Firms & Banks

Entrepreneurial firms enter a contract with the bank on their island k that specifies the loan rate and the leverage of entrepreneurs (or equivalently: the loan rate, the loan volume and the total amount of capital bought). Bankers are indifferent between any combination of loan rates and leverage on their iso-profit (in expectation) curve:

$$\bar{\Omega}_t^b = \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \int_{\bar{\omega}_{bt+1}}^{\infty} \left[\tilde{R}_{Lt+1}(\omega) - R_t(1-\gamma))L_t + (R_t - R_{Dt})D_t + (R^S_{t+1} - R_t)Q^S_t S^L_{kt} \right] dF_{kt+1}(\omega). \quad (36)$$

Entrepreneurial firm jk active from time t to $t+1$ maximizes its properly discounted value for entrepreneurs $\mathbb{E}_t(\Lambda^E_{t,t+1}\Omega^{Firm}_{jkt+1})$, by choosing a point on the bank's isoprofit curve.[17] From the perspective of the firms, the total loan volume L_t intermediated by each bank is exogenous (and given by either $\frac{\bar{B}_t}{\gamma}$ or $\frac{B^{AC}_t}{\gamma}$ depending on the type of capital requirements). As in Mendicino et al. (forthcoming), firms also take the bank's default cutoff as given. Using Eq. (5), in equilibrium it must be that $s_t\bar{B}_t = \bar{\Omega}^b_t$. The contracting problem between the entrepreneurial firm and the bank on island k is then given by:

$$\max_{K_{jkt}, L_{jkt}, R_{Ljkt}} \mathbb{E}_t \Lambda^E_{t,t+1}\Omega^{Firm}_{jkt+1} \quad (37)$$

subject to Eq. (7), Eq. (5).

The FOCs are presented in Appendix A.7.

2.5 Fiscal Policy

As discussed above, there are two types of government bonds in this model: one-period bonds and long bonds. Both are assumed to be in fixed real supply: for the one-period bonds we assume a zero net-supply, while for the long bonds we assume a positive real supply S^L, a parameter to be calibrated. To introduce a demand side shock, we also assume the fiscal authority engages in government spending G_t, governed by the following AR(1) process:

$$log(G_t) = (1-\rho_g)log(G) + \rho_g log(G_{t-1}) + \sigma_g \epsilon_{Gt},\ \epsilon_{Gt} \sim N(0,1). \quad (38)$$

[17] There is no reason for entrepreneurial firms to make bankers better off than necessary for them to participate, therefore the contract they offer lies on the bank's isoprofit curve.

We assume that the government balances its budget in every period by charging households a lump-sum tax.

2.6 Monetary Policy

We assume that there is a central bank which sets the nominal gross interest rate R_t according to the following Taylor rule:

$$R_t = R^{1-\phi_R} R_{t-1}^{\phi_R} \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\phi_\pi(1-\phi_R)} \left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_Y(1-\phi_R)} \tau_t, \tag{39}$$

where R is the long-term target monetary policy rate, and $\bar{\Pi}$ is steady state inflation. ϕ_R is a smoothing parameter, while ϕ_Y and ϕ_π govern how strongly the central bank reacts to deviations from GDP and inflation, respectively. τ_t is a monetary policy shock evolving according to

$$log(\tau_t) = \rho_\tau log(\tau_{t-1}) + \sigma_\tau \epsilon_{\tau t}, \quad \epsilon_{\tau t} \sim N(0,1). \tag{40}$$

2.7 Production

The description of the production side of the economy follows a standard New Keynesian formulation and its full description is relegated to Appendix A.3. Here, it shall suffice to state a few elements. The aggregate production function is

$$Y_t = \theta_t K_{t-1}^{\alpha} H_t^{1-\alpha}, \text{ with } \alpha \in [0,1], \tag{41}$$

where aggregate productivity θ_t is stochastic and follows an AR(1) process:

$$log(\theta_t) = \rho_\theta log(\theta_{t-1}) + \sigma_\theta \epsilon_{\theta t}, \quad \epsilon_{\theta t} \sim N(0,1). \tag{42}$$

The New Keynesian Phillips Curve of the model, arising from the problem of a unit continuum of final good producers facing a stochastic elasticity of substitution between final goods μ_t, as well as Rotemberg (1982) price adjustment costs is

$$\theta_R \left(\frac{\Pi_t}{\bar{\Pi}} - 1\right) \frac{\Pi_t}{\bar{\Pi}} = \mathbb{E}_t \Lambda_{t,t+1} \theta_R \left(\frac{\Pi_{t+1}}{\bar{\Pi}} - 1\right) \frac{\Pi_{t+1}}{\bar{\Pi}} \frac{Y_{t+1}}{Y_t} + mc_t \mu_t + (1-\mu_t), \tag{43}$$

where μ_t is a stochastic mark-up variable that also follows an AR(1) process:

$$log(\mu_t) = (1-\rho_\mu)log(\mu) + \rho_\mu log(\mu_{t-1}) + \sigma_\mu \epsilon_{\mu t}, \quad \epsilon_{\mu t} \sim N(0,1). \tag{44}$$

Physical capital is produced by combining the final good with undepreciated capital, subject to an adjustment cost of $\mathcal{C}\left(\frac{I_t}{K_{t-1}}\right)$ as in Jermann (1998).[18] The aggregate capital stock evolves according to:

$$K_t = I_t + (1-\delta)K_{t-1} + \mathcal{C}(\frac{I_t}{K_{t-1}})K_{t-1}. \tag{45}$$

2.8 Capital Management Firms

There is a unit continuum of competitive capital management firms. They charge households a fee ς_t per unit of capital, and face costs of $\frac{\kappa_H}{2}(K_t^H)^2$. Their maximization problem is:

$$\max_{K_t^H} \varsigma_t K_t^H - \frac{\kappa_H}{2}(K_t^H)^2. \tag{46}$$

3 Solution, estimation, and model validation

This section outlines the computational method used to obtain the numerical solution of the model, discusses the calibration strategy, and explores the quantitative properties of the model.

3.1 Solution method

The model is solved around the zero inflation steady state ($\bar{\Pi} = 1$), keeping in line with much of the New Keynesian literature (see Galí, 2015). We employ third-order perturbation methods to obtain an approximation of the policy functions around the deterministic steady state.[19] The integrals involving the realized ex-post returns on bank loans (as well their derivatives) cannot be written as an explicit function of the state variables, which introduces

[18] The functional form is $\mathcal{C}\left(\frac{I_t}{K_{t-1}}\right) = \frac{a_{k,1}}{1-\frac{1}{\kappa}}\left(\frac{I_t}{K_{t-1}}\right)^{1-\frac{1}{\kappa}} + a_{k,2}$. While κ is estimated, $a_{k,1}$ and $a_{k,2}$ are set such that in steady state $I = \delta K$ and $\mathcal{C}(\delta) = 1$.

[19] See Christiano et al. (2014), Born and Pfeifer (2014), and Mendicino et al. (forthcoming) for discussions on the necessity of third-order approximations to appropriately capture the effects of volatility shocks, such as those affecting the cumulative distribution functions of the firm-idiosyncratic and island-specific shocks.

a complication. We follow Mendicino et al. (forthcoming) in overcoming this challenge by approximating the integrals by a sum of third-order Taylor approximations. More details are provided in Appendix A.7.

3.2 Model estimation

The model is calibrated to quarterly Euro Area data from 1995 Q1 to 2016 Q4. Following standard practices, the calibration of the model proceeds in two steps.[20]

First step. The coefficient of relative risk aversion σ is set to 1, which implies log-utility, the Frisch elasticity of labor supply φ_H to 1, the capital-share parameter of the intermediate goods production function α to 0.25, and the value of capital depreciation δ to 0.025. The elasticity of substitution parameters for differentiated labor services ϵ_W and final goods μ are set to 5 and 7.25, respectively, resulting in a wage markup of 20% (Smets and Wouters, 2003), and a markup of 16% in the goods market which is consistent with Euro Area estimates reported in Christopoulou and Vermeulen (2012). The scaling parameter ξ_N associated with labor dis-utility is set to normalize a steady-state labor supply of $H = 1$. Following Stähler and Thomas (2012), the steady state government spending G is set to 22.56% of GDP. The capital management cost κ_H is set to 0.0014. It targets the share of physical capital intermediated by households of 22% in the EA data (Mendicino et al., 2020). Following Born and Pfeifer (2014), we estimate the government spending shocks externally by OLS on Equation (38) (in logs).

The maturity of long-term bonds m is set to 13.6, which implies an average maturity of bank bond holdings of 3.4 years (Hoffmann, Langfield, Pierobon, and Vuillemey, 2019). The value of bankruptcy parameters δ_B and δ_M are both set equal to 0.30, in line with empirical studies (e.g. Alderson and Betker, 1995; Djankov, Hart, McLiesh, and Shleifer, 2008; Granja, Matvos, and Seru, 2017). We set both θ_B and θ_E to 0.975, implying that bankers and entrepreneurs remain active for ten years on average. Finally, the minimum capital requirement γ is set to 0.08, consistent with the general requirement under Basel II.

[20]See Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramirez, and Uribe (2011) and Born and Pfeifer (2014) for examples of DSGE models estimated in a two-step procedure using the Simulated Method of Moments.

Second step. The remaining parameters are estimated using the Simulated Method of Moments (SMM).[21,22] We obtain the model implied moments by simulating our baseline economy, under which banks' regulatory capital is defined on the basis of the amortized-cost of their bonds portfolio. Our estimation targets include a number of macroeconomic, financial, and banking moments. We target the standard deviations and first two auto-correlations of GDP, consumption, investment, inflation, wages, the policy rate and labor hours, as well as their correlation with GDP. Following Born and Pfeifer (2014), we allow for measurement error in wages. [23] We also target a range of moments related to financial markets. These are the mean and standard deviation of the conditional expectation of firm and bank default rates and the unconditional correlation between the two default probabilities, the mean and standard deviation of the loan rate spread, the average deposit rate spread, the average central bank policy rate, the average aggregate loan to GDP ratio, the share of physical capital owned by households, and the average ratio of loans to bonds on bank's balance sheets. Finally, we target the size of GDP contractions after a large decrease in bank equity: Baron, Verner, and Xiong (2021) report an average 4% equity decline within a year after a 30% drop in bank equity.

