Bank Loan Portfolio and Monetary Transmission*

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Abstract

We develop a tractable theoretical framework to study the macroeconomic implications of bank portfolio choice while capturing monetary policy transmission through an interest-rate and a bond-supply channel. We prove that labor demand and supply endogenously determine steady-state inflation. Our analysis illustrates that the bank portfolio choice drives the crowding-out effects of bank lending and overall financial risk. Contractionary monetary policy, in the short and long run, reduces both commercial and collateralized household loans and induces a flight to safety as lending pivots toward the latter. This reallocation mitigates financial risk but causes a negative spillover from construction to production.

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1 Introduction

We construct a tractable theoretical framework of money, banking and finance to study (i) the macroeconomic impact of bank portfolio choice between commercial and collateralized household loans and (ii) the transmission of monetary policy through an endogenous bank portfolio choice. Our study is motivated by two sets of empirical observations on bank lending: the complexity of bank lending risk and the crowding-out effects of bank loans.

Household mortgage loans and commercial and industrial loans are twin pillars of bank lending, making up over 70% of total loans in the U.S. over the last twenty years.[1] These two loan types accrue different risks, with commercial and industrial loans generally being riskier than real estate loans due to widespread securitization and federal guarantees for the latter (Cebenoyan and Strahan (2004) and Foos et al. (2010)).[2] Banks manage lending risks by adjusting the composition of their loan portfolios. For example, Bidder et al. (2021) and Dell'Ariccia et al. (2021) find evidence that in an effort to cope with loss, banks curtail commercial lending and reallocate lending to other assets, such as mortgages. Therefore, the need to better assess financial risk calls for a theoretical framework that allows for differential risks across loan types and for banks to choose the composition of their loan portfolios.

There is another growing body of empirical work on the crowding-out effects of bank lending. Some studies find that during housing booms, banks prioritize mortgage lending over commercial lending, causing reduced investment and other real activities (*e.g.*, see Section 2 for a discussion of Chakraborty et al. (2018), Fieldhouse (2019), Chakraborty et al. (2020), Suh and Yang (2020), and Li et al. (2022)). Yet, Bezemer et al. (2020) document a positive effect of mortgage credit expansion on business credit growth in advanced economies but a negative effect in emerging and developing economies. The seemingly contradictory empirical evidence highlights the need for a theoretical framework that connects the bank portfolio choice with real activities to better understand whether bank lending leads to competing or complementary effects on the production and construction sectors.

To address these two observations, we design our framework to accommodate a bank portfolio choice, household demand for collateralized loans, entrepreneurial demand for risky business loans, production and construction sectors, and fractional-reserve banking. Through fractional-reserve banking, monetary policy in our model is transmitted *via* an *interest-rate* channel and a *bond-supply* channel. Our model delivers a wide range of analytical and quantitative insights in both the short and long run that shed light on the monetary policy effects on bank lending, the implications of bank portfolio decisions for overall financial risk, and the real consequences of one type of loan crowding out the other.

Despite the complex nature of the desired model, we strive to maintain tractability to obtain insights into how various elements work jointly to shape macroeconomic outcomes. To this end, we model safe collateralized household loans in the spirit of Kiyotaki and Moore (1997) and risky

[1] According to data obtained from Federal Deposit Insurance Corporation, FDIC.

[2] See Section 5 for further evidence.

business loans *à la* Carlstrom and Fuerst (1997). For the former, there are patient and impatient households in our model who, respectively, become savers and borrowers in equilibrium. Household loans are subject to a loan-to-value (henceforth LTV) requirement. For the latter, there are entrepreneurs who operate risky investment projects to produce capital goods. They borrow from banks at a fixed interest rate. If the project fails, the entrepreneur will default on their debt and be audited by the bank.

These modeling choices improve tractability in two aspects. First, we simplify the model by focusing on commercial loans as the only risky debt rather than including the risks associated with collateralized household debt. This simplification reduces model complexity while still capturing the key empirical observation that commercial debt tends to be riskier than collateralized household debt. Second, the Calstrom-Fuerst structure generates the result that only the aggregate entrepreneurial capital stock matters for solving the equilibrium despite idiosyncratic project outcomes. This approach renders our analysis close to the representative-agent style.

Another factor that helps improve analytical tractability is that we model monetary transmission in the form of fractional reserve banking. We impose a proportional reserve requirement on banks and finance reserve interest payments by bond issuance and money injection. Compared to Bernanke and Blinder (1988, 1992), which also feature a fractional reserve requirement, our setup has two distinct differences. First, we are interested in how monetary policy affects portfolio decisions through reserves instead of the policy effects on the sheer volume of loans. Second, monetary policy is transmitted through an interest-rate channel and a bond-supply channel in our setup. With the interest-rate channel, policy measures, such as the required reserve ratio and the interest rate paid on reserves, can directly impact the tightness of the bank lending constraint, thereby affecting real lending rates. These lending rates subsequently transmit policy effects to the rest of the economy, including asset/goods prices and optimal decisions. With the bond-supply channel, the supply of nominal bonds is used to finance reserve interest payments, and thus, the reserve rate directly influences labor supply through households' bond demand and balanced budgets.

The monetary policy transmission mechanism in our model applies to a broad context of regulations in fractional reserve banking aimed at limiting bank lending, such as reserve requirements, capital requirements, premiums on deposit insurance, Basel regulations, *etc.* The key takeaway here is that constrained bank lending is a simple and effective way for monetary policy to be transmitted to the entire economy. Our setup serves as an alternative approach to frontier monetary contexts, such as those with nominal rigidities and search frictions.

With all of the above modeling choices, plus quasi-linear preferences, our model is tractable to the extent that solving the steady-state equilibrium boils down to one equation and one unknown. As a novel result, the steady-state inflation rate in our model is an endogenous variable. The monetary authority injects money and issues nominal bonds to pay interest on reserves, the amount of which endogenously depends on the policy reserve rate. Our solution algorithm in our online Appendix, the order in which we solve for all the forty-plus steady-state variables, illustrates how the labor market clearing determines inflation. Labor-market clearing is the only equilibrium condition involving all decision-makers, directly or indirectly. In particular, bank decisions influence interest rates, and entrepreneurs' decisions affect capital prices, both of which matter for the labor demand by construction and production firms and the labor supply of household borrowers and savers. Since inflation permeates every aspect of the economy, it takes the labor market to bring all its economic influences together to fully determine the equilibrium inflation rate, which is the case not only in the long run but also in the short run. This result reconciles the fact that, in practice, central banks closely monitor labor market conditions when making policy decisions such as inflation targeting.

In addition to theoretical analysis, we calibrate our framework to the US economy and quantitatively evaluate long-run policy impacts and short-run dynamic responses to economic shocks. Our main results are summarized in four points. First, through impacting the bank portfolio choice, various short-run shocks and long-run policy changes can cause crowding out of loan types observed in data and have implications for overall financial risk. Our quantitative study illustrates that financial crowding out may lead to real crowding out between goods production and housing construction. For example, our model suggests that adverse total factor productivity favors the housing market, increases the collateralized loan-to-commercial loan ratio (CA/C), and reduces financial risk. On the other hand, adverse construction, housing demand, and LTV shocks favor the goods market, decrease the CA/C ratio, and increase the financial risk.

Second, the expansion of one loan type is not always associated with the reduction of the other, which could serve as a potential explanation for the empirical findings by Bezemer et al. (2020) for advanced economies. In particular, our model suggests that long-run monetary and macroprudential policies (in the form of changing the LTV requirement), as well as short-run monetary shocks, move both loan types in the same direction (*i.e.*, either both increase or decrease in volume). Nevertheless, in such a case, crowding out still exists but is subtle and manifests itself in relative terms. For example, a contractionary monetary policy that raises real interest rates causes a reduction in both collateralized (CA) and commercial (C) loans but a rise in the ratio of CA relative to C loans. As a result, contractionary monetary policy mitigates the overall financial risk as banks pivot toward collateralized loans while reducing commercial loan default risk. Additionally, we demonstrate that the crowding-out effect of loan redistribution causes spillovers from the housing market to the production sector, leading to long-run adverse effects under tighter monetary policy.

Third, all else equal, inflation tightens the bank lending constraint and raises real lending rates, which renders a dual effect on the economy. On the one hand, given low inflation rates, higher interest rates suppress the demand for capital, output, and housing due to the worsening financial conditions. Therefore, the labor demand from both the production and construction sectors shrinks. On the other hand, aggregate labor supply strictly increases with inflation as higher interest rates cause both household borrowers and savers to work more. Higher inflation, and thus, interest rates, exacerbate the financial burden on household borrowers, prompting them to work more. Household savers also work more as capital prices rise due to the worsening lending conditions. The crossing of the labor demand and supply curves determines the steady-state level of inflation. Our quantitative studies suggest that there tends to be a unique crossing point. As a result, a policy change that shifts labor demand up (or labor supply down) is inflationary, and *vice versa*.

Lastly, instead of imposing mortgages as household debt, we allow households to use real assets, that is, both capital and houses, as collateral. We theoretically prove that household borrowers find it optimal to use only housing as collateral for their loans in the steady state. That is, house-backed debt, *e.g.*, mortgages, endogenously arises as the only form of household collateralized debt in a steady state with constrained bank lending. This result indicates a strong connection with the empirical fact that most household debt (about 73%) is in the form of mortgages.[3]

The rest of this paper is organized as follows. Section 2 sketches the related literature. Section 3 presents the model environment, defines the equilibrium, and characterizes the steady state. Section 4 conducts quantitative studies of long-run policy effects and short-run responses to various shocks. Section 5 provides empirical support to our findings. Section 6 concludes the paper.

2 Related Literature

Our paper directly addresses the empirical research on the crowding-out effects of bank lending on the economy. For instance, Chakraborty et al. (2018) document that active banks in robust housing markets prioritize mortgage over commercial lending, reducing investment for borrowing firms. This finding underscores that house price appreciation can have adverse effects on the real economy. Fieldhouse (2019) shows that US housing credit policies, subsidizing residential mortgage expansion, unintentionally crowd out commercial lending and related real activity. Moreover, Chakraborty et al. (2020) demonstrate that the US Federal Reserve's mortgage-backed security purchases, as part of quantitative easing efforts, boosted mortgage origination for beneficiary banks but reduced commercial lending and borrowing firms' investment. Bidder et al. (2021) explore how banks manage loss and find that those that are exposed to shocks tighten credit for both business loans and non-securitized mortgages while expanding credit to mortgages to be securitized, and thus rebalance the portfolio to have less risk. Dell'Ariccia et al. (2021) exploit heterogeneity in bank exposure to the compositional shift from tangible to intangible capital and show that exposed banks curtail commercial lending and reallocate lending to other assets, such as mortgages.

From the international perspective, Bezemer et al. (2020) find a positive effect of mortgage credit expansion on business credit growth in advanced economies and a negative effect in emerging and developing economies by using a novel disaggregated bank credit data set. Suh and Yang (2020) provide international firm-level evidence that large housing price booms are detrimental to investment, suggesting a possible reallocation of resources from the production sector to the housing sector during such phases. Li et al. (2022) find Australian evidence that crowding out of business loans towards housing loans in response to increased opportunities in strong housing markets and curtailed business investment. Our paper complements this literature by providing a theoretical structure that demonstrates how a loan reallocation by banks can generate crowding-out effects in

[3]Data obtained from FRBNY Consumer Credit Panel.

the financial and real sectors and impact overall financial risk.

Our paper clearly belongs to the vast literature on banking, and is closest in relation to the theoretical subdivision that studies the macroeconomic implications of bank lending decisions in a monetary context. To name a few, Berentsen et al. (2007) show that bank-like financial intermediaries can help improve the allocation and that when credit rationing occurs, increasing the rate of inflation can be welfare-improving. Sun (2007), Corbae and D'Erasmo (2021), Dong et al. (2021), Head et al. (2022), Wang et al. (2022), Chiu et al. (2023), Altermatt and Wang (2024) address the consequences of imperfect competition in the banking industry. Bech and Monnet (2016) and Williamson (2019) study central bank intervention in the context of interbank lending.

Our unique angle relative to the above papers is that we incorporate differential loan risks and endogenize bank decisions over collateralized household and commercial loans.[4] In our model, banks' optimal loan distribution choice directly affects capital and housing investments, which then influence production, construction, household consumption, savings, and so on. In addition, the tractability of our theoretical structure allows for insights into how labor market interactions affect inflation. Tractability also offers analytical and quantitative convenience that renders a rich set of results on both long-run policy effects and short-run dynamic responses that arise from banks' needs to adjust their loan portfolios.

Some papers in the macro-finance literature have modeled financial frictions with differential loan types somewhat similar to our setup. Lombardo and McAdam (2012) study the financial market frictions in a model of the euro area. They model the financial constraints faced by households through limited enforceability and collateralized debt (as in Iacoviello (2005)) and those faced by firms through costly state verification and default risk (*e.g.*, Bernanke et al. (1999)). Clerc et al. (2015) analyze macroprudential policies in a dynamic general equilibrium model where household, firm, and bank debt are all subject to default risk. Rawat (2017) studies the interaction between firm and household credit constraints over the business cycle. The model combines household debt in the spirit of Kiyotaki and Moore (1997) and business debt as in Bernanke et al. (1999). Yoo (2017) evaluates the relative effectiveness of a policy to inject capital into banks versus a policy to relieve households of mortgage debt. The paper combines household debt *à la* Iacoviello (2005), business debt in the costly state verification (CSV) setup of Gale and Hellwig (1985), and bank leverage constraint following Gerali et al. (2010). In contrast to our model, all of these models are either in real terms or nominal with price rigidities. Moreover, none of these models allow for a portfolio choice made by banks.

Closest to our paper, Song (2021) examines how the credit supply mechanisms in the financial intermediation sector influence monetary policy. Our paper differs from Song (2021) in focus and approach. Song studies whether monetary policy's effectiveness is enhanced or reduced by the credit supply channel, while we focus on the crowding-out effects of bank loan portfolio choice and how monetary policy makes its impact on the economy through the bank choice. Moreover,

[4]See Dia and VanHoose (2017) for a review of efforts to apply developments in bank modeling to augment macroeconomic models.

on the banking side, the bank portfolio choice in Song (2021) is driven by the differential costs arising from loan defaults and an adjustment cost to the portfolio. In contrast, we do not consider such costs but instead focus on the bank's portfolio choice when faced with a reserve requirement and various market interest rates on depositing and lending. On the monetary side, Song (2021) takes the New-Keynesian style with nominal rigidities, whereas our model does not have nominal rigidities; instead, monetary policy is transmitted in a simple mechanism through the fractional reserve requirement.

Finally, our paper adds to a recent strand of the macro-finance literature that theoretically investigates how monetary policy affects financial stability through its impact on asset prices (*e.g.*, Caballero and Simsek (2019) and Caballero and Simsek (2024)). Although our model does not directly address financial stability, it provides insight into how risk is accumulated in the financial sector. In particular, we show that the amount of financial risk is determined not only through risks associated with each type of loan but also through banks' loan distribution choices. For example, a rise in the riskiness of one type of loan does not necessarily lead to worsening overall risk if there is a simultaneous increase in the relative amount of safer loans. Such an insight would not have been obtained in a model with a single loan type. Therefore, modeling loans of various risk types is critical for gauging the overall financial risk.

