Rethinking Mortgage Design: The Trade-off Between Household Insurance and Financial Stability*

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Abstract

This paper investigates how mortgage structure shapes the transmission of inflation shocks through a "dual channel" in which household wealth effects compete with the bank credit-supply response. We develop a quantitative general equilibrium model featuring heterogeneous households and capital-constrained intermediaries to isolate these opposing forces. We find that, in fixed-rate mortgage (FRM) economies, the Fisher-channel windfall for borrowers is mirrored by concentrated valuation losses for banks; the resulting capital erosion activates a financial accelerator and generates a recession. Conversely, the model shows that adjustable-rate mortgage (ARM) economies mitigate systemic risk by limiting valuation losses on mortgage assets. The model also reveals important distributional consequences of mortgage structure: the FRM economy "socializes" the cost of the shock, disproportionately harming renters and poorer households through the recession while benefiting highly leveraged borrowers. The ARM economy, by contrast, "privatizes" the risk by concentrating the impact on indebted borrowers. We test these predictions using evidence from the 2021–2023 U.S. tightening cycle and find that higher household ARM shares are associated with weaker local economic activity, whereas greater bank ARM exposure is associated with stronger credit growth—patterns consistent with the model's two channels.

JEL Classification: E52, G21, R31, E44

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1 Introduction

Unexpected inflation redistributes wealth from nominal creditors to nominal debtors through the Fisher channel. In standard heterogeneous-agent models, this redistribution is often expansionary because it shifts resources toward higher-marginal-propensity-to-consume borrowers. We show that this conclusion can reverse when debt is long-term, nominal, and intermediated by leveraged banks. In that case, inflation not only raises borrower net worth, but also weakens bank balance sheets by reducing the value of long-term nominal assets and tightening credit supply. The aggregate effects of inflation are therefore governed by a dual channel: a household demand channel that is expansionary and a bank capital channel that is contractionary.

Mortgage contract structure determines how this trade-off is resolved. In an economy dominated by long-term nominal fixed-rate mortgages (FRMs), unexpected inflation generates a large Fisher effect because the real value of fixed nominal repayments falls, delivering a windfall to indebted households. But these gains are the mirror image of losses on the balance sheets of financial intermediaries that hold the associated mortgage claims. As bank asset values decline, bank capital erodes, funding constraints tighten, and credit supply contracts. In an economy dominated by adjustable-rate mortgages (ARMs), by contrast, mortgage payments reset as nominal rates rise, so the redistribution associated with inflation is smaller and the valuation losses on bank balance sheets are more limited.

We study these mechanisms using two complementary approaches: a quantitative model and an empirical analysis of the 2021–2023 inflation surge. To formalize these mechanisms and explore their general equilibrium implications, we develop a quantitative model with heterogeneous households and a constrained banking sector. The model features overlapping generations of households who make life-cycle decisions about consumption, savings, and housing tenure—choosing to rent, own a home outright, or finance a purchase with a mortgage. Banks issue both long-term defaultable mortgages (either FRMs or ARMs) to households and short-term working capital loans to firms. To isolate the impact of inflation on these long-term nominal contracts, we assume that all prices are flexible. This modeling choice is deliberate. Long-term nominal debt arguably represents the most significant nominal rigidity in the economy. Our goal is to isolate how unexpected inflation interacts with this rigidity to redistribute wealth (the Fisher channel) and impair financial intermediation (the bank capital channel). By abstracting from high-frequency price stickiness, we focus on these balance sheet effects and the resulting credit-supply dynamics, rather than the aggregate demand channels typically emphasized in New Keynesian frameworks.

We first use the model to analyze the economy's response to an unexpected inflation shock calibrated to the 2021–2023 episode.[1] We find that the two mortgage regimes (FRM and ARM) behave very

[1] We take the size and path of the inflation shock as given. A strand of recent work emphasizes fiscal contributions

differently. In the FRM economy, while households with fixed-rate debt receive a significant wealth windfall as inflation erodes the real value of their loans, the corresponding losses are concentrated on the leveraged and constrained balance sheets of banks. This triggers a strong financial accelerator dynamic (Bernanke et al., 1999; Gertler and Kiyotaki, 2010): bank capital declines sharply (more than 40 percent), forcing banks to curtail credit supply (the lending rate increases by more than 4 percentage points). The resulting recession features declines in output (2.5 percent), consumption (2.0 percent), house prices (2.0 percent), and wages (3.2 percent).

While the U.S. economy did not enter a formal recession during 2021–2023, the model aligns closely with the underlying dynamics of this episode and offers key insights into this "missing recession." The acute financial instability observed in spring 2023 is consistent with the model's bank-capital channel: the stress was closely related to valuation losses on long-duration fixed-rate assets. Our analysis suggests that the FRM-induced impairment of credit supply was a major, if partially obscured, headwind. The fact that a deep contraction was averted is attributable to several critical factors. First, pandemic-era fiscal buffers likely supported household demand. Second, extraordinary liquidity interventions (notably the Bank Term Funding Program) averted a systemic credit freeze when bank stress materialized (see Amador and Bianchi (2024) for a theory of credit easing in run-driven crises). Third, as we demonstrate later, the FRM structure creates a conflict between price stability and financial stability, constraining the central bank's reaction function. A relatively accommodative stance early in the inflation episode, characterized by a delay in aggressive tightening, significantly mitigated the immediate valuation shock to bank capital (see also Diamond et al. (2025), who show that temporarily passive monetary policy is precisely what amplifies the stimulative effects of fiscal redistribution during the post-Covid episode).