Tables 1 and 2 provide the values of moments targeted in the data, and compare them to their model generated counterparts. Parameters value are reported in the Appendix (Table 5). We obtain data on GDP, consumption, investment, government spending, total wages, hours worked, the GDP deflator and population from the OECD Quarterly National Accounts. Data on financial corporation loan volumes and loan rates, riskless interest rates, and household deposits are obtained from the ECB Statistical Data Warehouse.[24] All series are adjusted for seasonality and those series that exhibit trends are detrended using the Hodrick-Prescott filter.[25] The moments for the mean and standard deviation of firm and bank defaults, the correlation between firm and bank defaults, and the mean and standard deviation of the rate of return on bank equity are taken from Mendicino et al. (forthcom-

[21]The set of estimated parameters is $\beta, \xi_B, \xi_E, \sigma_{\omega_k}, \rho_{\omega_k}, \rho_{\omega_j}, \sigma_{\omega_j}, \bar{\sigma}_{\omega_k}, \bar{\sigma}_{\omega_j}, \sigma_\theta, \rho_\theta, \sigma_\tau, \rho_\tau, \sigma_\mu, \rho_\mu, b, \theta_R, \theta_W$, $\kappa, \phi_R, \phi_\Pi, \phi_Y, S, \sigma_{mw}$, where σ_{mw} is the standard deviation of wage measurement error.

[22]The good properties of SMM for estimation of non-linear DSGE models have been established in Ruge-Murcia (2012).

[23]See Justiniano, Primiceri, and Tambalotti (2013) for evidence advocating this.

[24]The loan volume and deposit volume series include all available maturities. The loan spread is constructed as a volume weighted average over maturities, where the riskless rate is taken as the short term rate published by the ECB for maturities less than 1 year, the 2-year yield on triple A Euro Area government bonds (published by the ECB) for maturities between 1 and 5 years, and the corresponding 5-year yield for maturities over 5 years.

[25]Following Ravn and Uhlig (2002), we set the HP parameter to 1600. For those series that are not directly available with seasonal adjustment, such as deposits, seasonal adjustment is done using X13-ARIMA using the R package seasonal.

Table 1
Calibration targets and model fit (macroeconomic)

	$\sigma_{x_t}/\sigma_{\Delta^{HP}y_t}$ (Y: $\sigma_{\Delta^{HP}y_t}$)		$\rho(x_t, \Delta^{HP}y_t)$	
	Data	Model	Data	Model
$\Delta^{HP}Y$	1.1863	1.4518	1	1
$\Delta^{HP}C$	0.74583	0.77006	0.91477	0.67242
$\Delta^{HP}I$	2.594	2.835	0.92967	0.69279
Π	0.22932	0.49302	0.32624	0.29579
$\Delta^{HP}w$	0.47752	0.54799	-0.16383	-0.31783
R	0.30794	0.39885	0.48931	0.44924
H	1.8275	3.3319	0.21735	0.60476
	$\rho(x_t, x_{t-1})$		$\rho(x_t, x_{t-2})$	
$\Delta^{HP}Y$	0.90536	0.82923	0.70487	0.63722
$\Delta^{HP}C$	0.88846	0.92796	0.7018	0.77752
$\Delta^{HP}I$	0.87191	0.95585	0.75353	0.85149
Π	0.43746	0.69024	0.37162	0.5155
$\Delta^{HP}w$	0.86828	0.846	0.78703	0.60734
R	0.97055	0.83076	0.92207	0.65966
H	0.91493	0.96879	0.83698	0.92657

Notes: All series are seasonally adjusted and all variables except Π and R are in logs. Δ^{HP} indicates the Hodrick-Prescott filter with HP parameter 1600. Data sources and variable definitions are described in Appendix B.

ing).[26] Appendix B contains further details on the data sources and construction, and the calibration strategy.

The model fits the data well, especially for key financial variables. It struggles to match the relative volatility of hours worked, which is not surprising given that the model contains no labor market frictions.

3.3 Model validation

In this section, we validate the performance of our model by assessing it against the empirical literature on loan pricing implications of realized and unrealized bank losses.

In a recent study, Volk (2024) finds that "banks with 1 pp higher share of unrealized

[26]The moments are for the Euro Area and almost the same time period: Mendicino et al. (forthcoming) use data from 1992Q1:2016Q4

Table 2
Calibration targets and model fit (financial)

Moment	Description	Data	Model
$100\mathbb{E}_t\left(\int_0^\infty F_{jt+1}(\bar{\omega}_{jt+1}(\omega_k))d\omega_k\right)$	Mean Firm Default	0.66173	0.7464
$100\mathbb{E}F_{kt+1}(\bar{\omega}_{kt+1})$	Mean Bank Default	0.16615	0.20922
$\rho(\int_0^\infty F_{jt+1}(\bar{\omega}_{jt+1}(\omega_k))d\omega_k, F_{kt+1}(\bar{\omega}_k))$	Corr(Firm D., Bank D.)	0.6421	0.60191
$100\sigma\left(\int_0^\infty F_{jt+1}(\bar{\omega}_{jt+1}(\omega_k))d\omega_k\right)$	Std Firm Def.	0.54945	0.3623
$100\sigma\left(F_{kt+1}(\bar{\omega}_{kt+1})\right)$	Std Bank Def.	0.4219	0.46664
$100\sigma_{\rho_t^B}$	Std ROE Banks	2.0636	3.2557
$100(\mathbb{E}\rho_t^B - 1)$	Mean ROE Banks	1.6038	2.6433
$\mathbb{E}\frac{L_t}{Y_t}$	Mean L/Y	2.3474	2.4099
$100\mathbb{E}(R_{Lt} - R_t)$	Mean Loan spread	0.54866	0.16715
$\sigma_{(R_{Lt}-R_t)}/\sigma_{\Delta^{HP}Y_t}$	Sd Loan spread	0.13665	0.10071
$\mathbb{E}R_t$	Mean Policy Rate	1.0043	1.0045
$\mathbb{E}(L_t/S_t^L)$	Loan-to-Bond Ratio	3.6	3.6169
$\mathbb{E}(K_{Ht}/K_t)$	HH Capital Share	0.22	0.23222
$\mathbb{E}(R_t - R_{Dt}) * 400$	Deposit Spread	1	1.002
$\mathbb{E}\frac{\Delta_4 log(Y_{t+4})}{\Delta_4 log(EQ_t)} \mid p_1(\Delta_4 log(EQ_t))$	GDP Loss From Large Equity Loss	-0.13333	-0.14815

Notes: All series are seasonally adjusted. Δ^{HP} indicates the Hodrick-Prescott filter with HP parameter 1600. $\Delta_4 x_t$ indicates the fourth difference (that is, one-year difference) $x_t - x_{t-4}$, and $p_1(x)$ indicates that x is below it's first percentile. Data sources and variable definitions are described in Appendix B.

losses in their risk-weighted assets charge on average 8 bps higher corporate lending rate in Slovenia. These unrealized losses have a lower impact compared to actual changes in capital, for which the literature establishes the impact of around 10-25 bps." We simulate our baseline model economy, i.e. the model in which banks are subject to amortized cost requirements, for 100,000 periods and define banks' unrealized losses as the percentage difference between amortized-cost value equity and fair value equity:

$$Unrealized_t = 100\frac{B_t^{AC} - B_t}{mean(B^{AC})}. \tag{47}$$

The actually realized losses in capital are defined as:

$$Realized_t = 100\frac{B_t^{AC} - mean(B^{AC})}{mean(B^{AC})} \tag{48}$$

We then investigate the loan pricing implications of realized and unrealized bank losses using

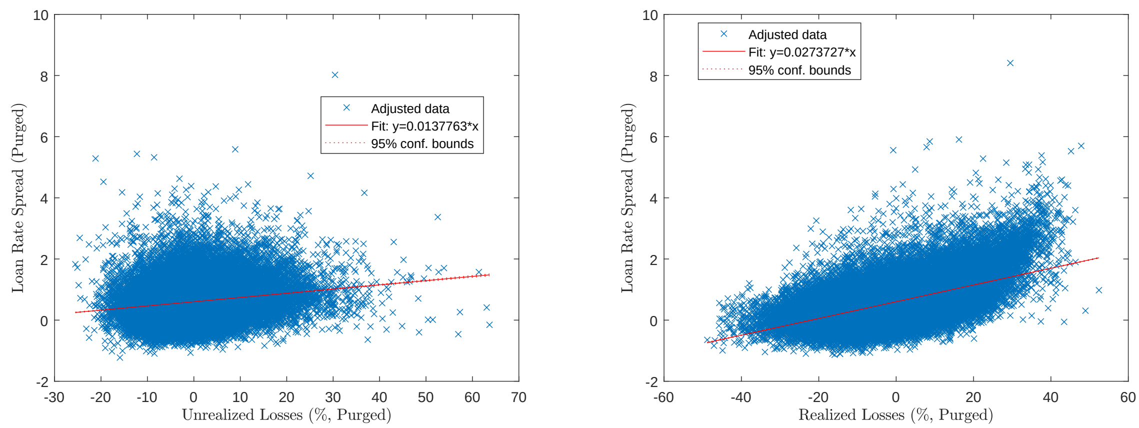


Figure 1. Loan pricing effects: realized vs. unrealized losses

Notes: The figure presents coefficients from the linear regression in Equation (49). Both equations are estimated on simulated data from the baseline model.

linear regressions of the following form:

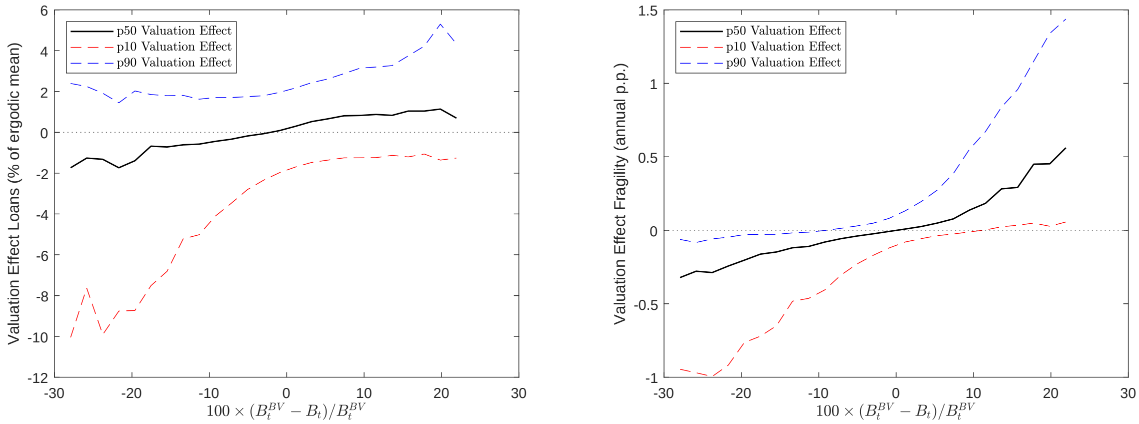
$$spread_t = \beta_0 + \beta_1 Unrealized_t + \beta_2 Realized_t, \tag{49}$$

where the dependent variable is the *spread* between the loan rate and the policy rate (defined in annual percentage points, i.e., $spread_t = 400(R_t^L - R_t)$.

The results are depicted in Figure 1. In line with the literature, we find that unrealized losses on banks' balance sheet have a significant positive impact on loan pricing ($\beta_1 \approx 0.0137$, corresponding to an approximately 5.5 bps increase in the annualized loan rate), and that this response is weaker than the one associated with actual changes in bank capital ($\beta_2 \approx 0.0273$, corresponding to an approximately 11 bps increase in the annualized loan rate).

4 The effects of capital requirements

In this section, we analyze the performance of the economy under alternative regulatory accounting frameworks, identifying the approach that maximizes social welfare. Throughout the analysis, we compare endogenous responses in the baseline economy, with an economy in which banks' regulatory capital is defined on the basis of the fair value of the bonds, using an identical sequence of exogenous shocks.



(a) Loans **(b) Fragility**

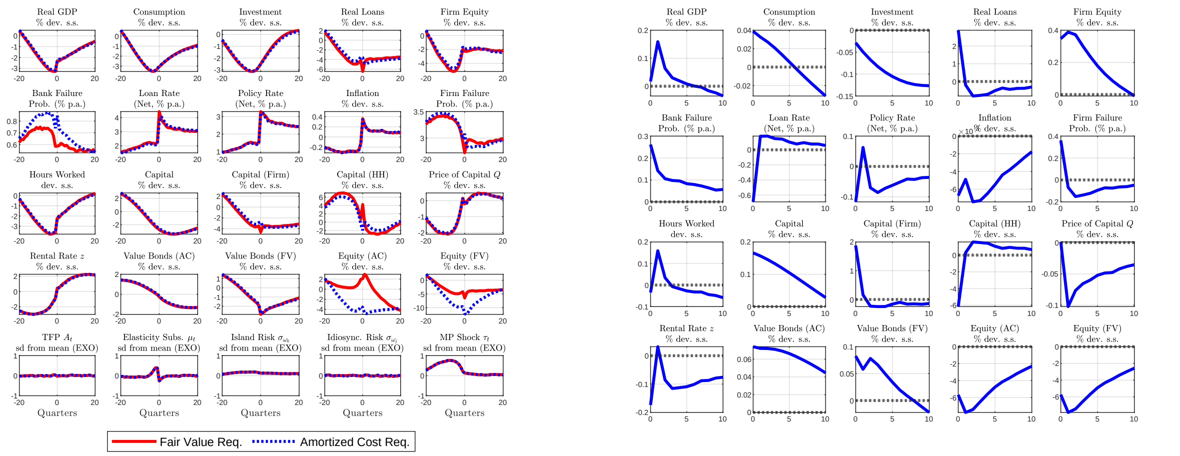
Figure 2. Valuation Effects

Notes: The left panel of this figure shows the Valuation Effect on Loans, defined as the difference in bank loans between the baseline economy (amortized-cost regime) and the alternate economy (fair-value regime) for different levels of unrealized losses or gains. The difference in bank loans is reported as a percentage of the ergodic mean of loans under the amortized-cost regime. The right panel of this figure shows the Valuation Effect on Fragility, defined as the difference in the annualized bank default probability between the baseline economy (amortized-cost regime) and the alternate economy (fair-value regime) for different levels of unrealized losses or gains. The p50, p10 and p90 Valuation Effects are defined as, respectively, the 50th, 10th and 90th percentile of the relevant differences conditional on the level of unrealized losses or gains.

4.1 Credit supply and fragility

We first assess the effects that prudential treatment of unrealized gains and losses has on credit supply and bank default probabilities. To do so, we perform the following exercise. Simulating the baseline economy for 100,000 periods, we compute loan quantity and bank failure probability for different levels of unrealized losses or gains on banks' balance sheet (defined as $(B_t^{AC} - B_t)/B_t^{AC}$). Then, we simulate an alternate economy in which regulatory capital is defined on the basis of the fair value of bonds, where we compute the same variables for different *hypothetical* levels of unrealized losses or gains (i.e., we compute the losses or gains that a bank would have accumulated on its balance sheet, were it subject to the amortized-cost approach).

The left panel of Figure 2 depicts the Valuation Effect on Loans as the difference in bank loans between the baseline economy (amortized-cost regime) and the alternate economy (fair-value regime) for different levels of unrealized losses or gains. The difference in bank loans is reported as a percentage of the ergodic mean of loans under the amortized-cost regime.



(a) Levels **(b) Differences (Amortized Cost - Fair Value)**

Figure 3. Anatomy: Episodes with large accumulated unrealized losses

Notes: Time 0 denotes the start of a spell in which banks' balance sheet contain large accumulated unrealized losses, such that $AL_{-1} < p_{90}(AL)$ and $AL_0 \geq p_{90}(AL)$, where $AL_t \equiv B_t^{AC} - B_t$. Exogenous variables are labeled as EXO.

The right panel of Figure 2 depicts the Valuation Effect on Fragility as the difference in the annualized bank default probability between the baseline economy (amortized-cost regime) and the alternate economy (fair-value regime) for different levels of unrealized losses or gains. These figures show that both the valuation effects are increasing: when unrealized losses in banks' portfolio accumulate over time, their default probabilities are higher in the amortized-cost regime. At the same time, banks extend more loans in this situation as they are relatively less constrained by the capital requirement prevailing in the amortized-cost regime. Considering that the average annual bank failure probability is 0.66%, the results are economically significant, with a median valuation effect on fragility of about 0.2 p.p. for accumulated unrealized losses amounting to 10% of regulatory equity.

4.2 Anatomy: Episodes with large accumulated unrealized losses

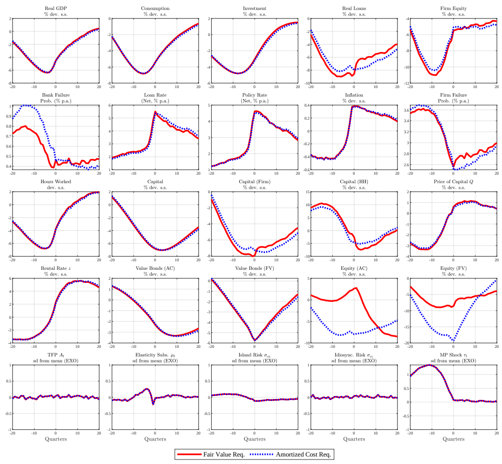
To understand the results, we plot the simulated time series around episodes in which banks' balance sheet contain large accumulated unrealized losses. The criteria for these episodes is that $AL_t \equiv B_t^{AC} - B_t$ exceeds its 90th percentile ($p_{90}(AL)$). Let $t = 0$ be the first period of such an episode: $AL_{-1} < p_{90}(AL)$ and $AL_0 \geq p_{90}(AL)$. It is crucial to note that we use an identical sequence of exogenous shocks across the simulations in both regulatory regimes (as well as identical to those used in all previous exercises). Nevertheless, macroeconomic conditions *endogenously* differ in the two regimes — *exclusively* due to the difference in regulatory treatment of unrealized gains and losses on banks' bonds portfolio.

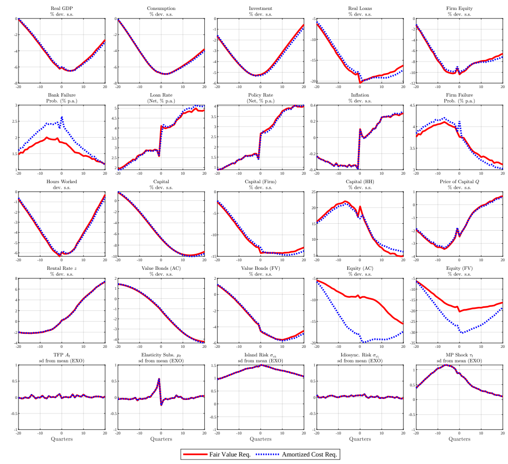
Figure 3 shows the average path leading to large accumulated unrealized losses. The figure depicts both endogenous and exogenous variables (labeled EXO). Periods with large accumulated unrealized losses occur after a series of negative TFP shocks and positive monetary policy shocks. This leads to a gradual hike in the policy rate, reminiscent of the monetary policy conducted both in the US and Europe starting in fall 2022. In consequence, the market value of bonds drops, leading to a large fall in the fair value of bank equity, and in line with the evidence around 2022-2023 from Marsh and Laliberte (2023). What then happens depends on the regulatory accounting framework. Under amortized-cost regime, banks are able to maintain a higher loan supply compared to fair-value regime. However, since the solvency of banks depends on the fair value of their assets, this is associated with a gradual increase in their default probability during the policy rate tightening. In contrast to this, banks under fair-value regime have to restrict lending proportionally to the decrease in the fair value of their equity. At the peak of the monetary policy tightening phase, loan rates are 60 basis points higher compared to the amortized-cost regime. This in fact leads to lower bank failure probabilities during the policy rate tightening, which reverts when the policy rate hits its peak. During the subsequent transition back to the steady state, the bank failure probability under both fair-value and amortized-cost regimes is almost identical, but loan supply is now lower under the latter regime. This is because the amortized-cost value of equity is far more sluggish than the fair value of equity.