3 The Model

Time is discrete and continues forever. The economy is populated by patient and impatient households, entrepreneurs, banks, production firms, construction firms, and a central bank. Banks accept deposits from households and issue *commercial loans* to finance entrepreneurial projects and *collateralized loans* to finance household investments. Entrepreneurs produce new capital goods. Households and entrepreneurs own the total capital stock. Construction firms build and sell houses to households. Both production and construction firms hire labor supplied by households and entrepreneurs. Production firms rent capital. Banks, production firms, and construction firms operate in a competitive market.

Banks are required to hold at least a fraction $\bar{R}_t \in (0,1)$ of their deposits as reserves. The central bank pays interest on bank reserves at a gross nominal rate of R^b_t. In each t, the central bank issues a one-period nominal bond B_t that will mature in $t+1$. These bonds are used to finance reserve interest:

$$B_t = \left(R^b_{t-1} - 1\right) p_{t-1} S_{t-1}, \tag{1}$$

where S_t denotes the real aggregate bank reserves in period t. The central bank issues money to cover bond payments:

$$M_t - M_{t-1} = R^g_{t-1} B_{t-1}. \tag{2}$$

Monetary policy instruments R^b_t and $\bar{R}_t$ can be adjusted to influence the bank-lending conditions through an interest-rate channel and the household labor supply through a bond-supply channel.

Timing of events. 1) Aggregate shocks are realized; 2) Households and entrepreneurs supply labor to production and construction firms. Households and entrepreneurs rent capital to production firms; 3) Production and construction take place, after which capital and housing depreciate; 4) Wages and rents are paid to households and entrepreneurs. Previous collateralized loans are repaid, and banks pay interest on previous deposits; 5) The central bank injects money to pay for the principal and interest on previously-held government bonds, and issues new bonds to finance the interest on previously held bank reserves; 6) Households make new deposits in banks. Banks put up reserves in their central bank accounts and lend to households and entrepreneurs. The former invests in housing, nominal bonds, and capital, and the latter invests in projects to produce capital goods; 7) Project outcomes are realized, and commercial loans are repaid, or defaulted on. Households and entrepreneurs consume.

Households. There is a measure $(1-\varrho)$ of infinitely-lived households. A fraction of α is considered *patient households* with a discount factor of $\beta^1 < 1$, and the rest *impatient households* with a discount factor of $\beta^2 < \beta^1$. Let $j = 1, 2$ denote household types. Each household has the periodic preference, $(\ln c_{j,t} + \varphi \ln h_{j,t} - \gamma l_{j,t})$, where $c_{j,t}$ is consumption, $h_{j,t}$ is housing services, and $l_{j,t}$ is hours worked. Let R_t^g, R_t^d and R_t^m respectively be the gross nominal interest rate on bonds, deposits, and collateralized loans between t and $t+1$. Moreover, q_t^k and q_t^h respectively are real capital and real housing prices, w_t is the real wage rate, and r_t^k is the rental rate of capital. δ^k and δ^h represent the capital and housing depreciation rates, respectively. $\Pi_{j,t}$ is a household's total dividend income, including dividends from production firms, banks, and construction firms. Let $\pi_t = \frac{p_t}{p_{t-1}}$ denote the gross inflation rate, where p_t is the nominal price. Since money is dominated in the rate of return, households will make bank deposits with money provided that $R_t^d \geq 1$ for all t. We will focus on equilibrium with active banking activities, that is, with $R_t^d \geq 1$ for all t.

Taking prices, rates, dividends, and policy $(q_t^k, q_t^h, w_t, r_t^k, R_t^g, R_t^d, R_t^m, \Pi_{j,t}, \xi)$ as given, a representative type-j household chooses consumption of the final goods $(c_{j,t})$, capital $(k_{j,t})$ and housing $(h_{j,t})$ investments, hours worked $(l_{j,t})$, deposits $(d_{j,t})$, collateralized debt $(m_{j,t})$, and bond holdings $(b_{j,t})$ to solve the following maximization problem:

$$\max_{(c_{j,t},k_{j,t},h_{j,t},l_{j,t},d_{j,t},m_{j,t},b_{j,t})} E\sum_{t=0}^{\infty}\beta^j \left(\ln c_{j,t} + \varphi \ln h_{j,t} - \gamma l_{j,t}\right),$$

where $\varphi > 0$ represents household's preferences for housing services and $\gamma > 0$ governs the labor supply preference. The maximization problem is subject to: (i) the budget constraint,

$$\begin{aligned} &c_{j,t} + q_t^k \left[k_{j,t} - \left(1-\delta^k\right) k_{j,t-1}\right] + q_t^h \left[h_{j,t} - \left(1-\delta^h\right) h_{j,t-1}\right] + d_{j,t} + b_{j,t} \\ &+\frac{R_{t-1}^m}{\pi_t} m_{j,t-1} = w_t l_{j,t} + r_t^k k_{j,t-1} + \frac{R_{t-1}^d}{\pi_t} d_{j,t-1} + \frac{R_{t-1}^g}{\pi_t} b_{j,t-1} + m_{j,t} + \Pi_{j,t}; \end{aligned} \tag{3}$$

(ii) the collateral constraint for household loans,

$$R_t^m m_{j,t} \leq \xi E_t \left\{ \left[q_{t+1}^k k_{j,t} + q_{t+1}^h h_{j,t} \right] \pi_{t+1} \right\}; \tag{4}$$

and (iii) the regularity conditions such as $c_{j,t} > 0$ and $k_{j,t}, h_{j,t}, l_{j,t} \geq 0$. The budget constraint in (3) is rather standard. The left-hand side of this condition is the total household expenditure in a given period, which includes consumption, investments in capital, housing and bonds, bank deposits, and loan payments. The right-hand side is the household's total income from wages, rentals, deposits, bonds, new loans, and dividends. The collateral constraint in (4) stipulates that new debt must not exceed a proportion $\xi \in (0,1)$ of the expected value of all collaterals consisting of household capital and housing holdings and so, ξ represents a *loan-to-value ratio* (LTV) requirement. Let $\lambda_{j,t}$ be the multiplier of the collateral constraint. For each type-j household, the optimality conditions are given by:

$$\gamma c_{j,t} = w_t \tag{5}$$

$$q_t^k = \beta^j E_t \left[\frac{c_{j,t}}{c_{j,t+1}} \left(r_{t+1}^k + \left(1 - \delta^k\right) q_{t+1}^k \right) \right] + c_{j,t} \lambda_{j,t} \xi E_t (q_{t+1}^k \pi_{t+1}) \tag{6}$$

$$q_t^h = E_t \left[\frac{\varphi c_{j,t}}{h_{j,t}} + \beta^j \frac{c_{j,t}}{c_{j,t+1}} q_{t+1}^h \left(1 - \delta^h\right) \right] + c_{j,t} \lambda_{j,t} \xi E_t (q_{t+1}^h \pi_{t+1}) \tag{7}$$

$$1 \geq \beta^j R_t^d E_t \left[\frac{1}{\pi_{t+1}} \frac{c_{j,t}}{c_{j,t+1}} \right], \quad d_{j,t} \geq 0 \tag{8}$$

$$1 \leq R_t^m E_t \left[\beta^j \frac{1}{\pi_{t+1}} \frac{c_{j,t}}{c_{j,t+1}} + \lambda_{jt} c_{j,t} \right], \quad m_{j,t} \geq 0 \tag{9}$$

$$1 \geq \beta^j R_t^g E_t \left[\frac{1}{\pi_{t+1}} \frac{c_{j,t}}{c_{j,t+1}} \right], \quad b_{j,t} \geq 0 \tag{10}$$

$$0 = \lambda_{jt} E_t \left[\xi \left(q_{t+1}^k k_{j,t} + q_{t+1}^h h_{j,t} \right) \pi_{t+1} - R_t^m m_{j,t} \right], \quad \lambda_{jt} \geq 0. \tag{11}$$

Entrepreneurs. There are infinitely-lived risk-neutral entrepreneurs of measure ϱ, with preferences $E_0 \sum_{t=0}^{\infty} (\beta^e)^t c_t^e$, where c_t^e is the consumption of the entrepreneur and β^e is the discount factor such that $\beta^e < \beta_1$. Entrepreneurs supply labor inelastically to production and construction firms. Each entrepreneur is endowed with a project every period that utilizes consumption goods to produce capital goods. All projects are one period in duration. With an investment of i_t, the project produces $\omega_t i_t$ units of capital goods, where $\omega_t \sim \Phi(\cdot)$ is *i.i.d.* across entrepreneurs and over time with non-negative support, $E(\omega_t) = 1$ and density $\phi(\cdot)$. Project outcome realization, ω_t, is *private information* of the entrepreneur, and the bank must incur a monitoring cost to observe the true outcome.

Optimal contracting decision. While collateralized loans are intertemporal, commercial loans are intratemporal in nature.[5] Entrepreneurs use internal funds and funds borrowed from

[5] This assumption is for analytical convenience and is not critical for obtaining results.

banks, both in terms of consumption goods, to produce capital goods. After the project outcome is realized, the entrepreneur repays the loan by the end of the period. The layout of the debt contract for the commercial loan is in the spirit of Carlstrom and Fuerst (1997).

For an investment i_t, an entrepreneur with a net worth of n_t will borrow $\max[i_t - n_t, 0]$. By investing i_t units of consumption goods, the entrepreneur's project produces $\omega_t i_t$ units of capital goods. Let R_t be the real gross commercial loan rate. That is, the entrepreneur pays R_t units of capital goods for each unit of consumption goods borrowed. The entrepreneur has limited liability to the loan; after the project outcome is realized, the entrepreneur either makes the repayment according to R_t or defaults on the loan. Upon default, the bank will verify and forfeit all of the actual project output. The monitoring cost per project is equal to $\mu q_t^k i_t$ units of consumption goods, where $\mu \in (0,1)$. The repayment measured in units of consumption goods is $R_t(i_t - n_t)$ with no default and $\omega_t i_t$ with default. Given R_t, there exists a critical value $\bar{\omega}_t$ such that the entrepreneur will default if the realization of the project outcome is

$$\bar{\omega}_t < \bar{\omega}_t(R_t) \equiv \frac{1}{i_t} R_t (i_t - n_t) . \tag{12}$$

Therefore, the lower the *default threshold*, $\bar{\omega}_t$, the less likely a commercial loan default. Given the above, the expected income of an entrepreneur with a net worth n_t is given by:

$$q_t^k i_t \left\{ \int_{\bar{\omega}_t}^{\infty} \omega_t d\Phi(\omega_t) - \bar{\omega}_t [1 - \Phi(\bar{\omega}_t)] \right\} \equiv q_t^k i_t f(\bar{\omega}_t) . \tag{13}$$

Moreover, the expected payoff of the bank for a loan with the borrower's net worth n_t is given by:

$$q_t^k i_t \left\{ \bar{\omega}_t [1 - \Phi(\bar{\omega}_t)] + \int_0^{\bar{\omega}_t} \omega_t d\Phi(\omega_t) - \mu \Phi(\bar{\omega}_t) \right\} \equiv q_t^k i_t g(\bar{\omega}_t) . \tag{14}$$

Given $E(\omega_t) = 1$, it is important to note from the above two equations that

$$f(\bar{\omega}_t) + g(\bar{\omega}_t) = 1 - \mu \Phi(\bar{\omega}_t) . \tag{15}$$

Thus, on average, $\mu \Phi(\bar{\omega}_t)$ of the produced capital is destroyed by monitoring and the rest is distributed between the entrepreneur $f(\bar{\omega}_t)$ and the bank $g(\bar{\omega}_t)$. We assume that the entrepreneurs offer loan contracts to competitive banks. Given net worth n_t, an entrepreneur chooses the size of investment (i_t) and the interest rate R_t through choosing $(\bar{\omega}_t)$ according to (12), to solve the following contract design problem to maximize her expected payoff of borrowing:

$$\max_{(i_t, \bar{\omega}_t)} \left\{ q_t^k i_t f(\bar{\omega}_t) \right\} \; s.t. \; q_t^k i_t g(\bar{\omega}_t) \geq R_t^c (i_t - n_t) ,$$

where R_t^c is the expected gross intratemporal loan rate. Note that R_t^c differs from R_t in two aspects: First, R_t is the commercial loan rate specified in the contract. Yet the contract may be defaulted on, and thus R_t represents a risky rate. In contrast, R_t^c is essentially a risk-free rate, which is the expected rate after taking into account the potential default. Secondly, R_t is the rate that converts a loan of consumption goods into a payment of capital goods in return, whereas R_t^c is a rate in terms of consumption goods only. Let λ_t be the Lagrangian multiplier. The first-order conditions for the above contracting problem are given by:

$$\begin{aligned} q_t^k f(\bar{\omega}_t) + \lambda_t \left[q_t^k g(\bar{\omega}_t) - R_t^c \right] &= 0 \\ q_t^k i_t f'(\bar{\omega}_t) + \lambda_t q_t^k i_t g'(\bar{\omega}_t) &= 0 \\ q_t^k i_t g(\bar{\omega}_t) - R_t^c (i_t - n_t) &= 0, \end{aligned} \tag{16}$$

where $f'(\bar{\omega}_t) = -[1 - \Phi(\bar{\omega}_t)] < 0$ and $g'(\bar{\omega}_t) = 1 - \Phi(\bar{\omega}_t) - \mu\phi(\bar{\omega}_t) > 0$. Eliminating the multiplier:

$$q_t^k f(\bar{\omega}_t) = \frac{f'(\bar{\omega}_t)}{g'(\bar{\omega}_t)} \left[q_t^k g(\bar{\omega}_t) - R_t^c \right], \tag{17}$$

which is the condition that determines the choice of $\bar{\omega}_t$. It is obvious that the threshold $\bar{\omega}_t$ depends on the capital price, q_t^k, and the intra-temporal loan rate, R_t^c, but not the net worth n_t. This is a convenient result that makes aggregating more tractable. Accordingly, the optimal intratemporal lending rate does not depend on n_t, either, because (12) and (16) together imply

$$R_t = \frac{\bar{\omega}_t i_t}{i_t - n_t} = \frac{\bar{\omega}_t R_t^c}{q_t^k g(\bar{\omega}_t)}. \tag{18}$$

The optimal investment (size) is solved from (16) and is linear in n_t:

$$i_t \left(q_t^k, n_t, R_t^c \right) = \frac{n_t}{1 - \frac{q_t^k g\left(\bar{\omega}_t\left(q_t^k, R_t^c\right)\right)}{R_t^c}}. \tag{19}$$

The aggregate new investment, given net worth n_t, across all entrepreneurs is

$$\varrho i_t \left(q_t^k, n_t \right) \left[1 - \mu\Phi\left(\bar{\omega}_t \left(q_t^k, R_t^c \right) \right) \right] = \frac{1 - \mu\Phi\left(\bar{\omega}_t\left(q_t^k, R_t^c\right)\right)}{1 - \frac{q_t^k g\left(\bar{\omega}_t\left(q_t^k, R_t^c\right)\right)}{R_t^c}} \varrho n_t. \tag{20}$$