Beyond these aggregate outcomes, the model uncovers some important distributional consequences. We find that the FRM system effectively "socializes" the cost of the shock. The bank-driven recession disproportionately harms renters and the poor through income losses. Meanwhile, wealthy and highly leveraged homeowners enjoy a net welfare gain as their real debt burden declines. The ARM system, in contrast, "privatizes" the risk. The economic pain is concentrated on indebted borrowers, who face immediate payment shocks, while the wider economy and non-indebted households remain largely insulated.

We use this framework to explore how the regulatory environment mediates these macroeconomic trade-offs, focusing first on the role of bank leverage. Our analysis reveals that the financial fragility inherent in the FRM system is highly sensitive to the initial capitalization of the banking sector. When banks are highly leveraged, the negative impact of rising rates on their fixed-

to the post-pandemic inflation surge: see Bianchi and Melosi (2022) and Bianchi et al. (2023) for theory, and Barro and Bianchi (2026) and Hazell and Hobler (2025) for evidence. Bernanke and Blanchard (2025) provide a complementary decomposition emphasizing the initial role of price shocks and the subsequent labor-market adjustment.

rate assets is magnified, leading to a deeper credit crunch and recession. In contrast, the ARM economy remains resilient across different levels of leverage, as the underlying interest rate risk is transferred away from financial intermediaries. This points to an important policy implication: tighter macroprudential regulation, particularly concerning bank capital requirements, is essential for mitigating the systemic risks associated with FRM markets.

The model also sheds light on the interaction between mortgage structure and the central bank's policy stance. In an FRM economy, policymakers face a dilemma when responding to inflation. An aggressive tightening, while aimed at controlling prices, simultaneously exacerbates the valuation losses on bank balance sheets, amplifying financial instability and deepening the recession. This highlights a constraint on monetary policy efficacy due to the conflict between price stability and financial stability. Conversely, the central bank in an ARM economy is more flexible, as the banking sector is insulated from interest rate risk, allowing for a more decisive response to inflation without triggering systemic financial distress.

We empirically test the dual-channel hypothesis using the 2021–2023 rise in inflation. Our empirical strategy leverages this episode through a multi-layered approach that moves from state-level aggregate outcomes down to granular bank-, bank-county-, and industry-level behavior. We first provide evidence on the dual channel using a state-level "horse-race" regression with state-border-pair fixed effects. This approach compares economic outcomes in neighboring states, controlling for unobserved regional shocks. After conditioning on a rich set of predetermined state characteristics, we find that the two channels operate with opposite signs and are both economically and statistically significant. A higher share of FRMs held by consumers acts as a powerful insurance, significantly boosting state-level consumption, GDP, and personal income. At the same time, greater exposure to banks holding FRMs acts as a significant drag on these outcomes.

We then provide direct evidence for the credit-supply mechanism through a series of more granular tests. We first document market-based evidence for the underlying bank distress. Equity-market data reveal that banks with greater exposure to FRMs experienced larger stock-price declines, deeper drawdowns, and greater volatility during this period. Second, using bank-level Call Report data, we show that banks with higher pre-existing ARM shares (and thus lower FRM exposure) increased their overall and commercial loan growth. Third, to help separate supply from demand, we use bank-county lending data and employ county fixed effects. This specification shows that, within the same local market, banks with more ARMs expanded lending to small businesses more aggressively. Finally, we link this credit expansion to real economic outcomes using a Rajan and Zingales (1998) framework. We find that employment in sectors with a high dependence on external finance grew more in regions served by a more ARM-exposed banking sector.

Literature Review Our paper contributes to three interconnected strands of literature. First, we relate to work on the redistribution generated by unexpected inflation through household balance sheets. Foundational work by Doepke and Schneider (2006b) (see also Doepke and Schneider, 2006a, Doepke and Schneider, 2006c, and Doepke et al., 2015) quantifies nominal positions and shows that surprise inflation typically transfers resources from older net creditors to younger net debtors. The aggregate consequences depend on life-cycle differences in consumption, saving, and labor supply, not on the accounting transfer alone. Sheedy (2014) shows that nominal-GDP targeting can improve risk sharing and can dominate inflation targeting in a model with nominal debt and incomplete financial markets. Auclert (2019) formalizes the redistribution channel of monetary policy through heterogeneity in marginal propensities to consume, earnings exposure, and nominal positions, while Sterk and Tenreyro (2018) emphasize redistribution and durable purchases as important components of monetary transmission. Pallotti (2022) documents the magnitude and incidence of the nominal-wealth redistribution generated by the 2021 U.S. inflation shock, and Pallotti (2023) uses a heterogeneous-agent model to argue that this redistribution supported aggregate consumption and helps account for the "missing recession." Pallotti et al. (2024) extend the distributional evidence to the euro area, showing that welfare effects were strongly age-dependent and that net nominal positions were a central source of household heterogeneity; their evidence concerns inflation exposure broadly rather than an ARM-specific payment channel. Using high-frequency client data from a large Spanish bank, Ferreira et al. (2023) decompose the 2021 inflation shock into wealth, income, and relative-consumption channels. They find that the wealth and income channels dominate consumption-basket heterogeneity, that middle-aged households were largely insulated on average, and that older households with positive nominal positions experienced the largest losses.