4.3 The role of credit risk

The valuation effects plotted in Figure 2 suggest that there are several paths the economy can take over the monetary policy cycles. For instance, the median valuation effect on fragility for 20% accumulated unrealized losses is below 0.5 percentage points, while the 90th percentile effect for the same level of accumulated losses is close to 1.5 percentage points.

To understand these differences, we plot the simulated time series around episodes in which banks' balance sheet contain large accumulated unrealized losses, conditioning on the distribution of the valuation effects. The left (right) panel of Figure 4 shows the evolution of the economy in a window during which the valuation effect on fragility is in its first (fourth) quartile. These figures show that the underlying non-linearities in the valuation effects of fragility (for a given level of unrealized losses) are largely driven by the realization of island-





(a) Valuation effect on fragility in Q1 **(b) Valuation effect on fragility in Q4**

Figure 4. Anatomy: The role of credit risk

Notes: Time 0 denotes the start of a spell in which banks' balance sheet contain large accumulated unrealized losses, such that the fair value of equity is between 10 and 30% below the amortized cost value. Exogenous variables are labeled as EXO.

risk shocks. When island-risk is high (i.e., the island-specific shock, which banks cannot diversify away, has a high variance) banks have a significantly higher default probability than when island risk is low, independent of the accounting regime. In the context of this increased bank riskiness, the increase in the bank default probability due to the effectively higher leverage allowed by book-value requirements in the presence of unrealized losses in the representative bank's bond portfolio is particularly large.

4.4 Welfare-maximizing regulatory accounting approach

We now turn to identifying the regulatory accounting approach that maximizes social welfare in our model. We assess both whether regulatory capital should be defined on the basis of the amortized-cost or fair value of equity, and how high the capital requirements should be. We find that regulatory capital defined on the basis of the fair-value of the bonds is overall superior in terms of welfare to defining it on the basis of their amortized-cost.

Table 3 reports means and standard deviations of important financial and real economy variables by accounting regime. Additionally, Figure 5 shows how selected variables change with the level of the capital requirement in each of the regimes.

Table 3
Summary Statistics by Accounting Regime

Variable	Mean		SD	
	FV	AC	FV	AC
Loans (L)	4.117	4.1188	0.5135	0.5128
Bank Defaults p.a. ($400 \times F_{kt}(\bar{\omega}_{bt})$)	0.5198	0.5339	0.934	0.9859
Firm Defaults p.a ($400 \times \int_0^\infty F_{jt}(\bar{\omega}_{jt}(\omega_k))dF_{kt}$)	3.001	3.0071	1.0448	1.0563
Consumption (C)	1.0789	1.0787	0.0534	0.0535
Total Production (Y)	1.7277	1.7281	0.0859	0.0864
Inflation (Π)	0.9971	0.9971	0.0061	0.0062
Wage Inflation (Π_W)	0.9971	0.9971	0.0044	0.0044

On average, banks supply slightly lower loan volumes at slightly lower spreads under fair value requirements. The default probability of both banks and firms is slightly lower under fair-value requirements. In the case of firms, this is since lower aggregate lending translates into lower leverage. This effect is reinforced by the feedback loop between lower lower loan rates and lower firm default probabilities. Lower firm default probabilities then contribute to lower bank default probabilities. In combination, this implies that a lower part of aggregate output has to be used to cover the deadweight loss of defaults and in consequence a higher part is available for consumption. This explains why average consumption is higher under fair value requirements, despite the slightly lower average aggregate physical capital under that accounting regime. On average higher consumption (and slightly lower volatility) translates into welfare gains from fair-value accounting.[27] Our results thus lend support to the Basel III proposal of recognizing unrealized gains and losses in regulatory capital (i.e., removing prudential filters).

The differences in utility between both accounting regimes are moderate in magnitude. For an 8% capital charge, the gains from amortized-cost measure of regulatory capital are approximately 2.7 bps. Regarding the size of capital requirements, we find an optimal value of 13% – well above the Basel II capital charge, but below the 16% found in Mendicino et al. (forthcoming). Optimal (fair-value) capital requirements of 13% would be associated with an approximately 15 bps increase in consumption equivalent utility terms.

[27] In a New Keynesian setup without deadweight losses from default, Benigno and Woodford (2003) show that welfare is a function of the mean and variance of output (Y), price and wage inflation (Π, Π_W). In our model, there is an additional wedge between consumption and output stemming from default deadweight losses. Differences in the mean and standard deviation of price and wage inflation inflation are negligible in our results.

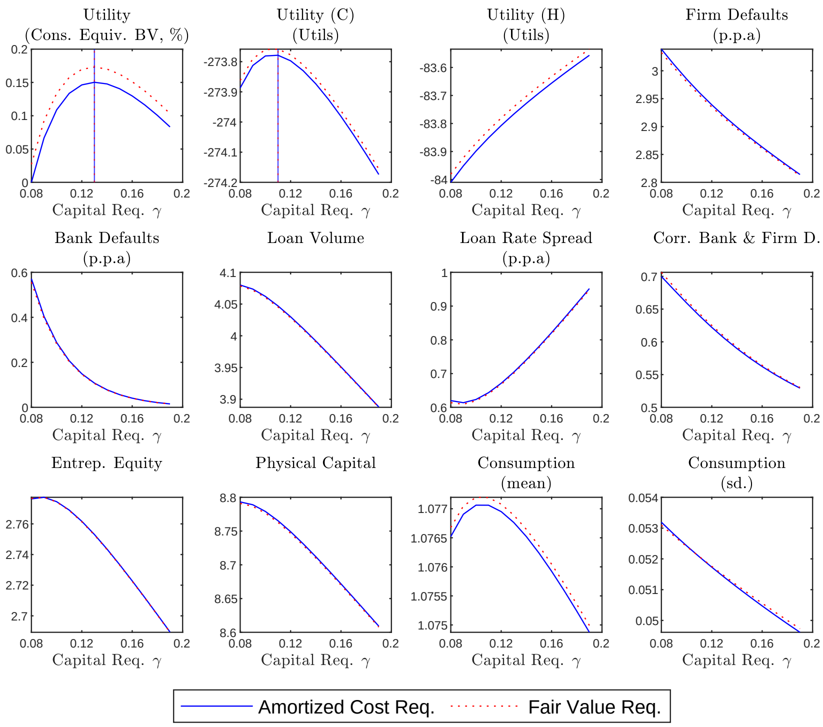


Figure 5. Optimal capital requirements

Notes: Utility is household utility, which is the relevant welfare benchmark as all banks and firms are owned by household. Utility (C) and Utility (H) are the parts attributed to consumption and labor, respectively. The benchmark for computing consumption equivalents is the baseline model with a capital requirement of 8%. All parameters other than the capital requirement γ are kept fixed.

5 Conclusion

This paper examines how the regulatory capital treatment of unrealized capital gains and losses on banks' debt securities, related to the impact of interest rate risk, affects financial stability and credit supply. To this purpose, it develops a dynamic general equilibrium model in which banks are exposed to both interest rate risk and credit risk.

We find that having regulatory capital defined on the basis of the fair-value of the bonds (as proposed in Basel III) is overall slightly superior in terms of welfare to having regulatory capital defined on the basis of their amortized-cost value. Measuring at fair value makes regulatory capital more sensitive to changes in the interest rate. This translates to a greater volatility in credit. At the same time, the terms of the financial contract between banks and firms are better aligned with macro-economic conditions and bank balance sheet fundamentals. The better pricing of risk makes both banks and firms safer on average, freeing up resources otherwise spent on deadweight losses from bankruptcies. This results in an overall higher level and lower volatility of consumption under fair-value accounting.

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Appendices

A Model Details

This Appendix describes elements of the standard New Keynesian models omitted in Section 2 of the main text, and presents the details of the equilibrium.

A.1 Household Problem

Households maximize Equation (1) subject to the budget constraint Equation (2). We begin by providing details of the components of household's cash flows, summarized by Σ_t in Equation (2). Households:

- receive net payoffs $(1-\theta_B)(1-\xi_B)\rho_t^B P_{t-1}B_{t-1}$ from bankers,
- receive net payoffs $(1-\theta_E)(1-\xi_E)\rho_t^E P_{t-1}E_{t-1}$ from entrepreneurs,
- receive $(P_t - P_t^m)Y_t - \frac{\theta_R}{2}(\Pi_t - 1)^2 P_t Y_t$ from final good producers (see Section A.3),
- receive profits $P_t\Pi_t^C$ from capital producers and $P_t(\varsigma_t K_t^H - \frac{\kappa_H}{2}(K_t^H)^2)$ from capital managers (see Section A.4),
- are charged a lump sum fee $\frac{\theta_W}{2}\left(\Pi_t^W - 1\right)^2 W_t$ from a labor union that negotiates wages (explained in the next subsection),
- are charged lump sum taxes LT_t by the government.