Other entrepreneurial decisions. At the end of each period, when the project outcome has been realized, the entrepreneur takes her available income at that point and decides on consumption and savings. That is, the consumption and savings decision comes after she has borrowed (if necessary) and invested in the project and then finally repaid or defaulted on the loan, depending on the project outcome. The entrepreneur's internal funds n_t are her period-t wage and rental income, as given by

$$n_t = w_t + \left[r_t^k + q_t^k \left(1 - \delta^k \right) \right] k_{t-1}^e. \tag{21}$$

Given n_t, the entrepreneur borrows $i_t - n_t$ if necessary and invests in her project. Depending on the realization of ω_t, the entrepreneur either makes the repayment or defaults, and thus, has all project output forfeited. In particular, the entrepreneur has the following end-of-period income depending on the realized value of ω_t:

$$\begin{cases} q_t^k \left[\omega_t i_t - R_t \left(i_t - n_t\right)\right], & \text{if } \omega_t \geq \bar{\omega}_t \\ 0, & \text{if } \omega_t < \bar{\omega}_t \end{cases} \tag{22}$$

If the income is zero, then trivially $c_t^e = k_t^e = 0$. For a positive income, equation (12) implies that the entrepreneurial income reduces to $q_t^k \left(\omega_t - \bar{\omega}_t\right) i_t$. Then, the entrepreneur solves the following utility maximization problem in recursive form, taking prices and transfers $\left\{q_t^k, w_t, r_t^k\right\}$ as given:

$$\begin{aligned} V\left(k_{t-1}^e, \omega_t\right) &= \max_{\left(c_t^e, k_t^e\right)} \left\{c_t^e + \beta^e E_t V\left(k_t^e, \omega_{t+1}\right)\right\} \\ & \quad s.t. \;\; c_t^e + q_t^k k_t^e = q_t^k \left(\omega_t - \bar{\omega}_t\right) i_t, \end{aligned} \tag{23}$$

where i_t is given by (19) and n_t by (21). The expectations are taken over the random processes for the aggregate states $\left\{A_{t+1}, A_{t+1}^h\right\}$ for goods production and construction, respectively, and the idiosyncratic state ω_{t+1}. An Euler equation for any solvent entrepreneur is:

$$q_t^k = \beta^e E_t \left[\frac{q_{t+1}^k \left[r_{t+1}^k + q_{t+1}^k \left(1 - \delta^k\right)\right] f\left(\bar{\omega}_{t+1}\right)}{1 - \frac{q_{t+1}^k g\left(\bar{\omega}_{t+1}\right)}{R_{t+1}^c}}\right], \tag{24}$$

where $\bar{\omega}_t$ solves the following:

$$q_t^k \left[1 - \mu \Phi\left(\bar{\omega}_t\right) - \frac{\mu \phi\left(\bar{\omega}_t\right) f\left(\bar{\omega}_t\right)}{1 - \Phi\left(\bar{\omega}_t\right)}\right] = R_t^c, \tag{25}$$

according to equations (13), (15), and (17). Equation (24) is independent of n_t, and therefore, the equation holds for all solvent entrepreneurs.

Banking sector. The banking sector is competitive with measure one of the banks owned by patient households. They take deposits from households and make loans to households and entrepreneurs in the form of collateralized and commercial loans, respectively. For a commercial loan, the bank will verify (by incurring the monitoring cost) and forfeit any hidden output if the entrepreneur defaults on the repayment. The collateralized loan, however, is pledged by the amount of capital and housing owned by the borrowing household. Finally, it is important to recall that commercial loans are intratemporal, and collateralized loans are one-period loans.

Given monetary policy $(\bar{R}_t, R_t^b)$, bank decisions involve interest rates $\left(R_t^d, R_t^m, R_t^c\right)$, which are nominal interest rates for deposits, collateralized loans, and commercial loans, respectively.[6] The profit maximization problem of a representative bank is given by:

$$\Pi_t^B = \max_{\left(C_t, CA_t, D_t, S_t\right)} E_t \left[R_t^c C_t + \beta^1 \frac{c_{1,t}}{c_{1,t+1}} \left(\frac{R_t^m CA_t}{\pi_{t+1}} + \frac{R_t^b S_t}{\pi_{t+1}} - \frac{R_t^d D_t}{\pi_{t+1}}\right)\right]$$

[6]Since the expected commercial loan rate, R_t^c, is an intra-temporal rate, the nominal and real levels of this rate are identical.

where C_t and CA_t are respectively the total amount of commercial and collateralized loans, S_t is the real reserves held by the bank, and D_t is the total amount of deposits accepted by this bank in real terms. The term $\beta^1 \frac{c_{1,t}}{c_{1,t+1}}$ represents the bank's discount factor, given the fact that the patient households are the bank owners. The above problem is subject to (i) the *balance sheet condition*, which ensures that the total amount of the deposit is sufficient to cover the total amount of loans made: $C_t + CA_t + S_t \leq D_t$; and (ii) the *reserve requirement*, $S_t \geq \bar{R}_t D_t$. It is straightforward that the balance sheet condition must hold with equality given any $R_t^d \geq 1$. Then, we set up the Lagrangian and use the binding balance sheet condition to eliminate C_t in the objective function. Let λ_t^B be the multiplier for $S_t \geq \bar{R}_t D_t$. The first-order conditions for interior choices are:

$$R_t^c - \beta^1 E_t \left[\frac{c_{1,t}}{c_{1,t+1}} \frac{R_t^d}{\pi_{t+1}} \right] - \lambda_t^B \bar{R}_t = 0 \tag{26a}$$

$$\beta^1 E_t \left[\frac{c_{1,t}}{c_{1,t+1}} \frac{R_t^m}{\pi_{t+1}} \right] - R_t^c = 0 \tag{26b}$$

$$\beta^1 E_t \left[\frac{c_{1,t}}{c_{1,t+1}} \frac{R_t^b}{\pi_{t+1}} \right] + \lambda_t^B - R_t^c = 0. \tag{26c}$$

Given conditions (26a) - (26c), the bank profit is zero, i.e., $\Pi_t^B = 0$ for all t.

Production sector. There is a perfectly competitive production sector with the following technology: $Y_t = A \left(L_t^y\right)^{\nu} \left(K_t^y\right)^{1-\nu}$, where $A > 0$ is the goods production productivity. K_t and L_t, respectively, are capital and labor inputs. Capital depreciates at the rate of δ^k immediately after the production of consumption goods. Labor supplied by entrepreneurs and households is perfectly substitutable for production. As is standard, firm optimal decisions are such that

$$w_t = \nu A \left(L_t^y\right)^{\nu-1} \left(K_t^y\right)^{1-\nu} \tag{27}$$

$$r_t^k = (1-\nu) A \left(L_t^y\right)^{\nu} \left(K_t^y\right)^{-\nu}. \tag{28}$$

Construction sector. The housing sector is also competitive. A measure one of the construction companies produce housing according to $Y_t^h = A^h L_t^h$, where $A^h > 0$ is construction productivity. The optimal construction decision is such that $w_t = q_t^h A^h$.

3.1 Equilibrium

Definition 1 *A competitive equilibrium with money and banking consists of*

$$\{c_{j,t}, k_{j,t}, h_{j,t}, l_{j,t}, d_{j,t}, m_{j,t}, b_{j,t}, c_t^e, k_t^e, Z_t, i_t, n_t, C_t, CA_t, D_t, S_t, Y_t, K_t^y, L_t^y,$$
$$H_t, Y_t^h, L_t^h, \lambda_{j,t}, \lambda_t^B, \bar{\omega}_t, R_t^c, R_t, R_t^d, R_t^g, R_t^m, q_t^k, q_t^h, w_t, r_t^k, \pi_t, M_t, B_t, \Pi_t\}_{j=1,2}$$

for all t such that given policy $\left(\bar{R}_t, R_t^b, \xi\right)$, (i) All decisions are optimal; (ii) All markets clear; (iii) Zero profit of all competitive firms and banks; (iv) Consistency: The laws of motion for capital and *housing stocks follow*

$$K^y_{t+1} = \left(1-\delta^k\right) K^y_t + \varrho i_t \left[1-\mu\Phi\left(\bar{\omega}_t\right)\right] \tag{29}$$

$$H_t = \left(1-\delta^h\right) H_{t-1} + A^h L^h_t; \tag{30}$$

(v) Banking: $R^d_t \geq 1$*; (vi) Central banking: (1) and (2) are upheld.*

Given the above definition of equilibrium, we now list the market-clearing conditions. First, note that given the linear investment and monitoring technologies, only the first moment of the wealth distribution across entrepreneurs affects aggregate outcomes. Denote Z_t as the aggregate entrepreneurial capital stock. Next, define C^e_t as the average entrepreneurial consumption, N_t as the average entrepreneurial net worth, and I_t as the average entrepreneurial investment. Then aggregating the budget constraints and conditions (19) and (21) across all entrepreneurs solves for

$$Z_t = \varrho\left[f\left(\bar{\omega}_t\right) I_t - \frac{C^e_t}{q^k_t}\right] \tag{31}$$

$$I_t = \frac{N_t}{1-\frac{q^k_t g(\bar{\omega}_t)}{R^c_t}} \tag{32}$$

$$N_t = w_t + \left[r^k_t + q^k_t\left(1-\delta^k\right)\right]\frac{Z_{t-1}}{\varrho}. \tag{33}$$

Given (32), the market-clearing conditions of labor, capital, housing, goods, deposits, bonds, collateralized loans, and commercial loans are

$$L^y_t + L^h_t = (1-\varrho)\left[\alpha l_{1,t} + (1-\alpha) l_{2,t}\right] + \varrho \tag{34}$$

$$K^y_t = (1-\varrho)\left\{\left[\alpha k_{1,t-1} + (1-\alpha) k_{2,t-1}\right] + Z_{t-1}\right. \tag{35}$$

$$H_t = (1-\varrho)\left\{\left[\alpha h_{1,t} + (1-\alpha) h_{2,t}\right]\right. \tag{36}$$

$$Y_t = (1-\varrho)\left[\alpha c_{1t} + (1-\alpha) c_{2t}\right] + \varrho C^e_t + \varrho I_t \tag{37}$$

$$D_t = (1-\varrho)\left[\alpha d_{1t} + (1-\alpha) d_{2t}\right] \tag{38}$$

$$\frac{B_t}{p_t} = (1-\varrho)\left[\alpha b_{1t} + (1-\alpha) b_{2t}\right] \tag{39}$$

$$CA_t = (1-\varrho)\left[\alpha m_{1t} + (1-\alpha) m_{2t}\right] \tag{40}$$

$$C_t = \varrho\left(I_t - N_t\right) \tag{41}$$

Condition (35) is for clearing the capital market. Note that the notation is such that $k_{j,t-1}$ and Z_{t-1} respectively denote the amounts of capital holdings by households and entrepreneurs at the end of $t-1$ and thus at the beginning of t.

3.2 Steady State

Consider monetary policy $(\bar{R}, R^b)$ that is time-invariant. A *steady state* is an equilibrium where all real variables remain constant over time. Therefore, the steady-state inflation rate is such that $\pi = \frac{p_{t+1}}{p_t} = \frac{M_{t+1}}{M_t}$. For a given combination of policies $(\bar{R}, R^b, \xi)$, the steady-state equilibrium is one of two possible types, either with $\lambda^B > 0$ or $\lambda^B = 0$. We refer to the former as a steady state with *constrained lending*, in which case the representative bank faces a binding reserve requirement and, thus, is constrained in the amount to lend. The one with $\lambda^B = 0$ is a steady state with *unconstrained lending* as the reserve requirement does not bind. Given the assumption that $R^b \geq 1$, the following theorem for the steady state arises and Appendix A contains a detailed proof:

Theorem 1 *Provided that $R^b \geq 1$, for a given set of policies $(\bar{R}, R^b, \xi)$, a steady state with money and banking has the following properties:*

***I**. $d_2 = b_2 = k_2 = 0$. Moreover, $R^d = R^g = \pi/\beta^1$ and $R^m = \pi R^c/\beta^1$ for any given π;*

***II**. If $(\bar{R}, R^b, \xi)$ are such that $\lambda^B > 0$, there exists a unique steady state with constrained lending, iff there exists a unique solution, π_{ss}, to*

$$L_{ss}^{y}(\pi) + L_{ss}^{h}(\pi) = (1-\varrho)\left[\alpha l_1^{ss}(\pi) + (1-\alpha)\, l_2^{ss}(\pi)\right] + \varrho, \tag{42}$$

and that conditions (A.19) to (A.23) are satisfied. Functions $L_{ss}^{h}(\pi)$, $L_{ss}^{y}(\pi)$, $l_1^{ss}(\pi)$, and $l_2^{ss}(\pi)$ are specified in Appendix A.1.[7] *Given π, all steady-state variables have a closed-form solution as listed in Appendix A.1. Provided that $\lambda^B > 0$, all real variables are functions of monetary policy $(\bar{R}, R^b)$, except for $m_1 = \lambda_1 = d_2 = b_2 = k_2 = 0$. In addition, $R^c > 1$ and $\frac{\pi}{\beta^1} R^c = R^m > R^d = R^g > R^b$;*

***III**. If $\lambda^B = 0$ given $(\bar{R}, R^b, \xi)$, the steady state with unconstrained lending is unique if it exists. In this case, $R^c = 1$, $R^d = R^g = R^m = R^b$, and $\pi = \beta^1 R^b$. Monetary policy $\bar{R}$ has no effect and R^b has no real effects on the economy.*

3.2.1 Property I - General Steady-State Features

Borrowers and savers. Property I shows that impatient households find it optimal not to make bank deposits, hold bonds, or invest in capital. Furthermore, later, Property II establishes that in a steady state with constrained lending, patient households do not borrow from the bank ($m_1 = 0$). Therefore, patient households are savers, and impatient households are borrowers, a standard result in models with the patient and impatient households.

Nominal and real interest rates. R^m is the nominal rate for a one-period collateralized loan, while R^c is an intra-period, real lending rate. Thus, to convert R^c to R^m, one must apply the inflation rate and the discount factor of the patient households, as they own banks. Moreover, all else equal, both the reserve constraint multiplier λ^B and the real lending rate R^c strictly increase with the inflation rate π. As the steady-state solutions of λ^B and R^c provided in Appendix A.1

[7] We use a subscript/superscript of "ss" to denote the analytical solution of a steady-state variable.

clearly shows that the higher the inflation rate, the tighter the lending constraint induced by the reserve requirement, and thus the greater the real lending rate. Finally, the nominal deposit rate and the nominal bond rate are both one-period saving rate and are equalized in equilibrium.

3.2.2 Property II - Steady State with Constrained Lending

Inflation and labor market conditions. An important condition for the existence and uniqueness of a constrained-lending steady state is that the inflation rate can be uniquely solved from the labor-market-clearing condition. This result sheds light on the connection between inflation and labor market conditions. The left-hand side (LHS) and the right-hand side (RHS) of (42) are respectively the aggregate labor demand and supply. Figure 5 illustrates how inflation is solved by (42). The curves are depicted using the calibrated parameters specified in Table 1. A blue curve is $LHS(\pi)$ and a red curve is $RHS(\pi)$ for a given set of policy $(\bar{R}, R^b, \xi)$. Solid and dotted lines represent the impact of different policy levels, which will be discussed in Section 4.2.