Closely related, Diamond et al. (2025) study the post-Covid episode in a New Keynesian model in which fiscal transfers combined with temporarily passive monetary policy inflate away nominal mortgages, generating a persistent, redistribution-driven boom. Although their mortgage intermediary faces a regulatory capital requirement, it re-raises deposits and equity from unconstrained savers each period and lends only to households. Therefore valuation losses pass through to saver wealth without touching credit to production.

Our contribution to this first strand is to show that the aggregate consequences of the Fisher channel depend on who holds the nominal claims. When fixed-rate mortgages sit on the balance sheets of banks with balance sheet constraints that also fund firms' working capital, the valuation losses that enrich borrowers deplete bank capital, contract credit to production, and can turn expansionary redistribution into a recession. We also take the resulting dual channel directly to the data: border-pair, bank-, bank-county-, and industry-level evidence from the 2021–2023 U.S. tightening shows household and bank mortgage exposures associated with opposite-signed movements in local activity and credit.

Second, our paper relates to research on mortgage contract structure and monetary-policy transmission. The conventional household cash-flow channel is strongest when mortgage payments reprice quickly. Using cross-country evidence, Calza et al. (2013) show that housing and residential-investment responses are stronger in more flexible mortgage markets, while consumption responses are particularly strong where variable-rate contracts and mortgage-equity withdrawal are common. Garriga et al. (2017) formalize how fixed- and adjustable-rate contracts alter monetary transmission. At the household level, Di Maggio et al. (2017) show that reductions in ARM payments during easing episodes raise consumption and voluntary deleveraging. Sciacovelli (2024) finds that ARM prevalence is especially consequential when adjustable-rate debt is held by liquidity-constrained households with high marginal propensities to consume. Cloyne et al. (2020) likewise find that mortgagors adjust expenditure more than outright owners, but their cross-country evidence indicates that general-equilibrium income effects and liquidity constraints are quantitatively more important than the direct change in mortgage payments alone. [2] Most recently, Foulis et al. (2026) exploit six million fixed-rate mortgage expiries in UK administrative data and find that a one-percentage-point reduction in mortgage rates raises consumption by about 3 percent over the following six months, primarily because households borrow against rate-induced house-price gains rather than because of lower debt service.

On the fixed-rate side, household transmission operates through refinancing, and its strength is state and path dependent: Eichenbaum et al. (2022) show that the consumption response to rate changes varies systematically with the pool of potential savings from refinancing, and Berger et al. (2021) show that past rate paths determine how many borrowers stand to gain from prepaying, so that long low-rate spells leave little scope for further stimulus. The 2021–2023 tightening is the mirror image of these episodes: with borrowers locked into record-low fixed coupons, the refinancing channel was largely dormant, and the FRM side of transmission ran instead through the market value of those locked-in loans on lender balance sheets—the margin at the center of our analysis.

Recent work broadens this literature from payment pass-through to housing-market dynamics, contract design, and financial stability. Hedlund et al. (2025) emphasize FRM lock-in and mortgage-market path dependence in explaining cross-country housing-market divergence during 2021–2024. Elenev and Liu (2024) provide a closely related theoretical analysis of the trade-off between ARM credit risk and FRM interest-rate risk in a quantitative model with flexible mortgage contracts, liquidity-driven default, sticky deposits, and intermediary capital constraints, and characterize

[2] The importance of debt structure extends beyond household mortgages. Ippolito et al. (2018) identify a "floating-rate channel" for firms, through which monetary policy changes the liquidity and investment of firms with floating-rate corporate debt.

how mortgage fixation length affects risk sharing and financial stability. Eberly and Krishnamurthy (2014) and Campbell et al. (2021) study related mortgage designs in which front-loaded payment relief or state-contingent maturity adjustment can stabilize households and the macroeconomy. Our paper complements these contributions by focusing on an unexpected inflation and price-level shock, by linking mortgage valuation losses to firms' working-capital finance, hiring, and wages, and by providing U.S. evidence that separately measures household and bank exposure to adjustable-rate mortgages.

This perspective also sharpens the interpretation of regional evidence on mortgage transmission. Cross-sectional estimates based only on household contract exposure can identify a valid partial-equilibrium cash-flow or wealth response while leaving the aggregate credit-supply response in the common component. By bringing household and intermediary exposures into the same quantitative and empirical framework, our dual-channel approach identifies when the household insurance provided by FRMs is offset by a contraction generated on the balance sheets of the intermediaries holding those contracts.

Third, our paper contributes to the literature on banks' exposure to interest-rate risk. English et al. (2018) show that bank equity values decline following unexpected increases in the level of interest rates or a steepening of the yield curve. Their cross-sectional results are nuanced: a larger positive repricing or maturity gap attenuates the negative response to a slope surprise, while core-deposit reliance, bank size, derivatives, and balance-sheet quantity adjustments also matter. Gomez et al. (2021) focus on cash-flow exposure and show that banks with larger positive income gaps earn more and contract lending less when policy rates rise. Altunok et al. (2025) provide the most direct evidence on mortgage composition, finding that banks with higher ARM shares earn more interest income, perform better in equity markets, and supply more credit during monetary tightening. On the theory side, Jermann and Quadrini (2012) study the macroeconomic effects of financial shocks, Quadrini (2017) isolates a bank-liabilities channel, and Bianchi and Bigio (2022) analyze monetary transmission through bank reserve and liquidity management; our mechanism instead starts from inflation-induced valuation losses on long-duration fixed-rate mortgages, which erode intermediary net worth and contract working-capital credit.