Therefore:

$$\begin{aligned}\Sigma_t = {} & (1-\theta_B)(1-\xi_B)\rho_t^B P_{t-1}B_{t-1} + (1-\theta_E)(1-\xi_E)\rho_t^E P_{t-1}E_{t-1} + P_t(\varsigma_t K_t^H - \frac{\kappa_H}{2}(K_t^H)^2) \\ & + P_t\Pi_t^C + (P_t - P_t^m)Y_t - \frac{\theta_R}{2}(\Pi_t - 1)^2 P_t Y_t - \frac{\theta_W}{2}\left(\Pi_t^W - 1\right)^2 W_t - LT_t. \qquad (A.1)\end{aligned}$$

The multiplier on the budget constraint Equation (2) (which is expressed in nominal terms) is $\frac{\lambda_t}{P_t}$. We obtain the first order conditions for consumption, capital, deposits, and riskless one-period bonds, as follows:

$$(C_t - bC_{t-1})^{-\sigma} - \beta b \mathbb{E}_t (C_{t+1} - bC_t)^{-\sigma} = \lambda_t, \tag{A.2}$$

$$\mathbb{E}_t \Lambda_{t,t+1} \left[z_{t+1} + (1-\delta) Q_{t+1} \right] = Q_t + \varsigma_t, \tag{A.3}$$

$$\beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \frac{R_t^D}{\Pi_{t+1}} = 1, \tag{A.4}$$

$$\beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \frac{R_t}{\Pi_{t+1}} = 1. \tag{A.5}$$

As explained in the main text, the labor supply decision is relegated to a labor union, whose problem is described in continuation.

A.2 Wage Setting

Wage setting is subject to Rotemberg (1982) adjustment costs governed by parameter θ_W which the labor union finances by charging households a lump-sum fee. No costs arise from adjusting wages according to the steady-state inflation $\bar{\Pi}$.[28] The labor packer's demand for variety h is:

$$H_{ht} = \left(\frac{W_{ht}}{W_t} \right)^{-\epsilon_W} H_t. \tag{A.6}$$

The labor union maximizes household utility subject to labor demand (Equation A.6) and the household budget constraint (with multiplier λ_t / P_t):

$$\max_{H_{ht}, W_{ht}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Bigg[\lambda_t \left(\frac{W_{ht}}{P_t} H_{ht} - \frac{\theta_W}{2} \left(\frac{W_{ht}}{\bar{\Pi} W_{ht-1}} - 1 \right)^2 \frac{W_t}{P_t} \right) - \frac{\xi_H H_{ht}^{1+\varphi_H}}{1+\varphi_H} - mrs_t \left(H_{ht} - \left(\frac{W_{ht}}{W_t} \right)^{-\epsilon_W} H_t \right) \Bigg], \tag{A.7}$$

where mrs_t is the Lagrange multiplier on the constraint in Equation (A.6).

We obtain the first order conditions for hours worked and wages as follows:

$$mrs_t = \lambda_t \frac{W_{ht}}{P_t} - \xi_H H_{ht}^{\varphi_H}, \tag{A.8}$$

[28] This may be thought of as wages being fully indexed to steady-state inflation: If the union does not actively adjust nominal wages, they grow by the steady-state inflation rate.

$$\theta_W \lambda_t \left(\frac{W_{ht}}{\bar{\Pi} W_{ht-1}} - 1 \right) \frac{W_t}{P_t} \frac{1}{\bar{\Pi} W_{ht-1}} = \lambda_t \frac{H_{ht}}{P_t} - \epsilon_W mrs_t \left(\frac{W_{ht}}{W_t} \right)^{-\epsilon_W - 1} \frac{H_t}{W_t}$$
$$- \beta \mathbb{E}_t \left[\lambda_{t+1} \theta_W \left(\frac{W_{ht+1}}{\bar{\Pi} W_{ht}} - 1 \right) \frac{W_{t+1}}{P_{t+1}} \frac{W_{ht+1}}{\bar{\Pi} W_{ht}^2} \right]. \quad \text{(A.9)}$$

Since the problem is identical for each variety h, there is no price dispersion and hence $W_{ht} = W_t$. Define the nominal wage inflation as $\Pi_t^W = \frac{W_t}{W_{t-1}}$. Then, the first order conditions can be combined to obtain the New Keynesian Wage Phillips Curve:

$$\theta_W \left(\frac{\Pi_t^W}{\bar{\Pi}} - 1 \right) \frac{\Pi_t^W}{\bar{\Pi}} = \theta_W \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{\Pi_{t+1}^W}{\bar{\Pi}} - 1 \right) \frac{\left(\Pi_{t+1}^W\right)^2}{\Pi_{t+1} \bar{\Pi}} \right] + (1 - \epsilon_W) H_t + \epsilon_W \frac{\xi_H H_t^{1+\varphi_H}}{\lambda_t w_t}, \quad \text{(A.10)}$$

where

$$w_t = \frac{w_{t-1} \Pi_t^W}{\Pi_t} \quad \text{(A.11)}$$

is the law of motion of real wages.

A.3 Production

A representative competitive intermediate good producer has access to Cobb-Douglas production technology:

$$Y_t^m = \theta_t K_{t-1}^{\alpha} H_t^{1-\alpha}, \quad \text{(A.12)}$$

where $\alpha \in [0, 1]$, and θ_t is an aggregate productivity shock that evolves according to an AR(1) process:

$$log(\theta_t) = \rho_\theta log(\theta_{t-1}) + \sigma_\theta \epsilon_{\theta t}, \quad \text{(A.13)}$$

with $\epsilon_{\theta t} \sim N(0, 1)$. Denote the price of the intermediate good by P_t^m and the real price as $\frac{P_t^m}{P_t} = mc_t$. Then, the profit maximization problem yields the following FOCs:

$$mc_t \alpha \frac{Y_t^m}{K_{t-1}} = z_t \quad \text{(A.14)}$$
$$mc_t (1 - \alpha) \frac{Y_t^m}{H_t} = w_t \quad \text{(A.15)}$$

To incorporate nominal price rigidities, we model a unit continuum of monopolistic final good producers, each producing a differentiated variety i using a linear technology with the intermediate good as the only input:

$$Y_{it} = Y_t^m(i). \tag{A.16}$$

The final good composite is the CES aggregate:

$$Y_t = \left(\int_0^1 Y_{it}^{\frac{\mu_t - 1}{\mu_t}} di \right)^{\frac{\mu_t}{\mu_t - 1}}, \tag{A.17}$$

where μ_t is a stochastic elasticity of substitution that follows an AR(1) process:

$$ln(\mu_t) = (1 - \rho_\mu) ln(\mu) + \rho_\mu ln(\mu_{t-1}) + \sigma_\mu \epsilon_{\mu t}, \tag{A.18}$$

where $\epsilon_{\mu t} \sim N(0,1)$ is an exogenous markup shock. Final good producers are subject to Rotemberg adjustment costs, governed by parameter θ_R, from steady state inflation $\bar{\Pi}$. They discount the future by the household discount factor $\beta^t \lambda_t$. Their maximization problem in real terms is:

$$\max_{P_t(i)} \mathbb{E}_t \sum_{n=0}^{\infty} \beta^n \frac{\lambda_{t+n}}{\lambda_t} \left[\frac{P_{t+n}(i)}{P_{t+n}} Y_{it+n} - mc_{t+n} Y_{it+n} - \frac{\theta_R}{2} \left(\frac{P_{t+n}(i)}{\bar{\Pi} P_{t+n-1}(i)} - 1 \right)^2 Y_{t+n} \right] \tag{A.19}$$

$$\text{s.t. } Y_{it} = \left(\frac{P_t(i)}{P_t} \right)^{-\mu_t} Y_t \tag{A.20}$$

The first order condition is:

$$(1 - \mu_t) \left(\frac{P_t(i)}{P_t} \right)^{-\mu_t} \frac{Y_t}{P_t} + mc_t \mu_t \left(\frac{P_t(i)}{P_t} \right)^{-\mu_t - 1} \frac{Y_t}{P_t} - \theta_R \left(\frac{P_t(i)}{\bar{\Pi} P_{t-1}(i)} - 1 \right) \frac{Y_t}{\bar{\Pi} P_{t-1}(i)}$$
$$+ \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \theta_R \left(\frac{P_{t+1}(i)}{\bar{\Pi} P_t(i)} - 1 \right) \frac{P_{t+1}}{\bar{\Pi} P_t^2} Y_{t+1}. \overset{!}{=} 0 \tag{A.21}$$

Since all final good producers face identical marginal costs, all charge the same price. Therefore the i index can be dropped and one obtains the New Keynesian Phillips Curve:

$$\theta_R \left(\frac{\Pi_t}{\bar{\Pi}} - 1 \right) \frac{\Pi_t}{\bar{\Pi}} = \mathbb{E}_t \Lambda_{t,t+1} \theta_R \left(\frac{\Pi_{t+1}}{\bar{\Pi}} - 1 \right) \frac{\Pi_{t+1}}{\bar{\Pi}} \frac{Y_{t+1}}{Y_t} + mc_t \mu_t + (1 - \mu_t) \tag{A.22}$$

Symmetry and the fact that there is a unit continuum of final good producers and intermediate good producers also implies that $Y_{it} = Y_t = \theta_t K_{t-1}^{\alpha} H_t^{1-\alpha}$.