Labor demand $LHS(\pi)$ is U-shaped and labor supply $RHS(\pi)$ is an increasing function. To help understand the curvatures, Figure 6 provides a decomposition of aggregate labor demand and supply: construction labor demand L^h, production labor demand L^y, saver labor supply l_1, and household-borrower labor supply l_2. The solutions to these steady-state variables are provided in Appendix A.1. The steady-state real lending rate is given by $R^c(\pi) = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1}{\pi} R^b \bar{R}\right)$ and obviously, $dR^c/d\pi > 0$. All else equal, the higher the inflation rate, the higher the real lending rate. This raises the borrowing cost for entrepreneurs and households, leading to higher capital prices and lower housing demand from household borrowers. The former reduces capital demand by production firms, and the latter suppresses labor demand by construction firms as construction withers. A higher capital price has nontrivial effects on production labor demand as it renders both an "income" effect and a "substitution" effect on production decisions similar to those from a consumer decision when faced with a rising cost. The income effect is about the increase in capital cost, reducing production overall and, thus, labor demand. The substitution effect means that a higher capital cost causes production firms to substitute away from capital for labor input. The income effect dominates at lower π (and thus R^c) while the substitution effect dominates at higher π, rendering the production-labor demand curve, and thus aggregate labor demand, U-shaped.

Both labor supply curves rise with π but for different reasons. Savers work more because of the higher capital price, and borrowers work more because of the higher loan rate. The crossing of the labor demand and supply curves determines inflation. Our quantitative experiments suggest that the two curves cross in the downward-sloping segment of the labor demand (see Figure 5). All else equal, a policy change that increases (decreases) labor demand, shifting the LHS curve upward (downward), is inflationary (deflationary). Conversely, a policy change that increases (decreases) labor supply, shifting the RHS curve upward (downward), is deflationary (inflationary).

Inflation targeting. Figure 5 provides valuable clues for the policy practice of *inflation targeting*. Although this figure presents steady-state results, the short-run inflation works in a similar way. The interaction of labor demand and supply determines equilibrium inflation. Short-run disturbances to the economy could shift either the labor demand or supply curve or both, causing the short-run equilibrium inflation to deviate from its long-run policy target. Given this, the central bank could adjust policy instruments, for example, R^b, to help the inflation rate move back toward its target level. Nevertheless, targeting an inflation level is challenging in practice for at least two reasons: one is that the source and magnitude of the short-run disturbance are often not clear, and the other is that fine-tuning the policy instruments, R^b or $\bar{R}$, moves both labor demand and supply curves simultaneously, making a precise landing back on the target challenging, especially in the context of lacking information about the original (and any subsequent) impact to the economy. Our findings highlight that the key to more effective inflation targeting is to closely monitor labor market conditions. That is, to try to obtain a better gauge of the origin/magnitude of the economic disturbance through tracking the changes in production and construction labor demand and those in household labor supply.

Monetary policy transmission. Property II shows that monetary policy can have a wide impact on the economy. The transmission mechanism is demonstrated by the analytical algorithm in Appendix A.1 for solving the steady state with $\lambda^B > 0$. Monetary policy takes effect through two channels: an *interest-rate channel* and a *bond-supply channel*. The key to the *interest-rate channel* is reflected by the solutions in Appendix A.1,

$$\lambda^B_{ss} = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1 R^b}{\pi}\right)$$

and

$$R^c_{ss} = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1}{\pi} R^b \bar{R}\right),$$

given π. The real lending rate R^c is a function of the tightness of the binding reserve/lending constraint λ^B that is directly affected by policy instruments $\bar{R}$ and R^b. Through R^c, any change to $\bar{R}$ and R^b is then transmitted to other interest rates, asset and goods prices, and individual decisions of households, entrepreneurs, and construction and production firms. The *bond-supply channel* is reflected in $(B/p)_{ss}$, b_1^{ss} and l_1^{ss} in Appendix A.1. The policy rate R^b directly affects real bond supply, B/p, which goes to impact individual savers' bond investment and then labor supply.

Housing collateral for household loans. The finding $k_2^{ss} = 0$ implies that borrowers' bank debt is collateralized by housing only. In models with patient and impatient households and capital as the only asset, such as Cordoba and Ripoll (2004), impatient households collateralize their debt by capital holdings. In contrast, our model allows households to use both capital and housing as collateral, but they choose to use housing solely. Unlike capital, housing provides a direct utility benefit. Accordingly, impatient households are strictly better off investing in just housing to take advantage of the direct utility benefit, the asset value, and the collateral value of housing.

3.2.3 Property III - Steady State with Unconstrained Lending

Monetary policy has no real effect in a steady state with $\lambda^B = 0$, if it exists. Intuitively, if $(\bar{R}, R^b)$ are such that the reserve requirement is lax for banks, then these policy parameters will not appear in any solution to non-monetary variables.[8] This knife-edge case of a steady state is not the focus of our study. Therefore, our quantitative studies only consider policy $(\bar{R}, R^b, \xi)$ such that $\lambda^B > 0$.

4 Quantitative Studies

4.1 Parameterization

We calibrate the model to the US economy, setting one period to correspond to a quarter. The discount factors for patient and impatient households adhere to the approach outlined in Iacoviello (2005). In particular, we use 0.99 for patient households and 0.95 for impatient households. The monitoring cost is set at 0.25, which is consistent with Carlstrom and Fuerst (1997). We set the value of the measure of entrepreneurs to 0.1 following Carlstrom and Fuerst (1997), and the measure of patient households to 0.64 following Iacoviello (2005). The depreciation rate of capital is 0.025, and the share of labor in production is 0.69, as is commonly used in the literature. The labor disutility parameter, γ, is calibrated so that households allocate approximately one-third of their available time to work, with total time normalized to one. In accordance with Greenwood et al. (1997), the housing depreciation rate is 0.0125. For the realization of the project outcome, ω_t, we assume a mean of one, with a normal distribution and a variance of σ. Similar to Carlstrom and Fuerst (1997), we use the entrepreneurs' discount factor β^e and σ to match (i) a quarterly bankruptcy rate of 0.974 percent and (ii) an average spread between the prime rate and the three-month commercial paper rate of 187 basis points per annum.[9]

The steady-state value of the loan-to-value ratio is set to 0.765 using data from the Federal Housing Agency. For the housing demand utility, we calibrate the model to match the household debt-to-GDP ratio, which stands at 71.52% based on the most recent data (2024:Q4) from the IMF. This calibration yields a reasonable housing investment-to-GDP ratio of 3.8% in our model, closely aligning with the BEA data for the last quarter of 2024. We set the reserve requirement to 10% as it was the last reserve rate implemented in the U.S. before it was reduced to zero in March 2020. Using data obtained from the Federal Reserve Board for interest rates on reserves, we set R^b to 2% annually, which is close to the long-run average.

For short-run dynamics, we consider the effects of adverse shocks on the following: total factor productivity (TFP) (A_t), construction (A_t^h), labor supply (γ_t), housing demand (φ_t), LTV (ξ_t),

[8] Proof for Property III is available upon request.

[9] We conduct a sensitivity analysis for the values of σ. In particular, we examine how the variables change as σ increases, which creates uncertainty for the *i.i.d.* shock, ω_t. The results are consistent with what we observe with the other policies. The results are available upon request.

reserve rate (R_t^b), and reserve requirement ($\bar{R}_t$). These shocks follow the AR(1) below:

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_{A,t}, \quad (43)$$

$$\ln A_t^h = \rho_{A^h} \ln A_{t-1}^h + \varepsilon_{A^h,t}, \quad (44)$$

$$\ln \gamma_t = (1-\rho_\gamma)\ln\bar{\gamma} + \rho_\gamma \ln \gamma_{t-1} + \varepsilon_{\gamma,t}, \quad (45)$$

$$\ln \varphi_t = (1-\rho_\varphi)\ln\bar{\varphi} + \rho_\varphi \ln \varphi_{t-1} + \varepsilon_{\varphi,t}, \quad (46)$$

$$\ln \xi_t = (1-\rho_\xi)\ln\bar{\xi} + \rho_\xi \ln \xi_{t-1} + \varepsilon_{\xi,t}, \quad (47)$$

$$\ln \bar{R}_t = (1-\rho_{\bar{R}})\ln\bar{R} + \rho_{\bar{R}} \ln \bar{R}_{t-1} + \varepsilon_{\bar{R},t}, \quad (48)$$

$$\ln R_t^b = (1-\rho_{R^b})\ln R^b + \rho_{R^b} \ln R_{t-1}^b + \varepsilon_{R^b,t}, \quad (49)$$

where $\{\bar{R}, R^b, \bar{\xi}\}$ are the long-run policy parameters that the central bank controls, $\rho_A, \rho_{A^h}, \rho_\gamma, \rho_\varphi, \rho_\xi, \rho_{\bar{R}}, \rho_{R^b} \in (-1,1)$ measure persistence, and $\{\varepsilon_{A,t}, \varepsilon_{A^h,t}, \varepsilon_{\gamma,t}, \varepsilon_{\varphi,t}, \varepsilon_{\xi,t}, \varepsilon_{\bar{R},t}, \varepsilon_{R^b,t}\}$ are *i.i.d.* standard normal processes. We follow the literature for stochastic processes where similar shocks have been used as outlined in Table 1. Our next step is to perform quantitative exercises to analyze the effects of policies in both the long and short run using this model parameterization.

4.2 Long-Run Policy Effects

For the long-run policy effects, we conduct comparative statics on the benchmark model with two sets of policies: the monetary policy of fractional reserve banking ($\bar{R}, R^b$) and the macroprudential

Table 1: Calibration

(Model Period: Quarter)	**Parameters**	**Value**	**Source**
Patient HH discount factor	β^1	0.99	Iacoviello (2005)
Impatient HH discount factor	β^2	0.95	Iacoviello (2005)
Entrepreneur's discount factor	β^e	0.97	SS target
Monitoring cost	μ	0.25	Carlstrom and Fuerst (1997)
Measure of entrepreneurs	ϱ	0.1	Carlstrom and Fuerst (1997)
Measure of patient HH	α	0.64	Iacoviello (2005)
Depreciation rate of capital	δ^k	0.025	literature
Depreciation rate of housing	δ^h	0.0125	Greenwood et al. (1997)
Share of labor in production	ν	0.69	literature
Standard deviation of $\Phi(\omega)$	σ	0.363	SS target
Steady State Values			
LTV	$\bar{\xi}$	0.765	Federal Housing Agency
Housing demand	$\bar{\varphi}$	0.1325	SS target
Labor disutility	$\bar{\gamma}$	2.7	SS target
Reserve requirement	$\bar{R}$	0.1	FED & FDIC
Reserve rate	R^b	1.005	Federal Reserve Board
Stochastic Processes			
Persistence of housing demand shock	ρ_φ	0.99	Liu et al. (2013)
Persistence of LTV shock	ρ_ξ	0.98	Liu et al. (2013)
Persistence of TFP shock	ρ_A	0.95	Iacoviello and Neri (2010)
Persistence of construction shock	ρ_{A^h}	0.997	Iacoviello and Neri (2010)
Persistence of labor supply shock	ρ_γ	0.92	Higgins and Sapci (2022)
Persistence of reserve requirement shock	$\rho_{\bar{R}}$	0.99	Carrera et al. (2012)
Persistence of reserve rate shock	ρ_{R^b}	0.92	Carrera et al. (2012)

policy of controlling the loan-to-value ratio ($\bar{\xi}$). Unless otherwise stated, all variables mentioned in this section refer to the steady-state levels. Welfare is defined as

$$\mathcal{W} = (1-\varrho)\left[\alpha\frac{\ln(c_1)+\varphi\ln(h_1)-\gamma l_1}{1-\beta^1} + (1-\alpha)\frac{\ln(c_2)+\varphi\ln(h_2)-\gamma l_2}{1-\beta^2}\right] + \varrho\frac{C^e}{1-\beta^e}.$$

We define *commercial loan leverage* as the average entrepreneurial debt relative to the average entrepreneurial equity in the project, *i.e.*,

$$\begin{array}{c}\text{Commercial}\\ \text{leverage}\end{array} = \frac{I-N}{N} = \left[\frac{R^c}{q^k g(\bar{\omega})} - 1\right]^{-1}.$$

A fall in the commercial loan leverage means de-leveraging of such loans. We provide a measure of the aggregate risk in the financial sector, the *Financial Risk Index* (FRI) defined as

$$FRI_t = \frac{\Phi(\bar{\omega}_t)\,C_t}{CA_t + C_t} = \frac{\Phi(\bar{\omega}_t)}{1+\frac{CA_t}{C_t}}. \tag{50}$$

FRI measures the total amount of defaulted commercial debt as a proportion of total debt. As is shown next, monetary and macroprudential policies alter the risk structure of the financial sector by affecting (i) the riskiness of commercial debt contract as indicated by $\bar{\omega}_t$; and (ii) the bank portfolio choice, which results in the CA/C ratio. Next, we will present the quantitative results on the long-run policy effects and use the analytical results from Theorem 1 to help reconcile the quantitative findings. Figures 1-2 illustrate the long-run effects of a tighter monetary policy, respectively for rises in $\bar{R}$ and R^b. Both a higher $\bar{R}$ and R^b increase the real loan rate and end up contracting economic activities. To see this, recall (A.1) to derive that for each unit of reserves, a bank earns a profit of $R^b - R^d = -\frac{\pi}{\beta^1}\lambda^B(1-\bar{R}) < 0$ given $\lambda^B > 0$. That is, banks earn a strict loss on keeping reserves. Both π and λ^B rise with R^b, as suggested by Figure 1, which implies that the marginal loss on reserves ($R^b - R^d$) rises with R^b. As for $\bar{R}$, recall from Theorem 1 that $R^d = \pi/\beta^1$, which implies $R^b - R^d = R^b - \frac{\pi}{\beta^1}$. Figure 1 suggests that π falls with $\bar{R}$. Therefore, banks' marginal loss on reserves also rises with $\bar{R}$. A direct consequence is that banks require higher loan profits in order to balance off the higher reserve losses. Therefore, R^c rises with both $\bar{R}$ and R^b, which suppresses bank lending.

4.2.1 Monetary Policy

Financial risk. Figures 1 and 2 show that the rise in R^c as a result of higher $\bar{R}$ or R^b shrinks both collateralized household loans and commercial loans. Additionally, bank lending displays a *flight to safety*, as reflected by a rise in the ratio of collateralized (CA) loans relative to commercial (C) loans. Reduced commercial lending also leads to deleveraging (*i.e.*, lower commercial leverage) and less default (*i.e.*, lower $\bar{\omega}$). As shown by (50), a rise in CA/C and a fall in $\bar{\omega}$ indicate that tighter monetary policy can help mitigate overall financial risk, reflected by a decrease of FRI.