A complementary benchmark is provided by Drechsler et al. (2021). They argue that banks use long-duration fixed-rate assets to hedge the interest-rate sensitivity of their deposit franchise, stabilizing both cash flows and equity values. Our mechanism is complementary rather than a rejection of that result. We study the case in which the deposit-franchise hedge is incomplete and valuation losses on fixed-rate mortgages pass through to persistent intermediary net worth, tighten the capital constraint, and reduce credit to nonfinancial firms. This distinction separates our market-value bank-capital channel from the cash-flow income-gap channel. Empirically, we connect mortgage composition not only to bank equity and lending, but also to local activity and employment in sectors that depend more heavily on external finance.

2 Quantitative Model

We build on the framework developed in Arslan et al. (2025), extending it to examine how mortgage structure affects the transmission of an inflation shock. The economy features six sectors: households, banks (financial intermediaries), rental housing companies, production firms, service sector, and government. Households derive utility from consuming non-durable goods and housing services, with the former produced by firms that employ labor from working-age households and rent capital from all households. A key friction arises from firms' need to finance a portion of wage payments through bank credit.

Households access housing services via two channels: direct homeownership or rentals from rental housing companies. The banking sector intermediates between depositors and borrowers, originating long-term residential mortgages while providing short-term working capital loans to firms. The government administers a pay-as-you-go social-security system and a mortgage-subsidy program, both financed by income taxes.

The model abstracts from aggregate uncertainty but analyzes transitional dynamics following unanticipated shocks. There is perfect foresight except during shock realizations. We also abstract from nominal rigidities in prices and wages. By doing so, the model highlights how changes in the price level interact with the mortgage structure to affect the real economy. In the stationary economy, we assume there is no inflation, and we present the stationary economy in real terms. In Section 4, we analyze how an unexpected inflation shock affects real variables. We assume the aggregate housing supply is fixed, $\bar{H}$.[3]

Given household heterogeneity in equilibrium, prices, value functions, and decision rules depend on both aggregate conditions and the household distribution, though we suppress this notation for clarity.

2.1 Households

Households supply labor inelastically during their working years until mandatory retirement age J_r, with total lifespan extending to J periods where $J > J_r$. The income for household i at age j follows:

$$y(j, z_j) = \begin{cases} (1 - \tau^s - \tau^m) w \exp(f(j) + z_j), & \text{if } j \leq J_r \\ (1 - \tau^m)\, w y_R(z_{J_r}), & \text{if } j > J_r \end{cases}$$

[3] In unreported robustness checks, the results of the paper are essentially unchanged if we allow endogenous housing supply.

The specification incorporates a deterministic age-earnings profile through $f(j)$, while idiosyncratic productivity shocks z_j evolve stochastically according to a first-order autoregressive process:

$$z_j = \rho_\varepsilon z_{j-1} + \varepsilon_j, \quad \varepsilon_j \sim \text{i.i.d. } \mathcal{N}(0, \sigma_\varepsilon^2)$$

Here, w represents the market price per efficiency unit of labor, with τ^s denoting the social-security tax rate and τ^m denoting the mortgage subsidy tax rate. Post-retirement benefits $y_R(z_{J_r})$ are calculated as a function of pre-retirement income and calibrated to mirror the U.S. Social Security benefit formula.

Household preferences follow an Epstein–Zin specification over consumption goods and housing services:

$$V_{j,i} = \left(u(c_j^i, s_j^i) + \beta \mathbb{E}_j \left[V_{j+1,i}^{1-\sigma} \right]^{\frac{1-\rho}{1-\sigma}} \right)^{\frac{1}{1-\rho}}$$

where the discount factor β captures time preference, c_j^i denotes non-durable consumption, s_j^i represents housing service flows for household i at age j, $\mathbb{E}_j$ is the conditional expectation operator, the parameter ρ is the inverse of the elasticity of intertemporal substitution, and σ measures risk aversion.

Housing Tenure Decisions: Households enter the economy with no inheritance, i.e., they have no financial wealth. Households can obtain housing services through rental housing companies, choosing their optimal housing quantity at the rental rate p_r per unit, or they can own a house by purchasing one at the market price p_h per unit. We assume that rental properties and owner-occupied properties come in different sizes. The maximum rental size is set to $\underline{\mathrm{h}}$, which also represents the minimum size for owner-occupied housing units, i.e., rental and owner-occupied housing markets are fully segmented. Subject to this constraint, households may choose any house size in either the rental or owner-occupied market. Transitions into homeownership and back to the rental market remain available throughout the life cycle. Although the model excludes unsecured debt, households may utilize mortgage financing for home purchases, constrained by down payment requirements. Mortgage terms, including down payment size and interest rates, are endogenously determined and depend on household characteristics. Houses depreciate at the rate δ_h. We assume households need to make maintenance payments proportional to the depreciation cost, $\delta_h p_h$, in every period to maintain the quality of their homes.

Current homeowners face a rich menu of options: continue in their existing residence, liquidate their property to return to renting, default, refinance, or adjust housing size by selling their current home and purchasing a new one. Real estate transactions are subject to multiple frictions. Property sales incur a proportional transaction cost of φ_s, reflecting brokerage commissions and related expenses. Mortgage origination imposes both a fixed charge φ_f and a variable fee φ_m proportional to loan size.

Mortgage default remains feasible but triggers exclusion from mortgage markets. Defaulting households transition to inactive renter status, regaining mortgage market access stochastically with per-period probability χ. This structure generates three distinct housing market states: (1) Owner-occupiers, (2) Active rental market participants, (3) Inactive renters.