A.4 Capital Producers

Perfectly competitive capital producers produce new capital by purchasing the final output good and combining it with undepreciated capital from last period, according to the following law of motion:

$$K_t = K_t^E + K_t^H. \tag{A.23}$$

$$K_t = I_t + (1-\delta)K_{t-1} + \mathcal{C}(\frac{I_t}{K_{t-1}})K_{t-1}. \tag{A.24}$$

They face investment adjustment costs as in Christiano et al. (2005). Their period profits (in real terms) are:

$$\Omega_t^C = Q_t K_t - I_t - Q_t(1-\delta)K_{t-1} \tag{A.25}$$

$$= (Q_t - 1)I_t + \mathcal{C}(\frac{I_t}{K_{t-1}})K_{t-1}. \tag{A.26}$$

Since they discount the future using the household discount factor $\beta^t \lambda_t$, their maximization problem is:

$$\max_{I_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \Omega_t^C. \tag{A.27}$$

And the first order condition simplifies to:

$$Q_t = 1 + \mathcal{C}'(\frac{I_t}{K_{t-1}}). \tag{A.28}$$

A.5 Market Clearing

Good market clearing implies that:

$$Y_t = C_t + I_t + G_t + \frac{\theta_R}{2}\left(\frac{\Pi_t}{\bar{\Pi}} - 1\right)^2 Y_t + \frac{\theta_W}{2}\left(\frac{\Pi_t^W}{\bar{\Pi}} - 1\right)^2 w_t$$
$$+ \Sigma_{ft} + \Sigma_{bt} + \frac{\kappa_H}{2}(K_t^H)^2 + c_f, \tag{A.29}$$

where Σ_{ft} and Σ_{bt} are default costs of entrepreneurial firms and banks, respectively. Real repossession costs of defaulting firms are given by

$$\Sigma_{ft} = \delta_M \left[Q_t(1-\delta)K_{t-1}^E + z_t K_{t-1}^E\right] \int_0^{\infty} \int_0^{\bar{\omega}_t(\omega_k)} \omega_k \omega_j dF_{jt}(\omega_j) dF_{kt}(\omega_k), \tag{A.30}$$

while the real repossession costs of defaulting banks are given by

$$\Sigma_{bt} = \delta_B \left[\int_0^{\bar{\omega}_{bt}} \tilde{R}_{Lt}(\omega) L_{t-1} dF_{kt}(\omega) \right]. \tag{A.31}$$

A.6 Proofs

Loan Supply. It has been shown in the main text that the optimal choice for the deposit rate R^*_{Dt} is independent of L_{kt}. Using this result, it is shown below that the bank's objective is convex in the loan volume for any given level of long-maturity bonds S^L_t (including the optimal level). For any given level of S^L_t, the bank's objective can be stated as a function of the loan volume:

$$\begin{aligned} f(L_{kt}) =& \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} [c_R L_{kt} + \\ & \int_{\bar{\omega}_{bkt+1}}^{\infty} \left((\tilde{R}_{Lkt+1}(\omega) - R_t) L_{kt} - (R^*_{Dt} - R_t) D_t + (R^S_{t+1} - R_t) S^L_t + R_t \bar{B}_{kt} - c_f \right) dF_{kt+1}(\omega) \Big] \end{aligned} \tag{A.32}$$

We have:

$$f'(L_{kt}) = \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[c_R + \int_{\bar{\omega}_{bkt+1}}^{\infty} \left[\tilde{R}_{Lkt+1}(\omega) - R_t \right] dF_{kt+1}(\omega) \right] \tag{A.33}$$

and

$$f''(L_{kt}) = \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[-\frac{\partial \bar{\omega}_{bkt+1}}{\partial L_{kt}} \left[\tilde{R}_{Lkt+1}(\bar{\omega}_{bkt+1}) - R_t \right] f_{kt+1}(\bar{\omega}_{bkt+1}) \right] \tag{A.34}$$

where by definition of the default threshold ω_b and the implicit function theorem:

$$\frac{\partial \bar{\omega}_{bkt+1}}{\partial L_{kt}} = -\frac{\tilde{R}_L(\bar{\omega}_{bkt+1}) - R_t}{\frac{\partial \tilde{R}_L(\bar{\omega}_{bkt+1})}{\partial \bar{\omega}_{bkt+1}} L_{kt}} \tag{A.35}$$

And by definition of the ex-post return on loans:

$$\frac{\partial \tilde{R}_L(\bar{\omega}_{bkt+1})}{\partial \bar{\omega}_{bkt+1}} = -\frac{\partial \bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})}{\partial \bar{\omega}_{bkt+1}} R_{Lkt} f_j(\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})) + (1-\mu_F)\frac{R_{Kt+1}}{1-\Theta_t}\int_0^{\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})} \omega dF_{jt+1}(\omega)$$

$$+ (1-\mu_F)\bar{\omega}_{bkt+1}\frac{R_{Kt+1}}{1-\Theta_t}\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1}) f_{jt+1}(\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})) \tag{A.36}$$

$$= [R_{Lkt} - (1-\mu_F)R_{Lkt}]\left(-\frac{\partial \bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})}{\partial \bar{\omega}_{bkt+1}}\right) + (1-\mu_F)\frac{R_{Kt+1}}{1-\Theta_t}\int_0^{\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})} \omega dF_{jt+1}(\omega) > 0 \tag{A.37}$$

The second equation follows since by definition of $\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})$:

$$\frac{\partial \bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})}{\partial \bar{\omega}_{bkt+1}} = -\frac{\bar{\omega}_{Ft+1}(\bar{\omega}_{bkt+1})}{\bar{\omega}_{bkt+1}} < 0 \tag{A.38}$$

Hence $f''(L_{kt})$ simplifies to:

$$f''(L_{kt}) = \mathbb{E}_t \Lambda_{t,t+1} \frac{(\tilde{R}_L(\bar{\omega}_{bkt+1}) - R_t)^2}{\frac{\partial \tilde{R}_L(\bar{\omega}_{bkt+1})}{\partial \bar{\omega}_{bkt+1}} L_t} f_{kt+1}(\bar{\omega}_{bkt+1}) \geq 0 \tag{A.39}$$

Next, note that by definition of the bound $\bar{\omega}_{bkt}$, if it exists:

$$(\tilde{R}_{Lkt+1}(\bar{\omega}_{bt+1}) - R_t)L_{kt} = \underbrace{(R_{Dt} - R_t)D_t}_{<0} - \underbrace{R_t B_{kt}}_{<0} + c_f - \underbrace{(\mathbb{E}_t R^S_{t+1} - R_t)Q^S_t S^L_t}_{=0} \tag{A.40}$$

where the LHS is bounded below by $-R_t L_{kt}$ and bounded above by $(R_{Lkt} - R_t)L_{kt}$. The signs on the RHS follow from the deposit FOC and the bond FOCs. It follows that:

$$f''(L_{kt}) = \begin{cases} = 0 \text{ if } \nexists \ \bar{\omega}_{bkt} \\ > 0 \text{ else} \end{cases} \tag{A.41}$$

The objective function is convex in in L_{kt} (but not strictly convex). Note that a default cutoff only exists for sufficiently high volumes such that potential losses from lending (bounded by $R_t L_{kt}$) can exceed profits from non-lending activities at least in some states of the world: $\exists \bar{\omega}_{bkt} \forall L_{kt} > \underline{L}_{kt} = \frac{(R_t - R_{Dt})D_t + ((\mathbb{E}_t R^S_{t+1} - R_t)Q^S_t S^L_t + R_t B_{kt}}{R_t}$. The constraint $\gamma L_{kt} \leq \bar{L}_t$ – where $\bar{L}_t = \frac{\bar{B}_t}{\gamma}$ under fair-value capital requirements and $\bar{L}_t = \frac{B^{AC}_t}{\gamma}$ under amortized-cost capital requirements – is clearly linear in L_{kt}. Hence, the Karush-Kuhn-Tucker conditions characterize a *minimum* for a given loan rate unless $\underline{L}_{kt} > \bar{L}_t$. Hence, unless in equilibrium

$\underline{L}_{kt} > \bar{L}_t$, there is a corner solution such that banks either choose to not intermediate any loans ($L_{kt} = 0$) or the maximum amount they can intermediate ($L_{kt} = \bar{L}_t$), depending on the loan rate R_{Lkt} that banks take as given.

On the other hand, when $\underline{L}_{kt} > \bar{L}_{kt}$ the capital constraint is binding and hence the bank extends the maximum loan volume that complies with capital requirements, i.e. $L_{kt} = \bar{L}_{kt}$, if:

$$\mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[c_R + \int_{\bar{\omega}_{bkt+1}}^{\infty} \left[\tilde{R}_{Lkt+1}(\omega) - R_t \right] dF_{kt+1}(\omega) \right] > 0 \tag{A.42}$$

The bank is indifferent between any $L_{kt} \in [0, \bar{L}_{kt}]$ if $\underline{L}_{kt} > \bar{L}_{kt}$ and:

$$\mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[c_R + \int_{\bar{\omega}_{bkt+1}}^{\infty} \left[\tilde{R}_{Lkt+1}(\omega) - R_t \right] dF_{kt+1}(\omega) \right] = 0 \tag{A.43}$$

□

A.7 Contracting problem between banks & entrepreneurial firms

Let λ^F_t denote the multiplier on the firm's financing constraint Eq. 7 and λ^{PC}_t the multiplier on the bank's participation constraint Eq. 5. The first order conditions of the contracting problem are given by:

$$(K^E_t) : \mathbb{E}_t \Lambda^E_{t,t+1} \int_0^{\infty} \int_{\bar{\omega}_{Ft+1}(\omega_k)}^{\infty} \omega_j \omega_k [Q_{t+1}(1-\delta) + z_{t+1}] dF_k(\omega_j) dF_j(\omega_j) - Q_t \lambda^F_t -$$
$$\lambda^{PC}_t \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[\int_{\bar{\omega}_{bt+1}}^{\infty} \frac{\partial \tilde{R}_{Lt+1}(\omega)}{\partial K^E_t} dF_k(\omega) \right] = 0 \tag{A.44}$$

$$(L_{jt}) : \mathbb{E}_t \frac{\Lambda^E_{t,t+1}}{\Pi_{t+1}} \int_0^{\infty} \int_{\bar{\omega}_{Ft+1}(\omega_k)}^{\infty} (-R_{Lt}) dF_k(\omega_j) dF_j(\omega_j) + \lambda^F_t -$$
$$\lambda^{PC}_t \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[\int_{\bar{\omega}_{bt+1}}^{\infty} \frac{\partial \tilde{R}_{Lt+1}(\omega)}{\partial L_t} dF_k(\omega) \right] = 0 \tag{A.45}$$

$$(R_{Lt}) : \mathbb{E}_t \frac{\Lambda^E_{t,t+1}}{\Pi_{t+1}} \int_0^{\infty} \int_{\bar{\omega}_{Ft+1}(\omega_k)}^{\infty} (-L_t) dF_k(\omega_j) dF_j(\omega_j) -$$
$$\lambda^{PC}_t \mathbb{E}_t \frac{\Lambda^B_{t,t+1}}{\Pi_{t+1}} \left[\int_{\bar{\omega}_{bt+1}}^{\infty} \frac{\partial \tilde{R}_{Lt+1}(\omega)}{\partial R_{Lt}} dF_k(\omega) \right] = 0 \tag{A.46}$$