Crowding out. A tighter monetary policy leads to *relative crowding out* of commercial loans by collateralized loans in the sense that there is a rise in CA/C while the volumes of both loan types shrink. The crowding-out effect on the financial side leads to real consequences. Figures 4a and 4b show the steady-state *output/housing elasticity*, which is defined as the percentage change in output relative to that in housing construction given a marginal change in a monetary policy parameter. As the figures illustrate, financial crowding out translates into real sector crowding out. Specifically, a 1% decline in housing output leads to an approximately 0.59% reduction in goods production for the benchmark cases, highlighting the strong interdependence and spillover effects between the two sectors. The figures also reveal that housing output is more responsive to policy changes than goods production. Moreover, as monetary policy becomes more contractionary, the elasticity decreases, indicating a weakening influence of housing on goods production.

Inflation. Figures 1 and 2 show that inflation falls in $\bar{R}$ but rises in R^b. To understand these effects, let us refer to Figure 5a, which displays the determination of the steady-state inflation using the labor-market-clearing condition (42). The blue lines in Figure 5a represent the aggregate labor demand, the LHS of (42), and the red lines represent the aggregate labor supply, the RHS of (42). The solid curves are given $\bar{R} = 0.1$, and the dotted ones are for $\bar{R} = 0.01$. The intersection of each pair of curves is the corresponding steady-state gross inflation rate, π_{ss}. Similarly, Figure 5b illustrates the effects of a fall in R^b on π_{ss}. In the figure, R^b takes the values of 1.0005 and 1.005, corresponding to 0.2% and 2% annual rates.

To understand how policy $\bar{R}$ or R^b impacts the positions of the curves $LHS(\pi)$ and $RHS(\pi)$, let us first explore the *interest-rate channel* and see how these policy parameters affect the function $R^c(\pi)$, which is the steady-state real lending rate taking π as given. Recall that $R^c_{ss}(\pi) = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1}{\pi} R^b \bar{R}\right)$. Then,

$$\frac{\partial R^c(\pi)}{\partial \bar{R}} = \frac{1}{(1-\bar{R})^2}\left(1 - \frac{\beta^1}{\pi} R^b\right) > 0$$

and

$$\frac{\partial R^c(\pi)}{\partial R^b} = \frac{1}{1-\bar{R}}\left(-\frac{\beta^1}{\pi}\bar{R}\right) < 0,$$

where the first inequality is because $\lambda^B > 0$ requires $\pi > \beta^1 R^b$. These partial derivatives are the direct, but not overall, effects of policy parameters on the steady-state real lending rate R^c. However, they are useful in shedding light on how policy moves the curves of $LHS(\pi)$ and $RHS(\pi)$. Given inflation rate, since $\partial R^c(\pi)/\partial \bar{R} > 0$, the required reserve ratio has a direct effect of increasing the real lending rate as it constrains the amount of lending. Therefore, in Figure 5a a decrease in $\bar{R}$ leads to a lower real lending rate $R^c(\pi)$ for any given π. The lower lending rate tends to increase labor demand as improved lending conditions stimulate production and construction. In the meantime, it tends to decrease labor supply as the lower lending rate also lowers the capital prices faced by household savers and the interest burden on household borrowers. This is generally consistent with how the demand and supply curves are respectively shifted by the decrease in $\bar{R}$

shown in Figure 5a. The labor demand and supply curves cross at a new steady-state inflation rate that is to the right of the original one. In other words, a higher $\bar{R}$ reduces inflation.

Now let us examine R^b. Given $\partial R^c(\pi)/\partial R^b < 0$, the reserve rate has an overall negative direct effect on the real lending rate for any given π. This can be understood by the steady-state solutions,

$$\lambda^B(\pi) = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1 R^b}{\pi}\right)$$

and

$$R^c(\pi) = \frac{\beta^1}{\pi}R^b + \lambda^B.$$

The latter equation implies that given π, R^b has both a positive and a negative *direct* effect on R^c. The positive effect is through the term $\frac{\beta^1}{\pi}R^b$. The negative one is through the direct negative effect of R^b on λ^B, *i.e.*, $\partial\lambda^B(\pi)/\partial R^b < 0$. This suggests that the overall result of $\partial R^c(\pi)/\partial R^b < 0$ is driven by the channel that, all else equal, a higher reserve rate increases bank profit and relaxes the lending constraint, as banks rely less on profiting from lending. Therefore, the policy experiment depicted in Figure 5b shows that a fall in R^b tends to increase labor supply and decrease labor demand due to the rising real lending rate.

In addition to the interest-rate channel, R^b takes effect through a *bond-supply* channel. The solutions $(B/p)_{ss}$ and b_1^{ss} imply $b_1 = \frac{R^b-1}{\pi(1-\varrho)\alpha}S$, which shows that R^b has a direct positive effect on b_1. Then (A.16) indicates that R^b has an indirect negative effect on savers' labor supply l_1 through b_1. In sum, both channels of interest rate and bond supply have a negative effect on labor supply function $RHS(\pi)$. As is shown by Figure 5b, dotted curves of $LHS(\pi)$ and $RHS(\pi)$ cross at a new inflation rate to the right of the original one. Therefore, a higher R^b ends up being inflationary.

Welfare. Figures 7a and 7b show that a contractionary monetary policy improves overall welfare for the range of policy measures considered. However, the policy's impact varies across agent types. Both entrepreneurs and household savers benefit from a tighter monetary policy. In particular, entrepreneurs are better off because the contractionary policy raises the real loan rate, which leads to higher capital prices and greater entrepreneurial income. Savers are better off because higher interest rates render greater earnings from asset holdings in addition to the benefits from increased capital prices. In contrast, household borrowers are adversely affected as higher loan rates make mortgages more costly. Finally, in Figures 7a and 7b, $\bar{R}$ takes values up to 25 percent[10] and R^b takes values up to 1.1 (providing an annual rate up to 40%). Policy values beyond these upper bounds do not support the steady state with constrained lending. This is due to impatient households no longer finding it optimal to borrow under such tight monetary policy.

[10]The maximum value we observe over the last two decades, according to data from the Federal Reserve Board.

4.2.2 Macroprudential Policy

Financial risk. Macroprudential policy is achieved by adjusting $\bar{\xi}$. Figure 3 demonstrates that increasing $\bar{\xi}$ is an expansionary policy as it raises both types of loans. CA loans react more to macroprudential policy than C loans. When $\bar{\xi}$ increases, CA increases at a rising rate whereas C increases at a decreasing rate and thus, CA/C ends up taking the pattern of CA loans. Moreover, more relaxed credit conditions increase the default and commercial leverage, making commercial loans riskier. Despite the increase in $\bar{\omega}$ and commercial leverage, the increase in CA/C dominates, resulting in a fall in FRI. These results highlight that considering the distributional effects of bank loans is critical in evaluating the true financial risk.

Crowding out. Relaxing macroprudential policy leads to a relative crowding out of C loans by CA loans as the CA/C ratio rises along with both loan volumes. Even when it is relative, crowding out on the financial side has uneven impacts on the real sectors. Figure 4c illustrates that the relaxed credit conditions for CA loans favor the housing market over the goods market, as indicated by the production/housing elasticity being below one. That is, the percentage expansion in construction is greater than that in production, given a relaxed policy. Moreover, the gap in the impacts on the two sectors widens as the collateralized credit conditions relax further.

Inflation. Expansionary macroprudential policy has a negligible impact on inflation, as is shown in Figure 5c. A higher $\bar{\xi}$ relaxes the collateral constraint and thus raises the collateral value of housing. Thus, demand for both housing and construction labor rises. Additionally, household borrowers work more to afford more housing and obtain larger loans, stimulating the labor supply. Since relaxing $\bar{\xi}$ directly benefits household borrowers, the change in labor supply marginally dominates the change in labor demand, causing the two curves to cross at slightly lower inflation.

Welfare. Figure 7c shows that expansionary macroprudential policy improves overall welfare slightly. Higher LTVs benefit both household savers and borrowers, while entrepreneurial welfare decreases. Expansionary macroprudential policy boosts housing demand by improving credit access and benefits savers due to higher house prices, causing an increase in deposits. Lower loan rates increase capital production, reducing capital prices and entrepreneurial income. Initially, firms substitute labor with cheaper capital, lowering labor demand, but as capital prices fall further, production and labor demand rise, creating a U-shaped effect on labor demand. Higher labor demand raises wages, benefiting savers and borrowers and increasing welfare.

4.3 Short-Run Dynamics

For short-run dynamic studies, we respectively introduce an unexpected 1% change in the innovations of the stochastic processes (43) to (49), to create *adverse* shocks in the economy. Figures 8 and 9 display impulse responses to these adverse shocks. Figures 8 summarizes the responses of the banking variables, and Figure 9 is for real variables.

Monetary policy shocks. As shown in Figure 8, similar to long-run effects, tighter monetary policy generally impacts both loan volumes negatively and the CA/C ratio positively. Such a policy shock also mitigates financial risk (FRI) by lowering commercial loan default ($\bar{\omega}$) and by inducing banks to pivot toward safe, collateralized household loans. The latter suggests that both long-run and short-run contractionary monetary policy impacts give rise to relative crowding out of collateralized household loans to commercial loans. As a result of such policy, production and construction are both affected negatively (Figure 9), while construction responds at a greater magnitude than production. Overall, a reserve rate shock (R^b) and a reserve requirement shock ($\bar{R}$) have qualitatively similar effects. The only difference is that upon initial impact, the unexpected positive shock to R^b stimulates the economy by positively affecting both loans. This is because banks initially receive an unexpectedly higher amount of interest payment, which helps temporarily relax the lending constraint.

Absolute and relative crowding out. Like the monetary policy shocks, the adverse construction shock (A^h) also leads to a *relative crowding out* by negatively impacting both loans. However, in contrast to the monetary policy shocks, the adverse construction shock affects the CA/C ratio negatively and, therefore, causes commercial lending to crowd out collateralized household lending. These findings have empirical implications as they suggest a closer look at the ratio of bank loan volumes across types to find clues of financial crowding out, especially when the volumes appear to move in the same direction. The rest of the shocks, *i.e.*, $(A, \varphi, \xi, \gamma)$, all lead to *absolute crowding out* as these shocks impact the volumes of the two types of loans in opposite directions. Adverse shocks to TFP (A) and labor supply (γ) favor collateralized household loans, while adverse shocks to housing demand (φ) and LTV (ξ) make banks favor commercial lending. Crowding out effects of the macroprudential policy are slightly different as long-run suggests a relative, but short-run suggests an absolute crowding out. The difference comes from the fact that long-run investment also decreases due to high capital prices stemming from the decrease in LTV. However, in the short run, capital prices barely change (if anything decreases), which allows entrepreneurs to invest in capital and thus slightly increase the demand for commercial loans. It is worth noting that a decrease in housing demand (φ) produces similar results to the decrease in LTV, as the latter affects the housing demand indirectly while the former has a direct effect.

Financial risk. The CA/C ratio, a direct consequence of the bank portfolio choice, is the driving factor of a shock's impact on the financial risk index (FRI), even though the commercial-lending risk ($\bar{\omega}$) is also a component of the FRI. As shown in Figure 8, the responses of CA/C and FRI go in opposite directions. Whenever the CA/C is positively affected, that is, banks pivot toward safe, collateralized household loans, the overall financial risk is negatively impacted; and *vice versa.* To see how CA/C overpowers $\bar{\omega}$ in their effects on FRI, take the construction shock (A^h) as an example. The adverse A^h shock has a negative effect on $\bar{\omega}$, causing less default on commercial loans. This should help reduce financial risk. However, the adverse A^h shock actually exacerbates financial risk, reflected by a positive response of FRI, because it leads to a negative response in

CA/C as banks favor the risky commercial lending in a relative term.

Real sectors. Figure 9 shows the responses of the real sector variables to different shocks. Adverse shocks cause an overall decrease in GDP, which is the sum of goods and housing production in the economy, but have differing effects on sectors. For instance, the shocks that directly affect the housing market, such as adverse housing demand and LTV shocks, favor goods production while simultaneously hurting construction. In contrast, the adverse TFP shock favors the housing market over goods production. A shock like labor supply that affects both construction and production leads to a reduction in both sectors. In addition, the housing market responds expectedly to all shocks. In particular, real house prices tend to decrease due to adverse TFP, housing demand, and LTV shocks. Meanwhile, house prices increase due to adverse construction, labor supply, and monetary policy shocks. The responses to the latter two are worth a closer examination.

First, labor supply shocks impact construction more than production because the former is more labor-intensive. Thus adverse labor supply shocks lead to a more significant decrease in construction, pushing up real house prices. Secondly, the housing sector is more sensitive to monetary policy shocks than the production sector because household borrowers are risk-averse, unlike entrepreneur borrowers, and therefore, the housing demand is more responsive to monetary policy, which affects lending conditions in general. As a result, adverse monetary policy shocks generate a greater reduction in construction relative to production and, thus, a rise in real house prices.

5 Empirical Support

5.1 Riskiness of Loan Types

In our theoretical framework, there are inherited risks associated with commercial loans that are not present in collateralized loans. While, in reality, people can also default on their mortgages, widespread collateralization, as well as federal guarantees, makes it a safer bet for banks (Cebenoyan and Strahan (2004) and Foos et al. (2010)). As shown in Table 3, Commercial and Industrial (C&I) loans have been twice as volatile as real estate loans over the past two decades, which includes both commercial and residential real estate loans. This gap widens further for residential loans alone. In fact, C&I loans are more than three times as volatile as residential real estate loans.

Table 2: Coefficient of Variation of C&I Loans Against Real Estate Loans

2004:6-2023:3	**Coefficient of variation**
Commercial and Industrial Loans	0.321
Real Estate Loans	0.166
Commercial Real Estate Loans	0.250
Residential Real Estate Loans	0.106

Source: Board of Governors of the Federal Reserve System (US).

Although volatility is important for the overall financial system as a risk measure, individual banks may be more concerned with the losses they may incur from each type of loan. Table 3 shows the charge-off rates of each type of loan, which are defined as the value of loans and leases that have been removed from the books and charged against loss reserves. Therefore, charge-off rates are determined by dividing the flow of a bank's net charge-offs (*i.e.*, gross charge-offs minus recoveries of a bank) during a quarter by the average amount of its outstanding loans throughout that quarter. Table 3 indicates that banks tend to experience greater losses with C&I loans than with real estate loans. As is the case with volatility measures, this gap expands further when comparing C&I loans to residential real estate loans. Interestingly, the bank size does not play a significant role in this situation. Smaller banks have higher charge-off rates for C&I loans and lower charge-off rates for single-family residential real estate loans. This implies that C&I loans pose a relatively greater risk for all banks, particularly smaller ones.

Table 3: Charge-off Rates of C&I Loans Against Real Estate Loans

Charge-off Rate (percent)	**All Commercial Banks**	**Top 100**	**Non-top 100**
All loans	0.883	0.982	0.627
Commercial and industrial loans	0.779	0.731	0.87
Loans secured by real estate	0.438	0.522	0.319
Single-family residential mortgages	0.389	0.433	0.197
Commercial real estate loans	0.487	0.614	0.395

Note: The ratios are multiplied by 400 to express them in annual percentages. Data are obtained from the Federal Reserve Board and cover the period 1985:1-2022:4.