Mortgage Structure: For tractability, we assume that mortgages are due by the end of life, so that the household's age captures the maturity of the mortgage contract. The mortgage contract can be characterized by its maturity, T, mortgage interest rate, r_m, and the periodic mortgage payment m. We assume that the mortgage payment, m, follows the standard amortization formula, which equates the present value of scheduled payments to the mortgage principal, d:

$$\begin{aligned} d &= m + \frac{m}{1+r_m} + \frac{m}{(1+r_m)^2} + ... + \frac{m}{(1+r_m)^{T-1}} \\ m &= d\frac{r_m}{1+r_m-(1+r_m)^{1-T}} \end{aligned} \tag{1}$$

Payments are due at the beginning of each period, with the first payment made at origination. Thus, the mortgage principal, d, the mortgage interest rate, r_m, and the maturity, which is tied to household age j through $T = J - j + 1$, determine the mortgage payment. Because default risk depends on household characteristics, mortgage interest rates would generally differ across households. However, to reduce the dimensionality of the problem, following Hatchondo et al. (2015) and Kaplan et al. (2020), we assume that the mortgage interest rate is set to the same "risk-free" mortgage rate, r_m^*, for all households, and individual default risk is incorporated into the mortgage price at origination. Higher default risk is reflected in a lower mortgage price, resulting in the household receiving fewer resources than the mortgage principal. A real-life interpretation is that households pay an upfront fee to reduce their individual mortgage rate to a uniform "risk-free" mortgage rate.

The distinction between FRMs and ARMs lies in how the "risk-free" mortgage interest rate r_m^* is set. Under an FRM, this rate is set equal to the bank lending rate, r_ℓ, at origination and remains fixed for the life of the mortgage contract. Under an ARM, the rate is reset to the current bank lending rate, r_ℓ, in every period. When the bank lending rate is constant, FRMs and ARMs are identical. When it changes, the two contracts have different implications.

Home Buyer's Problem: This section presents the dynamic optimization problem faced by a home buyer. Additional dynamic optimization problems of the households are provided in Appendix B.2. If an active renter decides to purchase a home, she selects a mortgage debt level d', which determines the mortgage price at origination, denoted by $q^m(d';a',h,z,j)$. This price depends on the chosen mortgage balance d', the household's choices of house size h and assets a', and the household's exogenous income state z and age j.

The optimization problem for an active renter who chooses to become a homeowner is formulated as:

$$V_j^{rh}(a,z) = \max_{c,d',h\geq \underline{\mathrm{h}},a'\geq 0} \left\{ \left(u(c,h) + \beta E \left(V_{j+1}^h(a',h,d',z')^{1-\sigma} \right)^{\frac{1-\rho}{1-\sigma}} \right)^{\frac{1}{1-\rho}} \right\} \tag{2}$$

subject to the budget constraint:

$$c + a' + p_h h + m(d', r_m^*, j) + \varphi_f I\left(d' > 0\right) = y(j,z) + a(1+r) + d'\left(q^m(d';a',h,z,j) - \varphi_m + \tau^d r_m^*\right)$$

and the borrowing constraints:

$$\begin{aligned} d' &\leq (1-\iota_d) p_h h \\ m(d', r_m^*, j) &\leq \iota_p y(j,z) \end{aligned}$$

where τ^d is the mortgage subsidy rate, V^h is the continuation value for a homeowner, c is the non-durable consumption, p_h is the house price, φ_f and φ_m are the fixed and variable costs of mortgage origination, I is an indicator function, r is the rate of return on financial assets, m is the periodic mortgage payment, r_m^* is the risk-free mortgage interest rate, ι_d is the minimum down payment requirement, and ι_p is the maximum payment-to-income limit.[4]

2.2 Firms

We consider a continuum of perfectly competitive firms that produce output, Y_g, using capital K and labor N_g. In addition to choosing the quantity of labor, each firm determines hours per worker, or the labor-utilization rate, denoted by u. The wage per efficiency unit, $w\left(\overline{w}, u\right)$ (the same wage that appears as w in $y\left(j, z_j\right)$) is assumed to depend on the intensity of labor utilization. Specifically, the wage function is given by:

$$w\left(\overline{w}, u\right) = \bar{w} + \vartheta \frac{u^{1+\psi}}{1+\psi},$$

where ϑ and ψ are positive constants. This formulation implies that higher labor utilization increases the wage per efficiency unit, reflecting the rising marginal cost of more intensive labor use. In this setup, firms choose u optimally to minimize costs, workers are assumed to supply hours elastically and at no direct disutility cost, and the variables u, $\overline{w}$, and hence $w\left(\overline{w}, u\right)$ are determined

[4] We present the model in real terms as we assume no nominal rigidity and zero inflation in the steady-state of the model. In Section 4, we discuss how unexpected inflation affects the model.

in equilibrium. This structure generates a positive relationship between aggregate hours and wages, effectively mimicking an aggregate labor supply response to changes in aggregate wages, even though individual labor supply is inelastic.