Using that $\bar{\omega}_{t+1}(\omega_k) = \frac{R_{Lt}L_j}{\omega_k \Pi_{t+1}[Q_{t+1}(1-\delta)K_{Et}+z_{t+1}K_{Et}]}$, these derivatives are given by:

$$\frac{\partial \tilde{R}_{Lt+1}(\omega_k)}{\partial K_{Et}} = \frac{\omega_k(1-\delta_M)\Pi_{t+1}[Q_{t+1}(1-\delta)+z_{t+1}]}{L_t}\Phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)$$
$$+\,\delta_M \frac{R_{Lt}}{K_{Et}}\frac{1}{\sigma_{jt+1}}\phi\left(\frac{ln(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right) \tag{A.47}$$

$$\frac{\partial \tilde{R}_{Lt+1}(\omega_k)}{\partial L_t} = -\frac{\omega_k(1-\delta_M)\Pi_{t+1}[Q_{t+1}(1-\delta)+z_{t+1}]K_{Et}}{L_t^2}\Phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)$$
$$-\,\delta_M \frac{R_{Lt}}{L_t}\frac{1}{\sigma_{jt+1}}\phi\left(\frac{ln(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right) \tag{A.48}$$

$$\frac{\partial \tilde{R}_{Lt+1}(\omega_k)}{\partial R_{Lt}} = (1 - F_{kt+1}(\bar{\omega}_{t+1}(\omega_k))) - \delta_M \frac{1}{\sigma_{jt+1}}\phi\left(\frac{ln(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right) \tag{A.49}$$

A.7.1 Taylor Approximation

The expectation of the ex-post realized loan rate and it's derivatives are highly non-linear functions of ω_k. Therefore, to solve the model in Dynare at third order, it is necessary to manually compute a third order approximation.[29] The procedure follows Mendicino et al.

[29]Derivatives of external functions are currently only implemented in Dynare up to second order.

(forthcoming). We need the approximation of just three terms involving ω_k:

$$A \equiv \Phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right), \tag{A.50}$$

$$\frac{\partial A}{\partial \omega_k} = -\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\frac{1}{\sigma_{jt+1}\omega_k}, \tag{A.51}$$

$$\frac{\partial^2 A}{\partial \omega_k^2} = -\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\left(\frac{1}{\sigma_{jt+1}\omega_k}\right)^2$$

$$+ \phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\frac{1}{\sigma_{jt+1}\omega_k^2}. \tag{A.52}$$

$$B \equiv \omega_k \Phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right), \tag{A.53}$$

$$\frac{\partial B}{\partial \omega_k} = -\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\frac{1}{\sigma_{jt+1}} + \Phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right), \tag{A.54}$$

$$\frac{\partial^2 B}{\partial \omega_k^2} = -\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\frac{1}{\sigma^2_{jt+1}\omega_k} \tag{A.55}$$

$$- \phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) - \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\frac{1}{\sigma_{jt+1}\omega_k}. \tag{A.56}$$

$$C \equiv \frac{1}{\sigma_{jt+1}}\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right), \tag{A.57}$$

$$\frac{\partial C}{\partial \omega_k} = \frac{1}{\sigma^2_{jt+1}\omega_k}\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right), \tag{A.58}$$

$$\frac{\partial^2 C}{\partial \omega_k^2} = -\frac{1}{\sigma^2_{jt+1}\omega_k^2}\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right) \tag{A.59}$$

$$+ \frac{1}{\sigma^3_{jt+1}\omega_k^2}\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right)^2 \tag{A.60}$$

$$- \frac{1}{\sigma^3_{jt+1}\omega_k^2}\phi\left(\frac{log(\bar{\omega}_{t+1}(\omega_k)) + \frac{\sigma^2_{jt+1}}{2}}{\sigma_{jt+1}}\right). \tag{A.61}$$

Then, as in Mendicino et al. (forthcoming), the expected ex-post realized loan rate can be approximated as:

$$\mathbb{E}_t \tilde{R}^L_{t+1} \approx \sum_{i=1}^{N} \left(\int_{x_i}^{x_{i+1}} T\left(\tilde{R}^L_{t+1}\right)(\omega_k) dF_{kt+1}(\omega_k) \right) + [1 - F_{kt+1}(x_{N+1})] R^L_t. \tag{A.62}$$

where the Taylor Approximation of the ex-post realized loan rate around a point $\bar{x}_i = \frac{x_i + x_{i+1}}{2}$ is given by:

$$T\left(\tilde{R}^L_{t+1}\right)(\omega_k) = \tilde{R}^L_{t+1}(\bar{x}_i) + \frac{\partial \tilde{R}^L_{t+1}}{\partial \omega_k}(\omega_k - \bar{x}_i) + \frac{1}{2}\frac{\partial^2 \tilde{R}^L_{t+1}}{\partial \omega_k^2}(\omega_k - \bar{x}_i)^2. \tag{A.63}$$

Using the expressions just derived:

$$T\left(\tilde{R}^L_t\right)(\omega_k) = \frac{(1-\delta_M)\Pi_{t+1}[Q_{t+1}(1-\delta) + z_{t+1}]K^E_t}{L_t} T(B) + R^L_t(1 - T(A)). \tag{A.64}$$

Then:

$$\begin{aligned} \int_{x_i}^{x_{i+1}} T\left(\tilde{R}^L_{t+1}\right)(\omega_k) dF_{kt+1}(\omega_k) = Q_0(\bar{x}_i) + Q_1(\bar{x}_i) \int_{x_i}^{x_{i+1}} \omega_k dF_{kt+1}(\omega_k) \\ + Q_2(\bar{x}_i) \int_{x_i}^{x_{i+1}} \omega_k^2 dF_{kt+1}(\omega_k), \end{aligned} \tag{A.65}$$

where

$$Q_0(\bar{x}_i) = [F_{kt+1}(\omega_{i+1}) - F_{kt+1}(\omega_i)] \left[\tilde{R}^L_{t+1}(\bar{x}_k) - \bar{x}_i \frac{\partial \tilde{R}^L_{t+1}}{\partial \omega_k} + \frac{1}{2}\bar{x}_i^2 \frac{\partial^2 \tilde{R}^L_{t+1}}{\partial \omega_k^2} \right], \tag{A.66}$$

$$Q_1(\bar{x}_i) = \left[\frac{\partial \tilde{R}^L_{t+1}}{\partial \omega_k} - \bar{x}_i \frac{\partial^2 \tilde{R}^L_{t+1}}{\partial \omega_k^2} \right], \tag{A.67}$$

$$Q_2(\bar{x}_i) = \frac{1}{2}\frac{\partial^2 \tilde{R}^L_{t+1}}{\partial \omega_k^2}. \tag{A.68}$$

We proceed similarly for the derivatives of the ex-post loan rate.

B Calibration

This Appendix presents additional details on the calibration strategy, and provides full details of the date sources.

As mentioned in Section 3 of the main text, measurement errors in wages are introduced following the evidence in Justiniano et al. (2013). Denote observed wages by w_t^{obs}. Measurement error in wages is specified as follows:

$$w_t^{obs} = w_t + exp(\sigma_{mw})\epsilon_{mw}, \tag{A.69}$$

where $\epsilon_{mw} \sim N(0,1)$. The length of the simulation is 1700 quarters after a burn-in of 1500 periods. The burn-in period ensures that the ergodic distribution is reached.[30] We specify priors on some parameters due to SMM's known tendency to pick parameters not supported by micro data (see An and Schorfheide, 2007 and Ruge-Murcia, 2012).[31]

Parameter	Description	Prior	Variance
ϕ_Π	Taylor Rule Weight Inflation	1.5	6
ϕ_Y	Taylor Rule Weight Inflation	0.5	2
ϕ_R	Taylor Rule Smoothing	1.5	2
κ	Investment Adjustment Costs	7	40
σ_{MW}	Wage Measurement Error	$e^{-7.13}$	1

Table 4
Priors

B.1 Data sources

Gross Domestic Product (GDP) deflator OECD Quarterly National Accounts. Euro Area (20 countries). Deflator, OECD reference year, seasonally adjusted. Millions of Euro. Index.

Population OECD Quarterly National Accounts. Euro Area (20 countries). Total Population. Thousands.

GDP OECD Quarterly National Accounts. Euro Area (20 countries). Gross domestic product - expenditure approach. National currency, current prices, quarterly levels, seasonally adjusted. Millions of Euro. *Transformation*: Divided by GDP deflator and total population.

[30] We follow Born and Pfeifer (2014) who use the same burn-in length.

[31] As discussed in Born and Pfeifer (2014), these priors are relatively flat.

Consumption Private final consumption expenditure. OECD Quarterly National Accounts. Euro Area (20 countries). National currency, current prices, quarterly levels, seasonally adjusted. Millions of Euro. *Transformation*: Divided by GDP deflator and total population.

Investment OECD Quarterly National Accounts. Euro Area (20 countries). Gross fixed capital formation. National currency, current prices, quarterly levels, seasonally adjusted. Millions of Euro. *Transformation*: Divided by GDP deflator and total population.

Inflation Log-change in GDP Deflator.

Employment OECD Quarterly National Accounts. Euro Area (20 countries). Employment, total (Persons). Thousands.

Hours OECD Quarterly National Accounts. Euro Area (20 countries). Employment, total (Hours Worked). Millions. *Transformation*: Demeaned Hours/Employment ($H = 1$ in the model corresponds to average hours worked).

Wages OECD Quarterly National Accounts. Euro Area (20 countries). Wages, total. Millions. *Transformation*: Wages divided by total hours worked and GDP deflator.