5.2 Relative Crowding Out

We now search for clues of relatively crowding out driven by contractionary monetary policy, as our model suggests. In particular, we have theoretically shown that while banks decrease both types of loans upon a tighter monetary policy, they display a "*flight to safety*" behavior and favor relatively safer loans by raising the CA/C ratio, creating a relative crowding out in the economy.

Empirically measuring the effects of monetary policy on loans is not simple due to endogeneity concerns. In particular, while monetary policy can affect loans, the amount of loans can also affect monetary policy. For instance, at a time when there are not enough loans, the central bank could decide to engage in expansionary monetary policy to relieve the pressure in the financial sector. Therefore, we conduct a five-variable VAR to better comprehend the effects of monetary policy on loans while addressing macroeconomic endogeneity: $\Delta Y_t = \alpha + A(L)\Delta Y_{t-1} + e_t$, where Y is the vector of variables that include (1) the ratio of real estate loans to commercial and industrial loans to capture the loan distribution of banks or the individual loans, (2) the federal funds effective rate to capture the monetary policy, (3) the industrial production index to account for the business cycle changes, (4) house prices, specifically Median Sales Price for New Houses Sold in the United States, to capture the housing market dynamics, and (5) Chicago Fed National Financial Conditions Index to account for the risk in the financial sector. $A(L)$ is a matrix of lagged coefficients, and e is the robust error term.[11] Δ indicates the first difference of the logged data to ensure the series are

[11] The most conservative Cholesky order is used in estimation, and the optimal lags are chosen by using both Akaike's information criterion and Schwarz's Bayesian information criterion.

stationary. The data period is 1963:1-2023:3 and is monthly.[12]

Figure 10 illustrates the impact of a one standard deviation increase in the federal funds effective rate on each loan type, commercial and industrial (C&I) and real estate. As expected, Figures 10a and 10b confirm that tighter monetary policy decreases both loans. However, Figure 10c shows that while both loans decrease, there is a significant increase in the ratio of real estate to commercial and industrial loans, which corresponds to the CA/C ratio. Overall, banks favor real estate loans relative to commercial and industrial loans when monetary policy is contractionary, creating a relative crowding out. These findings are consistent with our model predictions.

6 Conclusion

We have constructed a tractable theoretical macro model of money, banking and finance that allows banks to make a portfolio choice over risky commercial and collateralized household loans. Our key findings are the following: First, the bank portfolio choice is a crucial factor in driving the crowding-out effects of bank lending and the overall financial risk. Second, steady-state inflation is endogenously determined by the interaction of labor demand and supply. Third, various sources of short-run disturbances or long-run policy changes can lead to absolute or relative crowding out. Absolute crowding out occurs when the volumes of the two loans move in opposite directions and, therefore, generally have opposite effects on the housing and production sectors. Relative crowding out moves the loan volumes in the same direction but still impacts the real sectors unevenly. Finally, contractionary monetary policy reduces loan volumes, pivots bank lending toward collateralized household loans, and mitigates financial risk.

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A Appendix: Proof of Theorem 1

The steady-state version of conditions (26a) - (26c) yields

$$R^c = \frac{\beta^1}{\pi} R^d + \lambda^B \bar{R} = \frac{\beta^1}{\pi} R^m = \frac{\beta^1}{\pi} R^b + \lambda^B. \tag{A.1}$$

If $\lambda^B = 0$, then $\frac{\pi}{\beta^1} R^c = R^m = R^d = R^b$. That is, there are no spreads between the nominal lending rate, the nominal deposit rate, and the nominal reserve rate. If $\lambda^B > 0$, banks only maintain the required amount of reserves, *i.e.*, $S = \bar{R}D$. Moreover, $\frac{\pi}{\beta^1} R^c = R^m > R^d > R^b$. In this case, the reserve rate R^b paid by the central bank is less than the deposit rate R^d, and therefore, banks incur a strict loss by keeping reserves as required. A direct consequence is that the lending rate R^m must be above the deposit rate so that banks earn a strictly positive profit from lending to balance off the loss from the required reserves. For the rest of the proof, we will focus on solving the steady state with $\lambda^B > 0$. The steady state of $\lambda^B = 0$ can be solved in a similar way. In the interest of saving space, the proof of Property III is available upon request.

All households, banks, and firms take policy parameters $\left(\bar{R}, R^b\right)$ as given when making decisions. Conditions (8) to (10) in steady state become

$$1 \geq \beta^j \frac{R^d}{\pi}, \quad d_j \geq 0 \tag{A.2}$$

$$1 \leq R^m \left[\beta^j \frac{1}{\pi} + \lambda_j c_j\right], \quad m_j \geq 0 \tag{A.3}$$

$$1 \geq \beta^j \frac{R^g}{\pi}, \quad b_j \geq 0, \tag{A.4}$$

where all pairs hold with complementary slackness. Given $\beta^2 < \beta^1$, condition (A.2) implies that in the steady state $1 = \beta^1 \frac{R^d}{\pi} = \beta^1 \frac{R^g}{\pi} > \beta^2 \frac{R^d}{\pi} = \beta^2 \frac{R^g}{\pi}$. The inequality in the above implies $d_2 = b_2 = 0$ and the equality yields $R^d = R^g = \pi/\beta^1$. Hence, we have Properties I of Theorem 1.

Condition (A.1) implies $R^c = 1$ if $\lambda^B = 0$ and $R^c > 1$ if $\lambda^B > 0$, which together with $R^d = \pi/\beta^1$ yields $R^b = \frac{\pi}{\beta^1}\left(1 - \lambda^B + \lambda^B \bar{R}\right)$. Take π as given and solve for $\lambda^B = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1 R^b}{\pi}\right)$. Then condition (A.1) yields $R^c = \frac{\beta^1}{\pi} R^b + \lambda^B \bar{R} = \frac{1}{1-\bar{R}}\left(1 - \frac{\beta^1}{\pi} R^b \bar{R}\right)$ and $R^m = R^b + \frac{\pi}{\beta^1}\lambda^B$. Note that the real lending rate, R^c, is a function of the SS inflation rate, π. Later, we will show that this is the key channel through which monetary policy makes long-run real impacts on the economy given $\lambda^B > 0$. Recall that $R^m > R^d$ if $\lambda^B > 0$. Thus given $\lambda^B > 0$ and $R^d = \pi/\beta^1$, we have $R^m > R^d = \frac{1}{\frac{1}{R^d}} \geq \frac{1}{\frac{1}{R^d} + \lambda_1 c_1} = \frac{1}{\frac{\beta^1}{\pi} + \lambda_1 c_1}$, where $\lambda_1 \geq 0$ is the multiplier of the household collateral constraint. Therefore, the first inequality in condition (A.4) for $j = 1$ is strict, which implies $m_1 = 0$. Given the collateral constraint (11), $m_1 = 0$ implies $\lambda_1 = 0$ for any strictly positive holdings of capital and housing by the patient households. Thus, we have $m_1 = \lambda_1 = 0$ in the steady state if $\lambda^B > 0$. Given $m_1 = 0$, an equilibrium with collateralized debt must have $m_2 > 0$. Then condition (A.4) for $j = 2$ requires $1 = R^m \left[\beta^2 \frac{1}{\pi} + \lambda_2 c_2\right]$, which given $\frac{\pi}{\beta^1} R^c = R^m$ yields $\lambda_2 = \frac{1}{\pi c_2}\left(\frac{\beta^1}{R^c} - \beta^2\right)$. Moreover, condition (11) solves for $m_2 = \frac{1}{R^c}\beta^1 \xi \left(q^k k_2 + q^h h_2\right)$. Assuming interior solutions, optimality conditions, (5) - (7), imply that in the steady state,

$$
\begin{aligned}
w &= \gamma c_1 = \gamma c_2 \equiv \gamma c && \text{(A.5)}\\
q^k &= \beta^1 \left(r^k + \left(1-\delta^k\right) q^k\right) && \text{(A.6)}\\
q^k &= \beta^2 \left(r^k + \left(1-\delta^k\right) q^k\right) + \pi c \lambda_2 \xi q^k && \text{(A.7)}\\
q^h &= \varphi \frac{c}{h_1} + \beta^1 \left(1-\delta^h\right) q^h && \text{(A.8)}\\
q^h &= \varphi \frac{c}{h_2} + \beta^2 \left(1-\delta^h\right) q^h + \pi c \lambda_2 \xi q^h. && \text{(A.9)}
\end{aligned}
$$

Equation (A.6) implies $r^k = q^k \left[\frac{1}{\beta^1} - \left(1-\delta^k\right)\right]$. Then substituting λ_2 and (A.6) into (A.7) yield $q^k = \frac{r^k}{\frac{\frac{\beta^1}{R_c}-\beta^2}{\beta^1-\beta^2}\xi - \left(1-\delta^k\right)}$, which becomes $\frac{\beta^1-\beta^2}{\frac{\beta^1}{R_c}-\beta^2} = \xi\beta^1$ given r^k. Given $R^c \geq 1$ if $\lambda^B \geq 0$, we have $\frac{\beta^1-\beta^2}{\frac{\beta^1}{R_c}-\beta^2} \geq 1$ and it is not possible to have $\frac{\beta^1-\beta^2}{\frac{\beta^1}{R_c}-\beta^2} = \xi\beta^1$ given $\xi, \beta^1 < 1$. It follows that condition (A.7) cannot hold with equality. Therefore, $q^k > \beta^2 \left(r^k + \left(1-\delta^k\right) q^k\right) + \pi c \lambda_2 \xi q^k$ and thus $k_2 = 0$. Then the equation for m_2 yields $m_2 = \frac{1}{R^c}\beta^1 \xi q^h h_2$. Finally, budget constraints of the patient and impatient households simplify to

$$
c + q^h \delta^h h_1 = w l_1 + \left(r^k - q^k \delta^k\right) k_1 + \left(\frac{1}{\beta^1} - 1\right)(d_1 + b_1)
$$

and

$$
c + q^h \delta^h h_2 = w l_2 + \left(1 - \frac{R^c}{\beta^1}\right) m_2,
$$

where we have incorporated $c_1 = c_2 = c$, $d_2 = k_2 = m_1 = 0$, $R^d = \pi/\beta^1$, $R^m = \pi R^c/\beta^1$, and that dividends are zero in equilibrium.

A.1 Algorithm for solving the steady state with $\lambda^B > 0$

The algorithm takes three steps: **Step 1**. Recall that given $\lambda^B > 0$, we have $m_1^{ss} = \lambda_1^{ss} = d_2^{ss} = k_2^{ss} = 0$. **Step 2**. This is a complex step in which we take the inflation rate π as given and solve for the rest of the steady state variables. Later in Step 3, we derive the equation for solving the steady state level of inflation, π_{ss}. First, recall that $R_{ss}^d = R_{ss}^g = \frac{\pi}{\beta^1}$, the solutions to $(\lambda^B, R^c, R^m, r^k)$, and the steady-state versions of (13), (24), (25) give $\lambda_{ss}^B = \frac{1}{1-R}\left(1 - \frac{\beta^1 R^b}{\pi}\right)$, $R_{ss}^c =$

$\frac{\beta^1}{\pi}R^b+\lambda^B_{ss}=\frac{1}{1-\bar{R}}\left(1-\frac{\beta^1}{\pi}R^b\bar{R}\right)$, $R^m_{ss}=R^b+\frac{\pi}{\beta^1}\lambda^B_{ss}$, $\bar{\omega}_{ss}=\Omega^{-1}\left(1-\frac{\beta^e}{\beta^1}R^c_{ss}\right)$, $f(\bar{\omega}_{ss})=\int_{\bar{\omega}_{ss}}^{\infty}\omega d\Phi(\omega)-\bar{\omega}_{ss}\left[1-\Phi(\bar{\omega}_{ss})\right]$, $q^k_{ss}=\frac{R^c_{ss}}{1-\mu\Phi(\bar{\omega}_{ss})+\left(\frac{\beta^e}{\beta^1}R^c_{ss}-1\right)f(\bar{\omega}_{ss})}$, $r^k_{ss}=q^k_{ss}\left[\frac{1}{\beta^1}-\left(1-\delta^k\right)\right]$. Next, given r^k_{ss}, the steady-state version of (28) yields $\left(\frac{K^y}{L^y}\right)_{ss}=\left[\frac{(1-\nu)A}{r^k_{ss}}\right]^{1/\nu}$. Given the above, equations (A.5) and (27) solve for $c_{ss}=\frac{w_{ss}}{\gamma}=\frac{\nu}{\gamma}A\left(\frac{K^y}{L^y}\right)^{1-\nu}_{ss}$. Then the steady-state version of equation (7) yields $q^h_{ss}=\frac{w_{ss}}{A^h}$. Given (π,c_{ss},R^c_{ss}), we solve for $\lambda^{ss}_2=\frac{1}{\pi c_{ss}}\left(\frac{\beta^1}{R^c_{ss}}-\beta^2\right)$. Then given $\left(c_{ss},q^h_{ss}\right)$, equation (A.8) solves for $h^{ss}_1=\frac{\varphi A^h}{\gamma\left[1-\beta^1\left(1-\delta^h\right)\right]}$. Equations (A.9) and λ^{ss}_2 together yield $h^{ss}_2=\frac{\varphi A^h}{\gamma\left[1-\beta^2\left(1-\delta^h\right)-\xi\left(\frac{\beta^1}{R^c_{ss}}-\beta^2\right)\right]}$. Note that h^{ss}_1 is independent of R^c_{ss} and thus monetary policy. Equations (36) and (30) imply $H_{ss}=(1-\varrho)\left[\alpha h^{ss}_1+(1-\alpha)h^{ss}_2\right]$ and $L^h_{ss}=\frac{\delta^h}{A^h}H_{ss}$. Next, according to (32) - (33) and (A.6), we can solve for the steady state levels of (Z,I,N). Then combine these with the goods-market-clearing condition (37) to solve for:

$$C^e_{ss} = \frac{\left(\frac{A}{\delta^k}\left[1-\mu\Phi(\bar{\omega}_{ss})\right]\left(\frac{K^y}{L^y}\right)^{-\nu}_{ss}-1\right)w_{ss}-\left(\frac{1}{\varrho}-1\right)c_{ss}\left(1-\frac{q^k_{ss}g(\bar{\omega}_{ss})}{R^c_{ss}}-\frac{q^k_{ss}f(\bar{\omega}_{ss})}{\beta^1}\right)}{1-\frac{q^k_{ss}g(\bar{\omega}_{ss})}{R^c_{ss}}-\frac{q^k_{ss}f(\bar{\omega}_{ss})}{\beta^1}+\frac{1}{\beta^1}\left(\frac{A}{\delta^k}\left[1-\mu\Phi(\bar{\omega}_{ss})\right]\left(\frac{K^y}{L^y}\right)^{-\nu}_{ss}-1\right)} \quad (A.10)$$

$$N_{ss} = \frac{\beta^1 w_{ss}-C^e_{ss}}{\beta^1-\frac{f(\bar{\omega}_{ss})}{\frac{1}{q^k_{ss}}-\frac{g(\bar{\omega}_{ss})}{R^c_{ss}}}} \quad (A.11)$$

$$I_{ss} = \frac{N_{ss}}{1-\frac{q^k_{ss}g(\bar{\omega}_{ss})}{R^c_{ss}}} \quad (A.12)$$

$$Z_{ss} = \varrho\left[f(\bar{\omega}_{ss})I_{ss}-\frac{C^e_{ss}}{q^k_{ss}}\right] \quad (A.13)$$

$$K^y_{ss} = \frac{\varrho}{\delta^k}I_{ss}\left[1-\mu\Phi(\bar{\omega}_{ss})\right]. \quad (A.14)$$