Following Cooley and Quadrini (1999), Mendoza (2010), and Jermann and Quadrini (2012), we assume that the firm finances a fraction μ of its wage bill in advance through bank borrowing and pays interest on that amount. The firm's problem is:

$$\max_{K,N_g,u} Y_g - (r+\delta_k)K - (1+\mu r_\ell)\, w\,(\overline{w},u)\, N_g, \tag{3}$$

where $Y_g = \mathbb{Z}K^\alpha \left(N_g u\right)^{1-\alpha}$ with $\mathbb{Z}$ as TFP, and δ_k is the depreciation rate of capital. Because a worker's labor income depends on hours worked, labor income and output decline when the firm reduces work hours in response to an increase in bank lending rate r_ℓ.[5]

2.3 Rental Housing Companies

Rental housing firms begin each period holding $(1-\delta_h)\,H_r$ units of housing capital, reflecting depreciation at rate δ_h. These firms make dynamic investment decisions, selecting the new housing stock H_r'. Operating revenues consist of rental income net of maintenance expenses, $(p_r-\kappa)\,H_r'$, where p_r denotes the per-unit rental rate and κ captures ongoing maintenance costs.

Shareholder distributions equal:

$$x_r = p_h\,(1-\delta_h)\,H_r - p_h H_r' + (p_r-\kappa)\,H_r'$$

Value maximization requires solving:

$$(1+r)\,V^{rc}\,(H_r) = \max_{H_r'} \left[x_r + V^{rc}\left(H_r'\right)\right] \tag{4}$$

Returns on rental company equity match those on physical capital along the equilibrium path, deviating only during unanticipated shock realizations.[6] This return equalization yields the following optimality condition linking rental rates to housing prices:

$$p_r = \kappa + p_h - \frac{(1-\delta_h)\,p_h'}{1+r'} \tag{5}$$

[5]We could have achieved the same effect with endogenous labor supply. In that case, the firm would reduce labor demand, which would reduce wages. Households would reduce labor supply and output would decline. We choose this formulation because it is computationally more tractable. In Arslan et al. (2025), we show that a model with GHH preferences and endogenous labor supply in the household block is equivalent to the formulation used here, in which firms choose labor utilization.

[6]Unexpected shocks may generate temporary return differentials between physical capital and rental property holdings. These valuation surprises are allocated to household portfolios proportionally based on asset positions.

This expression characterizes the supply side of the rental market, with demand arising endogenously from household tenure decisions.[7]

2.4 Banks

The financial-intermediation sector is competitive and populated by risk-averse banks that maximize expected utility over consumption streams: $u\left(c^B\right)$, with c^B denoting banker consumption. There is no entry or exit from the banking sector.

Financial intermediaries operate with two funding sources: internal equity capital ω and external wholesale funding B' obtained at the risk-free rate r', which is the same return households receive investing in good-producing firms or rental companies. On the asset side, banks extend working capital loans L_k' to firms at rate r_ℓ' and maintain portfolios of residential mortgages through both origination and secondary market purchases.

Consider mortgage type $\theta = (d; a, h, z, j)$ encompassing borrower characteristics. Let $\ell'(\theta)$ denote the bank's position in type-θ mortgages, including both new originations and seasoned loans. The bank's recursive problem becomes:

$$\Psi(L, B) = \max_{\left\{c^B, L_k', \ell, B'\right\}} \left\{\log\left(c^B\right) + \beta_L \Psi\left(L', B'\right)\right\} \tag{6}$$

subject to the balance sheet identity:

$$c^B + L_k' + \int_\theta p_\ell(\theta)\,\ell'(\theta)\,d\theta = \omega + B'$$

Here, β_L captures banker patience and $p_\ell(\theta)$ represents the market price of type-θ mortgages. Net worth dynamics follow:

$$\omega' = \int_\theta \int_{\theta'} v^l\left(\theta'\right) \Pi\left(\theta'|\theta\right) \ell'(\theta)\,d\theta + L_k'\left(1 + r_\ell'\right) - B'\left(1 + r'\right)$$

The total payoff $v^l(\theta) = m_\ell(\theta) + p_\ell(\theta)$ combines current period cash flows $m_\ell(\theta)$ with continuation values, where $\Pi(\theta'|\theta)$ captures endogenous state transitions driven by household decisions.

[7] This formulation implies perfectly elastic rental supply. In unreported robustness checks, the main results of the paper are robust to the introduction of adjustment frictions in the rental supply, which makes the rental supply less elastic. Such a formulation generates larger movements in price-rent ratio and lower changes in the homeownership rate, but it has quantitatively insignificant effects in the other aggregates and prices of the model economy.

Cash flows from mortgage holdings depend on borrower actions:

$$m_\ell(\theta) = \begin{cases} d & \text{upon prepayment} \\ p_h h (1-\varphi_e) & \text{upon default} \\ \frac{r_m^*}{1+r_m^* - (1+r_m^*)^{j-J}} d & \text{if continuing} \end{cases} \tag{7}$$

Limited commitment introduces a friction: banks may abscond with a fraction ξ of assets, forfeiting future banking privileges but retaining access to savings at rate r. This outside option value $\tilde{\Psi}^D(\xi\tilde{L}')$ depends on realizable asset values:

$$\tilde{L}' = \int_\theta \int_{\theta'} v^l(\theta')\,\Pi(\theta'|\theta)\,\ell'(\theta)\,d\theta' d\theta + L_k'(1+r_\ell')$$

Creditors impose an incentive-compatible borrowing limit ensuring repayment:

$$\Psi(L', B') \geq \tilde{\Psi}^D(\xi\tilde{L}')$$

The continuum structure within borrower types eliminates portfolio risk through perfect diversification.[8] Consequently, arbitrage requires uniform returns r_ℓ' across all assets, implying:

$$p_\ell(\theta) = \frac{1}{1+r_\ell'} \int_{\theta'} v^l(\theta')\,\Pi(\theta'|\theta)\,d\theta' \quad \forall\theta$$

This return equalization permits aggregation without tracking portfolio composition. The incentive constraint simplifies to a leverage restriction:

$$(1-\phi')(1+r_\ell')\,L' \geq (1+r')\,B'$$

where the endogenous haircut ϕ' emerges from the limited commitment friction.[9]

Optimal bank policies exhibit linear scaling in net worth:

$$L' = \beta_L\widehat{\lambda}\omega \quad \text{and} \quad B' = \beta_L(\widehat{\lambda}-1)\omega$$

with leverage ratio $\widehat{\lambda} = \frac{(1+r')}{1+r'-(1-\phi')(1+r_\ell')}$.