Rate of return on equity (RoE), bank default probability, and firm default probability : Mendicino et al. (forthcoming).

Loan-to-bond ratio Hoffmann et al. (2019)

For deposits and loans, which we collect from the ECB Statistical Date Warehouse, we proceed slightly differently. The ECB does not report values for a hypothetical constant composition Euro Area, such that care must be taken to compute relationships with the measure of GDP for the corresponding countries. For this reason, we construct data for the following countries: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands and Portugal.

The ECB data we use is only available monthly, so for each of the variables below, population weighted averages are computed for each quarter. Let $\omega_{ct} = \frac{Population_{ct}}{\sum_c Population_{ct}}$, where countries are indexed by c, quarters by t and month by m. ω_c are computed from the same OECD population data used above. Then the population-weighted averages for each quarter of variable x are:

$$\bar{x}_t = \frac{1}{4}\sum_{m \in t}\sum_{c} \omega_c x_{cm} \tag{A.70}$$

A further complication is that deposits and loans are not seasonally adjusted. We therefore manually do the adjustment with X-13 ARIMA using the R package seasonal.

Deposits ECB Statistical Data Warehouse.
(D1): Overnight deposits vis-a-vis euro area households reported by MFIs excl. ESCB. Outstanding amounts at the end of the period (stocks). Monthly.
(D2) Deposits with agreed maturity vis-a-vis euro area households reported by MFIs excl. ESCB, Total. Outstanding amounts at the end of the period (stocks). Monthly.
(D3): Deposits redeemable at notice vis-a-vis euro area households reported by MFIs excl. ESCB. Outstanding amounts at the end of the period (stocks). Monthly.
Sum of: (D1) + (D2) + (D3) of all countries listed above.
Transformation: Population weighted average for each quarter. Seasonally adjusted with X-13 ARIMA using the R package seasonal. Divided by nominal GDP and multiplied by real per capita GDP to get real per-capita deposits. To compute the correlation with GDP, the mean deposit-to-GDP ratio and it's standard deviation the sum of real per capita GDP for the same countries is used.

Loans ECB Statistical Data Warehouse.
(L1) : Loans vis-a-vis euro area NFCs reported by MFIs excl. ESCB. Up to 1 year maturity. Euro area (changing composition) counterpart, Non-Financial corporations (S.11) sector, denominated in Euro. Outstanding amounts at the end of the period (stocks). Monthly.
(L2) : Loans vis-a-vis euro area NFCs reported by MFIs excl. ESCB. Over 1 and up to 5 years maturity. Euro area (changing composition) counterpart, Non-Financial corporations (S.11) sector, denominated in Euro. Outstanding amounts at the end of the period (stocks). Monthly.
(L3) : Loans vis-a-vis euro area NFCs reported by MFIs excl. ESCB. Over 5 years maturity. Euro area (changing composition) counterpart, Non-Financial corporations (S.11) sector, denominated in Euro. Outstanding amounts at the end of the period (stocks). Monthly.
Sum of: (L1) + (L2) + (L3) of all countries listed above.
Transformation: Population weighted average for each quarters. Seasonally adjusted with

X-13 ARIMA using the R package seasonal. Divide by nominal GDP and multiply by real per capita GDP to get real per-capita loans. To compute the correlation with GDP, the mean deposit-to-GDP ratio and it's standard deviation the sum of real per capita GDP for the same countries is used.

Loan rate spread ECB Statistical Data Warehouse.
(LR1): Annualised agreed rate (AAR) / Narrowly defined effective rate (NDER), Credit and other institutions (MFI except MMFs and central banks) reporting sector - Loans, Up to 1 year original maturity, Outstanding amount business coverage, Non-Financial corporations (S.11) sector, denominated in Euro. Monthly.
(SR1): Euro Interbank Offered Rate.
(LR2): Annualised agreed rate (AAR) / Narrowly defined effective rate (NDER), Credit and other institutions (MFI except MMFs and central banks) reporting sector - Loans, Over 1 and up to 5 years original maturity, Outstanding amount business coverage, Non-Financial corporations (S.11) sector, denominated in Euro. Monthly.
(SR2): Yield curve spot rate, 2 year maturity. Government bond, nominal, all issuers whose rating is triple A - Euro area (changing composition). Monthly.
(LR3): Annualised agreed rate (AAR) / Narrowly defined effective rate (NDER), Credit and other institutions (MFI except MMFs and central banks) reporting sector - Loans, Over 5 years original maturity, Outstanding amount business coverage, Non-Financial corporations (S.11) sector, denominated in Euro. Monthly.
(SR3): Yield curve spot rate, 5 year maturity. Government bond, nominal, all issuers whose rating is triple A - Euro area (changing composition). Monthly.
Transformation:

$$\frac{((LR1)-(SR1))(L1)+((LR2)-(SR2))(L2)+((LR3)-(SR3))(L3)}{(L1)+(L2)+(L3)}$$

of all countries listed above. Compute population weighted average for each quarters.

Safe Rate ECB Statistical Data Warehouse. Using the data just described, we approximate the safe rate (the data counterpart to R_t) as:

$$\frac{(SR1)(L1)+(SR2)(L2)+(SR3)(L3)}{(L1)+(L2)+(L3)}$$

of all countries listed above. Then we compute the population weighted average for each quarter.

C Details Computation Consumption Equivalents

Denote variable x in model a by x_t^a and in model b by x_t^b, where a and b will be specified below. To compute consumption equivalents (CE) Δ_{CE}, we first calculate the expected lifetime utility at time t under two different models:[32]

$$\mathbb{E}(U_t^a) = \mathbb{E}\left(\mathbb{E}_t \sum_{n=0}^{\infty} \beta^n \left[\frac{\{C_{t+n}^a(h) - bC_{t+n-1}^a(h)\}^{1-\sigma}}{1-\sigma} - \frac{\xi_H H_{t+n}^a(h)^{1+\varphi_H}}{1+\varphi_H}\right]\right) \tag{A.71}$$

and similarly for model b. Next, the expected utility in model b can be related to the utility in model a as follows:

$$\mathbb{E}(U_t^a) = \mathbb{E}\left(\mathbb{E}_t \sum_{n=0}^{\infty} \beta^n \left[\frac{\{(1+\Delta_{CE})(C_{t+n}^b(h) - bC_{t+n-1}^b(h))\}^{1-\sigma}}{1-\sigma} - \frac{\xi_H H_{t+n}^b(h)^{1+\varphi_H}}{1+\varphi_H}\right]\right) \tag{A.72}$$

Under log-utility ($\sigma = 1$), using Eq. (A.71) in Eq. (A.72) yields:

$$\mathbb{E}(U_t^a) = \frac{ln(1+\Delta_{CE})}{1-\beta} + \mathbb{E}(U_t^b) \tag{A.73}$$

It follows:

$$\Delta_{CE} = exp[(1-\beta)(\mathbb{E}\{U_t^a - U_t^b\})] - 1 \tag{A.74}$$

Model a is for example of the model under fair value requirements, while model b is the model under amortized-cost requirements. The interpretation is that households, could they choose, would require $100\Delta_{CE}\%$ of consumption in every period to remain in the economy with amortized-cost value requirements.

D Additional Tables and Figures

[32] This may be interpreted as the expected utility of a person born at an arbitrary time t in the respective economy.

Table 5
Parameter Values

Symbol	Value	Description
α	0.25	Capital Share Production
β	0.995	HH Discount Factor
δ	0.025	Capital Depreciation Rate
θ_R	55.4563	Rotemberg Price Adjustment Cost
θ_W	1157.6892	Rotemberg Wage Adjustment Cost
φ_H	1	Inverse Frisch Elasticity of Labor
μ	7.25	Elasticity of Substitution Final Goods
ϵ_W	5	Elasticity of Substitution Labor
κ	7.5732	Investment Adjustment Cost
κ_H	0.0063535	Capital Management Cost
σ	1	HH Risk Aversion (Consumption)
ξ_H	0.83033	Disutility of Labor
θ_B	0.965	Survival Bankers
θ_E	0.97048	Survival Entrepreneurs
γ	0.08	Regulatory Capital Requirement
ϕ_Π	1.0664	Taylor Rule Weight Inflation
ϕ_y	0.57192	Taylor Rule Weight Output
ϕ_R	0.57954	Taylor Rule Weight Smoothing Weight
ξ_B	0.50078	Endowment Bankers
ξ_E	3.8038e-05	Endowment Entrepreneurs
b	0.76383	Habit Consumption
δ_M	0.3	Loss Entrepreneurial Default
δ_B	0.3	Loss Bank Default
$\bar{\sigma}_{\omega_j}$	0.16947	Steady State Std Idiosyncratic Shock
$\bar{\sigma}_{\omega_k}$	0.11443	Steady State Std Island Shock
σ_{ω_j}	0.00056851	Std Idiosyncratic Risk Shock
σ_{ω_k}	0.043043	Std Island Risk Shock
ρ_{ω_j}	0.22872	Autocorr. Idiosyncratic Risk Shock
ρ_{ω_k}	0.98459	Autocorr. Island Risk Shock
ρ_θ	0.021021	Autocorr. Productivity Shock
ρ_p	0.49082	Autocorr. Cost Push Shock
ρ_g	0.8297	Autocorr. Gov. Spending Shock
ρ_τ	0.88458	Autocorr. Monetary Policy Shock
σ_θ	0.00043939	Std. Productivity Shock
σ_p	0.18936	Std. Cost Push Shock
σ_g	0.0038184	Std. Gov. Spending Shock
σ_τ	0.00095329	Std. Monetary Policy Shock
S	1.1424	Real Supply Central Bank Asset
m	13.6	Gov. Bond Maturity
ϕ_{lc}	0	Bank Liquidity Management Cost
c_f	0.0026084	Bank Fixed Cost
c_R	0.0251	Bank Relationship Lending Benefit
ϵ_D	-400	Deposits Elasticity of Substituion