Given $\left((K^y/L^y)_{ss},K^y_{ss}\right)$, we have $L^y_{ss}=K^y_{ss}/\left(\frac{K^y}{L^y}\right)_{ss}$. Given $k^{ss}_2=0$, equation (35) implies $k^{ss}_1=\frac{K^y_{ss}-Z_{ss}}{(1-\varrho)\alpha}$. Then we have $m^{ss}_2=\xi q^h_{ss}h^{ss}_2\frac{\beta^1}{R^c_{ss}}$ and the bank balance-sheet condition yields

$$d^{ss}_1=\frac{\varrho\left(I_{ss}-N_{ss}\right)+(1-\varrho)(1-\alpha)m^{ss}_2}{\left(1-\bar{R}\right)(1-\varrho)\alpha}. \quad (A.15)$$

It is straightforward to obtain $Y_{ss},D_{ss},CA_{ss},S_{ss},C_{ss}$ from market-clearing conditions and the banking conditions. Given $S_{ss}=\bar{R}D_{ss}$, equation (1) implies $\left(\frac{B}{p}\right)_{ss}=\frac{R^b-1}{\pi}S_{ss}$ and (2) yields $\left(\frac{M}{p}\right)_{ss}=\frac{R^g_{ss}}{\pi-1}\left(\frac{B}{p}\right)_{ss}=\frac{\pi}{\beta^1(\pi-1)}\left(\frac{B}{p}\right)_{ss}$. Thus, $b^{ss}_1=\frac{(B/p)_{ss}}{(1-\varrho)\alpha}$. Note that $\left(\frac{B}{p}\right)_{ss}\geq 0$ requires the assumption $R^b\geq 1$. Then the households' budget constraints solve for

$$l^{ss}_1 = \frac{1}{w_{ss}}\left[c_{ss}+q^h_{ss}\delta^h h^{ss}_1-\left(r^k_{ss}-q^k_{ss}\delta^k\right)k^{ss}_1-\left(\frac{1}{\beta^1}-1\right)\left(d^{ss}_1+b^{ss}_1\right)\right] \quad (A.16)$$

$$l^{ss}_2 = \frac{1}{w_{ss}}\left[c_{ss}+q^h_{ss}\delta^h h^{ss}_2-\left(1-\frac{R^c_{ss}}{\beta^1}\right)m^{ss}_2\right]. \quad (A.17)$$

Step 3. All steady state variables on the left-hand sides of the equations derived so far are functions of π. The steady-state system boils down to solving for π_{ss} from the labor-market-clearing equation (42). There exists a unique steady state with $\lambda^B = 0$ if and only if there exists a unique solution to (42) that also satisfies the existence conditions specified next.

A.2 Existence conditions for a steady state with $\lambda^B > 0$

The above section gives a list of solutions to all steady state variables except for π_{ss}. For the existence of a steady state with $\lambda^B > 0$, the solution to (42), π_{ss}, must also satisfy $R^d_{ss} \geq 1$ and

$$\lambda^B_{ss}, \Omega\left(\bar{\omega}_{ss}\right), f\left(\bar{\omega}_{ss}\right), q^k_{ss}, r^k_{ss}, \lambda^{ss}_2, h^{ss}_2, K^y_{ss}, C^e_{ss}, N_{ss}, I_{ss}, Z_{ss}, k^{ss}_1, C_{ss}, l^{ss}_1, l^{ss}_2, \left(\frac{M}{p}\right)_{ss} > 0. \quad \text{(A.18)}$$

First, $R^d_{ss} \geq 1$ requires $\pi_{ss} \geq \beta^1$. Next, $\lambda^B_{ss} > 0$ requires $\pi_{ss} > \beta^1 R^b$. Together we have

$$\pi_{ss} \geq \beta^1 \text{ and } \pi_{ss} > \beta^1 R^b. \quad \text{(A.19)}$$

Next, $\Omega\left(\bar{\omega}_{ss}\right) > 0$ and $q^k_{ss} > 0$ together require that π_{ss} satisfy

$$1 - \frac{1 - \mu\Phi\left(\bar{\omega}_{ss}\right)}{f\left(\bar{\omega}_{ss}\right)} < \frac{\beta^e}{\beta^1} R^c_{ss}\left(\pi_{ss}\right) < 1. \quad \text{(A.20)}$$

Then $\lambda^{ss}_2 > 0$ and $h^{ss}_2 > 0$ together require π_{ss} satisfy

$$0 < \frac{\beta^1}{R^c_{ss}\left(\pi_{ss}\right)} - \beta^2 < \frac{1}{\xi}\left[1 - \beta^2\left(1 - \delta^h\right)\right]. \quad \text{(A.21)}$$

$f\left(\bar{\omega}_{ss}\right) > 0$ and $r^k_{ss} > 0$ together require

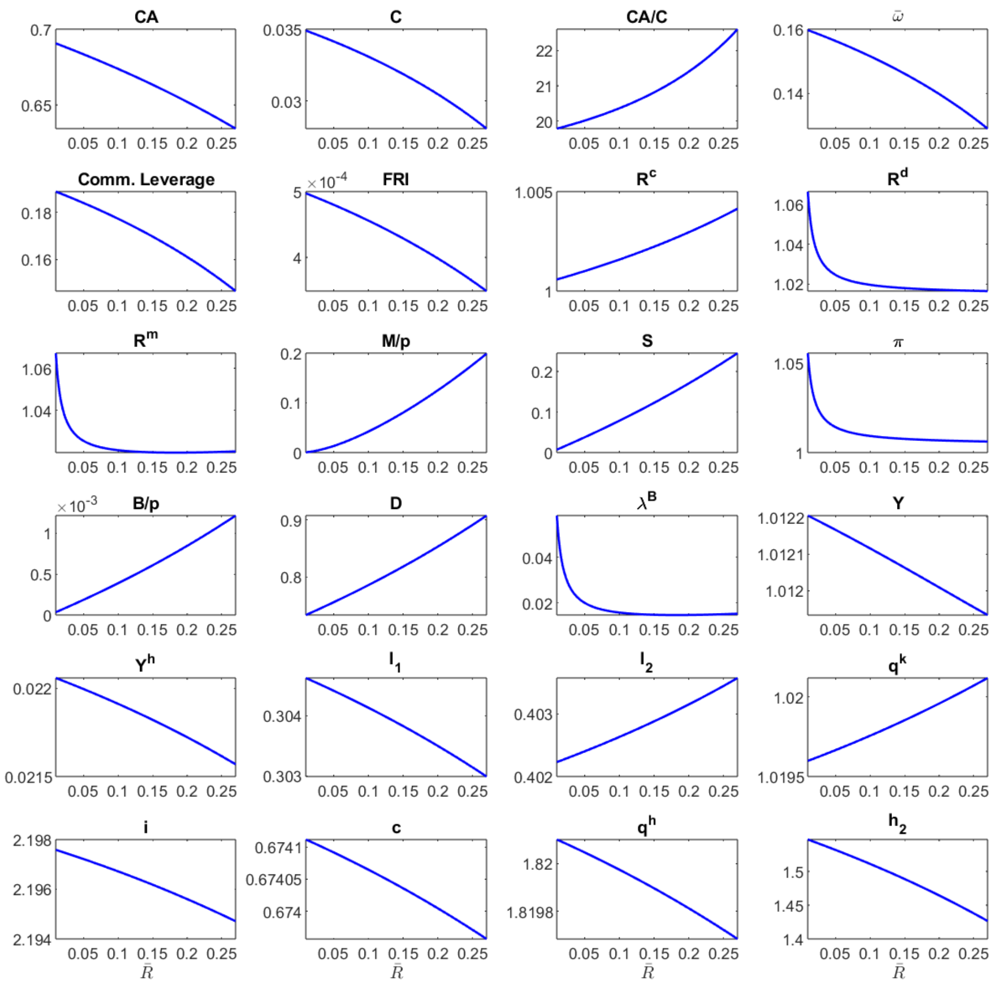
$$\int_{\bar{\omega}_{ss}(\pi_{ss})}^{\infty} \omega d\Phi\left(\omega\right) - \bar{\omega}_{ss}\left(\pi_{ss}\right)\left[1 - \Phi\left(\bar{\omega}_{ss}\left(\pi_{ss}\right)\right)\right] > 0, \text{ and } \frac{1}{\beta^1} - \left(1 - \delta^k\right) > 0. \quad \text{(A.22)}$$

$K^y_{ss} > 0$ always holds given $\mu \in (0, 1)$ and $\Phi(\cdot)$ is a CDF. Also, π_{ss} must also be such that

$$C^e_{ss}\left(\pi_{ss}\right), N_{ss}\left(\pi_{ss}\right), I_{ss}\left(\pi_{ss}\right), Z_{ss}\left(\pi_{ss}\right), k^{ss}_1\left(\pi_{ss}\right), C_{ss}\left(\pi_{ss}\right), l^{ss}_1\left(\pi_{ss}\right), l^{ss}_2\left(\pi_{ss}\right) > 0. \quad \text{(A.23)}$$

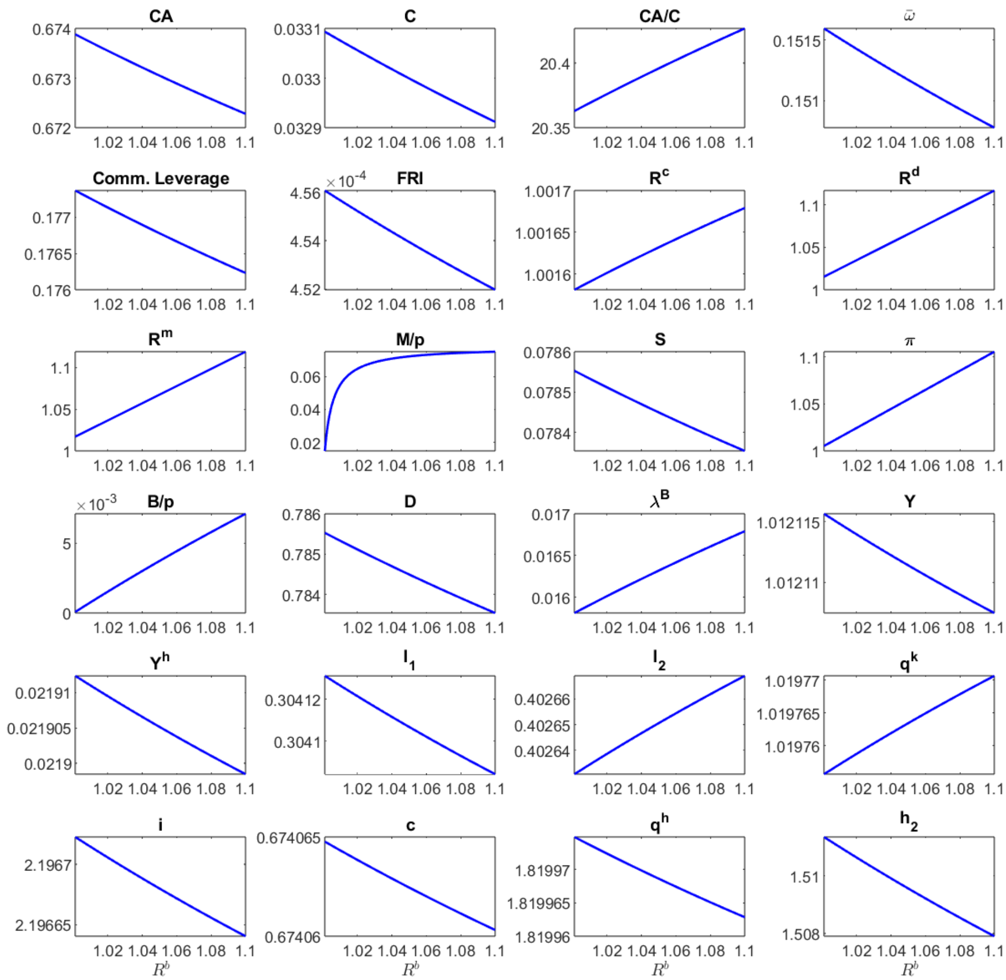
Hence, we have Properties II of Theorem 1.

Figure 1: Long-Run Effects of $\bar{R}$



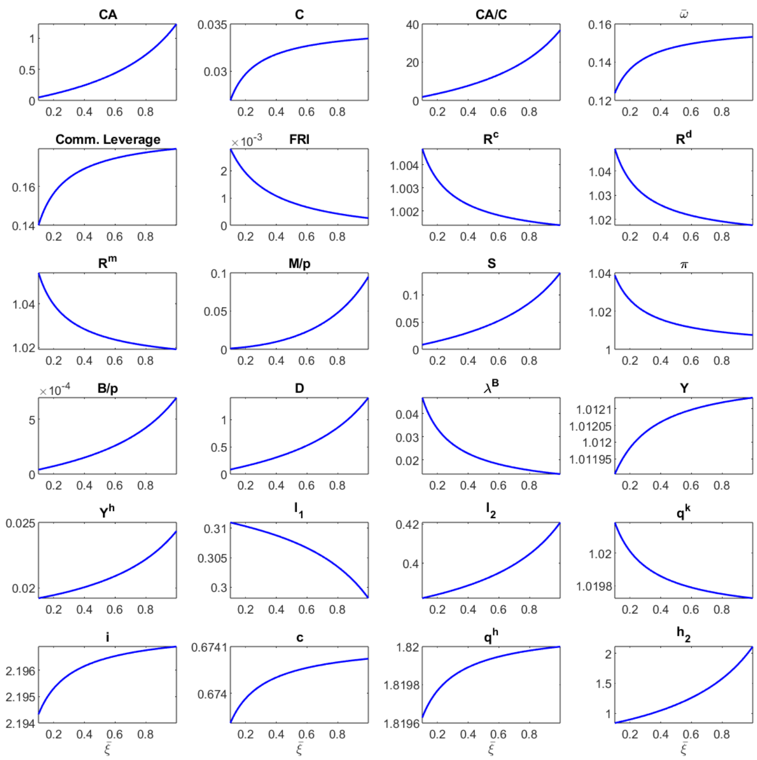
Note: The figure plots the steady-state values of variables associated with the banking and real sectors under different levels of $\bar{R}$.