[8] Within each borrower type θ, the continuum assumption ensures deterministic portfolio returns via the law of large numbers, preserving analytical tractability despite rich household heterogeneity.

[9] The haircut follows the recursive relation $\phi = \xi^{1-\beta_L}\left[(1+r')/(1+r_\ell') - (1-\phi')\right]^{\beta_L}$. Perfect commitment ($\xi = 0$) eliminates both haircuts and credit spreads.

Competition drives mortgage pricing to break-even levels:

$$dq^m(\theta) = p_\ell(\theta) \tag{8}$$

This condition determines the origination discount $q^m(\theta)$ as a function of borrower characteristics and loan amount.[10]

2.5 Residual Service Sector

The model includes several transaction costs: rental-unit maintenance, house sales, and mortgage origination. We assume that a labor-intensive service sector provides all of these services. Letting TC denote the sum of these costs, we have

$$TC = wN_s \tag{9}$$

where N_s is the labor demand in this sector.[11]

2.6 Government

The government operates two programs:

1. A balanced pay-as-you-go pension system, collecting taxes from workers and distributing benefits to retirees

$$\tau^s \sum_{j=1}^{J_r} \sum_z w\left(\exp(f(j)+z)\right)\, \lambda_j(z) = \sum_{j=J_r+1}^{J} \sum_z w y_R(j,z)\, \lambda_j(z), \tag{10}$$

   where $\lambda_j(z)$ is the measure of age-j households with productivity z.

2. Mortgage subsidy: Mortgage subsidies, which are proportional to mortgage-interest payments, are financed through labor-income taxes on all households, including retirees.

$$\tau^d \int \tilde{m}_\ell(\theta)\, d\lambda(\theta) = \tau^m \sum_{j=1}^{J_r} \sum_z w\left(\exp(f(j)+z)\right)\, \lambda_j(z) + \tau^m \sum_{j=J_r+1}^{J} \sum_z w y_R(j,z)\, \lambda_j(z) \tag{11}$$

   where $\tilde{m}_\ell(\theta) = r_m^* d(\theta)$ is the mortgage interest payment of a household with current state θ and λ is the distribution of households.

[10] In the absence of default risk, the origination price $q^m(\theta) = 1$. As the default risk increases, the loss of the bank is internalized by a lower origination price.

[11] In unreported robustness checks, the main results of the paper are essentially unchanged when these transaction costs are modeled as dead-weight losses.

2.7 Definition of Equilibrium

We provide the definition of equilibrium for the steady state. The transition equilibrium is defined analogously.

Definition 1. A stationary recursive competitive equilibrium consists of value functions for households, V^o $(o \in \{h, r, d\})$, for banks Ψ, for real estate companies, V^{rc}, policy functions for households' consumption (g_c), saving (g_a), housing services (g_s), housing stock (g_h), mortgage debt (g_d), tenure decisions (g_o), firms' labor $\left(N_g\right)$, capital (K), utilization (u), goods production $\left(Y_g\right)$, real estate companies' housing stock (H_r), banks' consumption (c_B), loans $\left(\ell, L^k, L\right)$, borrowing (B), service sector labor (N_s), prices for labor (w), assets (r), houses (p_h), rental properties (p_r), loans (r_ℓ, q^m), taxes (τ^s, τ^m), and a stationary distribution (λ) such that

1. Given prices and taxes, policy functions $(g_c, g_a, g_s, g_h, g_d, g_o)$ for households solve households' problems in equations B.1-B.5, and V^o denotes the associated household value functions.
2. Given prices, production firms' policy functions $\left(K, N_g, u\right)$ solve production firms' problem in equation 3, and Y_g is the associated output.
3. Given prices, rental housing companies' policy function (H_r) solves equation 4, and V^{rc} is the associated value function for rental housing companies.
4. Given prices, banks' policy functions(c_B, L, B) solve equation 6, and Ψ is the associated value function for banks.
5. q^m solves equation 8.
6. N_s solves equation 9.
7. Given stationary distribution λ, markets clear:

$$\text{asset market: } \int a d\lambda\left(\theta\right) = A = K + V^{rc}\left(H_r\right) + B$$

$$\text{labor market: } N_g + N_s = 1$$

$$\text{housing market: } \int s d\lambda\left(\theta\right) = \bar{H}$$

$$\text{credit market: } L_k + \int_\theta p_\ell\left(\theta\right)\ell\left(\theta\right) d\theta = L$$

$$\text{rental market: } \int s d\lambda\left(\theta, o \in \{r, d\}\right) = H_r$$

where $L_k = \mu w\left(\bar{w}, u\right) N_g$ is the firm's borrowing, $\ell\left(\theta\right) = \lambda\left(\theta\right)$; that is, banks' mortgage holdings equal household demand for mortgages. p_ℓ is given by

$$p_\ell\left(\theta\right) = \frac{1}{1 + r'_\ell}\int_{\theta'}\left(m_\ell\left(\theta'\right) + p_\ell\left(\theta'\right)\right)\Pi\left(\theta'|\theta\right) d\theta'.$$

8. Given stationary distribution λ, the government runs a balanced budget; that is, τ^s solves equation 10 and τ^m solves equation 11.