Figure 2: Long-Run Effects of R^b



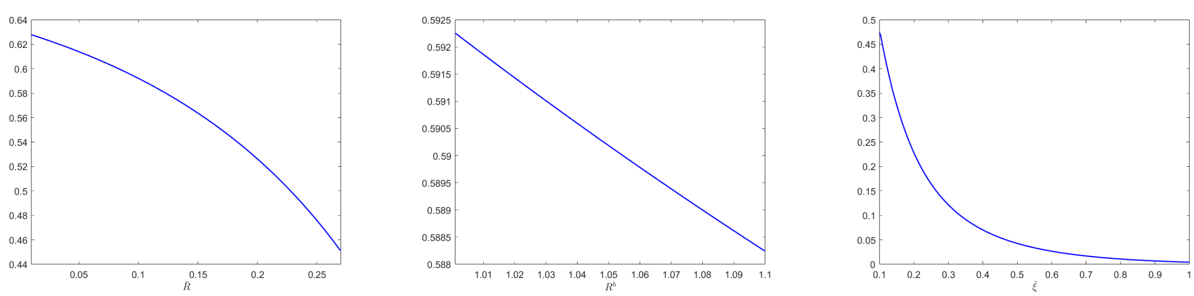
Note: The figure plots the steady-state values of variables associated with the banking and real sectors under different levels of R^b.

Figure 3: Long-Run Effects of $\bar{\xi}$



Note: The figure plots the steady-state values of variables associated with the banking and real sectors under different levels of $\bar{\xi}$.

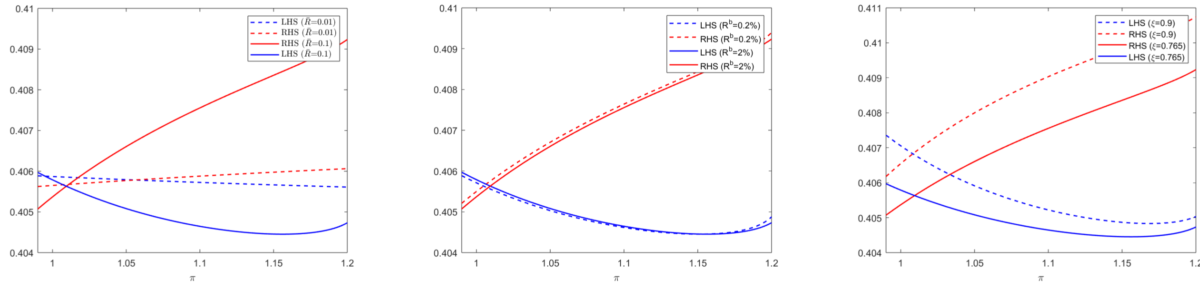
Figure 4: Steady-State Output/Housing Elasticity



(a) For Changes in $\bar{R}$ (b) For Changes in R^b (c) For Changes in $\bar{\xi}$

Note: The figure plots the gradient of Y (goods production) versus Y^h (house construction) as $\bar{R}$, R^b, and $\bar{\xi}$ change, respectively.

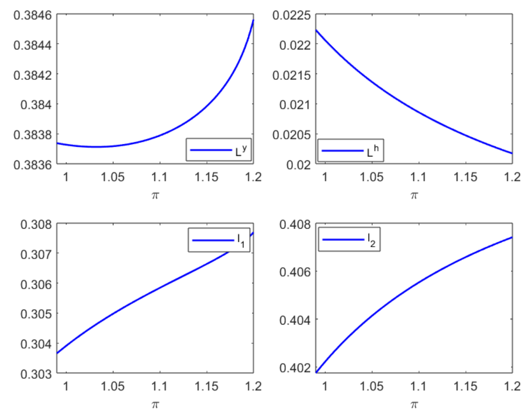
Figure 5: Policy Effects on Steady-State Inflation



(a) Effects of $\bar{R}$ (b) Effects of R^b (c) Effects of $\bar{\xi}$

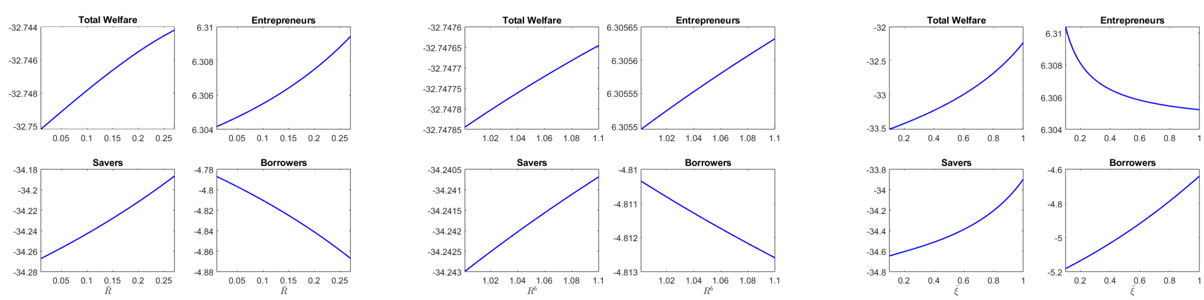
Note: The figure plots the demand (LHS) and supply (RHS) of the labor market clearing condition, helping determine steady-state inflation. The $\bar{R}$ takes values of 0.01 and 0.1 (1% and 10%), $\bar{\xi}$ takes values of 0.765 and 0.9 (76.5% and 90%), and R^b takes values of 1.0005 and 1.005, corresponding to 0.2% and 2% annual rates, respectively.

Figure 6: Decomposition of Aggregate Labor Demand and Supply



Note: The figure plots the levels of L^y, L^h, l_1, and l_2. They correspond to the labor demand in goods production, labor demand in construction, patient household labor supply, and impatient household labor supply, respectively.

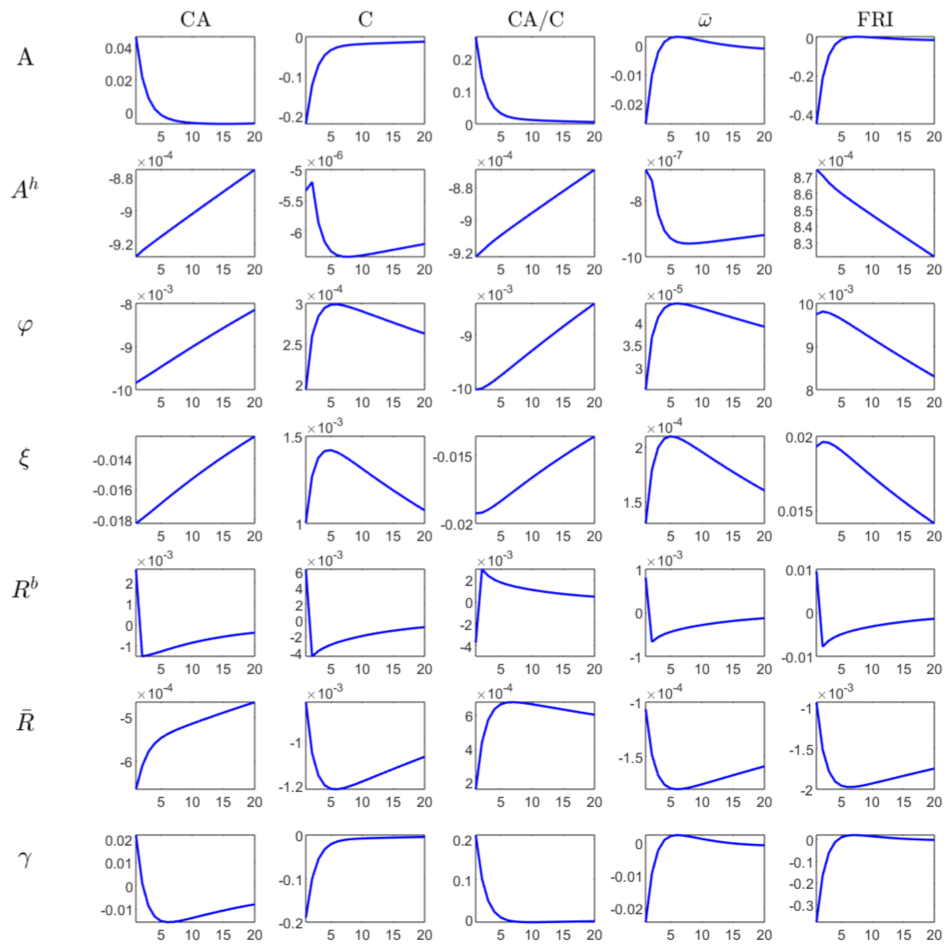
Figure 7: Effects of $\bar{R}$, R^b, and $\bar{\xi}$ on Welfare



(a) Effects of $\bar{R}$ on Welfare (b) Effects of R^b on Welfare (c) Effects of $\bar{\xi}$ on Welfare

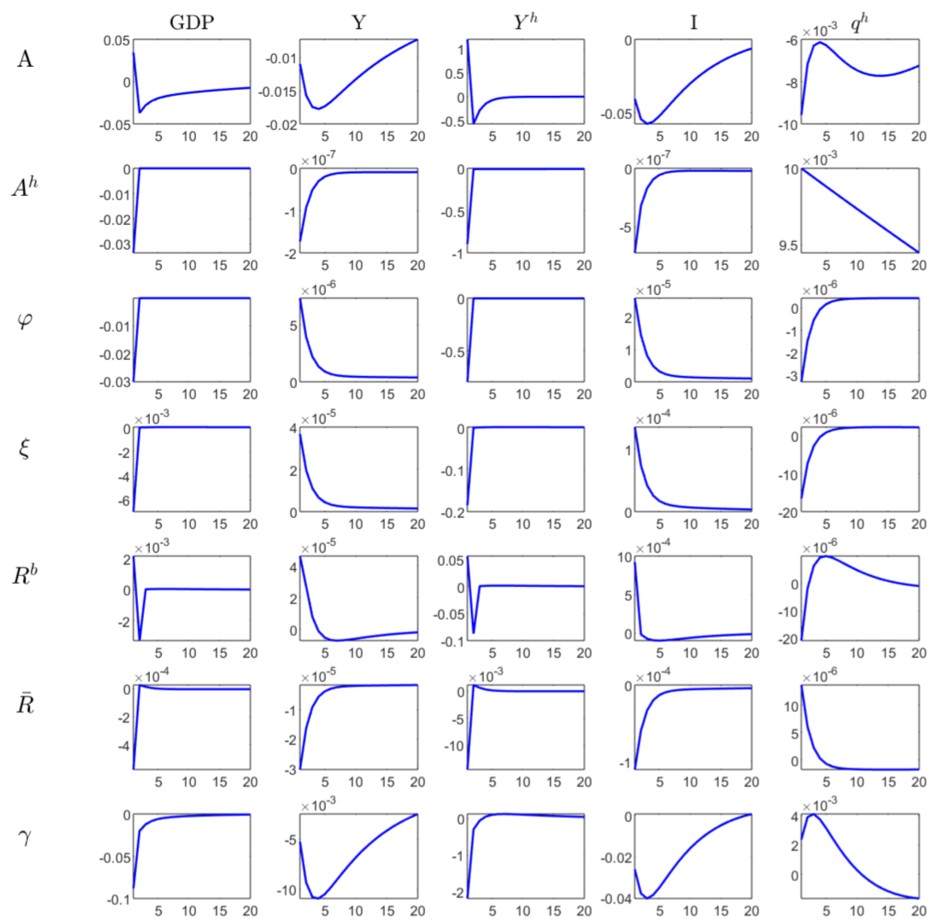
Note: The figure plots the welfare measures for the aggregate economy, savers, borrowers, and entrepreneurs for different levels of $\bar{R}$, R^b, and $\bar{\xi}$.

Figure 8: Impulse Responses of Banking Sector Variables to Adverse Shocks



Note: The figure plots the responses of variables associated with the banking sector to all adverse shocks in the economy. In particular, we initiate a 1% increase to the innovation of the reserve requirement shock ($\varepsilon_t^{\bar{R}}$) and reserve rate shock ($\varepsilon_t^{R^b}$), creating a contractionary monetary policy. We also initiate a 1% decrease in TFP (ε_t^{A}), construction ($\varepsilon_t^{A^h}$), LTV (ε_t^{ξ}), housing demand (ε_t^{φ}), and labor supply (ε_t^{γ}) shocks. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

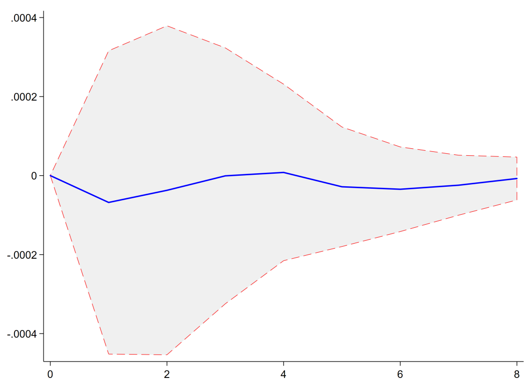
Figure 9: Impulse Responses of Real Sector Variables to Adverse Shocks



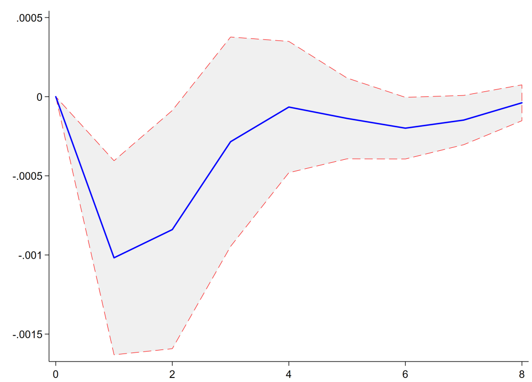
Note: The figure plots the responses of variables associated with the real sector to all adverse shocks in the economy. In particular, we initiate a 1% increase to the innovation of the reserve requirement shock ($\varepsilon_t^{\bar{R}}$) and reserve rate shock ($\varepsilon_t^{R^b}$), creating a contractionary monetary policy. We also initiate a 1% decrease in TFP (ε_t^{A}), construction ($\varepsilon_t^{A^h}$), LTV (ε_t^{ξ}), housing demand (ε_t^{φ}), and labor supply (ε_t^{γ}) shocks. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

Figure 10: Responses of Real Estate, C&I Loans, and Real Estate/C&I to an Increase in Federal Funds Effective Rate

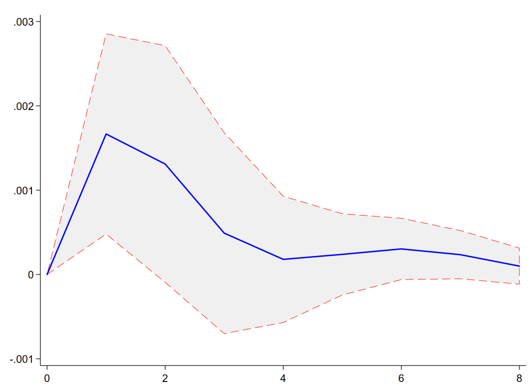
(a) Real Estate Loans



(b) Commercial and Industrial Loans



(c) Real Estate/C&I



Note: The figure plots the real estate loans, commercial and industrial loans, and the collateral to commercial loan ratio responses to a 1% increase in the federal funds effective rate. Shaded areas indicate the 95% confidence intervals.