9. The distribution λ is stationary and consistent with the policy functions of households:

$$\lambda = G(\lambda)$$

where the mapping G is obtained through the policy functions of households and evolution of exogenous states.

3 Calibration

A model period corresponds to two years. Absent aggregate shocks and with zero inflation, the calibration of the FRM and ARM economies is identical. Agents enter the economy at age 25, participate in the labor force through age 65, and survive until age 85. The calibration strategy combines parameters drawn from existing literature ("External") with those determined through model fitting ("Internal"), as detailed in Table I.

Household Preferences The utility function incorporates consumption and housing services through a CES specification: $u(c,s) = [(1-\gamma)c^{1-\epsilon} + \gamma s^{1-\epsilon}]^{\frac{1-\rho}{1-\epsilon}}$. We set the elasticity of substitution between housing and consumption to the standard value $\epsilon = 1$, so that in the limit the utility function takes the Cobb–Douglas form, consistent with the evidence in Piazzesi et al. (2007). The risk aversion and intertemporal elasticity parameters are set conventionally at $\sigma = \rho = 2$, yielding an intertemporal substitution elasticity of 0.5.[12] The housing preference weight γ is chosen to match the contribution of housing services to GDP, while the discount factor β targets the capital-output (K/Y_g) ratio.[13]

Labor Income Dynamics The stochastic component of working-age income follows an AR(1) process with annual persistence $\rho_\varepsilon = 0.96$ and standard deviation of the innovation $\sigma_\varepsilon = 0.17$, aligning with estimates from Storesletten et al. (2004). Post-retirement benefits follow the structure outlined in Guvenen and Smith (2014), approximating the U.S. Social Security system.

Production Technology Production employs a Cobb-Douglas technology with capital share $\alpha = \frac{1}{3}$. We normalize the steady-state value of aggregate productivity to $\mathbb{Z} = 1$. We set the capital depreciation rate, δ_k, to match the nonresidential-investment-to-output ratio. Following Arslan et

[12]Although equating the risk aversion and intertemporal elasticity parameters causes the utility function to reduce to CRRA, we use the EZ formulation in the solution of the household's problem as it reduces the curvature of the value functions to be interpolated, which significantly improves the computational accuracy of the solution.

[13]Targeting capital-output instead of capital-GDP ratio allows us to pin down the return on financial assets directly. That allows us to skip the market clearing loop in the calibration and speeds up the calibration of the model.

al. (2025), we set the hours elasticity parameter to $\psi = 0.5$.[14] The scale parameter ϑ is calibrated to set the utilization rate to $u = 1$ as a normalization.

TABLE I – Parameters (externally set and internally calibrated)

		Value	
Parameter	Explanation	External	Internal
σ	Risk aversion	2	
$1/\rho$	Elasticity of intertemporal substitution	0.5	
ϵ	Elasticity of substitution	1	
α	Capital share	$\frac{1}{3}$	
ψ	Curvature on hours	0.5	
ρ_ε	Persistence of income	0.921	
σ_ε	Standard deviation of AR(1) innovation	0.238	
φ_s	Selling cost for a household	7%	
φ_e	Selling cost for foreclosures	25%	
φ_f	Fixed cost of mortgage origination	0.02	
φ_m	Variable cost of mortgage origination	0.75%	
χ	Prob. of being an active renter	0.265	
$\bar{H}$	Aggregate house supply	1	
ι_p	Maximum payment-income limit	0.45	
ι_d	Minimum down payment limit	0	
β	Discount factor		0.944
$\underline{h}$	Minimum house size		0.313
τ^d	Mortgage subsidy		26.5%
γ	Weight of housing services in utility		0.192
μ	Share of wage bill financed from banks		0.437
β_L	Bank discount factor		0.711
ξ	Bankers' asset-diversion rate		0.254
κ	Rental maintenance cost		-0.006
δ_h	Housing depreciation rate		4.68%
δ_k	Capital depreciation rate		0.129

Notes: The model period is two years. Parameters reported at the model frequency: $\beta = 0.944$, $\delta_k = 0.129$, $\chi = 0.265$, $\rho_\varepsilon = 0.921$, $\sigma_\varepsilon = 0.238$, and $\varphi_f = 0.02$. At an annual frequency these correspond to $\beta \approx 0.97$, $\delta_k \approx 0.067$, a re-entry probability of about 0.14, $\rho_\varepsilon = 0.96$, and $\sigma_\varepsilon = 0.17$.

Housing Market The probability that credit-impaired households regain mortgage eligibility is calibrated at $\chi = 0.265$ per two-year model period, corresponding to an annual probability of about 0.14, reflecting the approximately seven-year duration of adverse credit events. Transaction

[14]This implies a Frisch elasticity of 2.

costs follow Campbell et al. (2011), with standard home sales incurring 7 percent costs (φ_s) while foreclosure proceedings require 25 percent (φ_e). Mortgage origination involves both a fixed cost ($\varphi_f = 4\%$ of annual GDP) and a variable fee ($\varphi_m = 0.75\%$ of the loan value), based on Board of Governors of the Federal Reserve System (2008). We impose no mandatory down payment ($\iota_p = 0$), though endogenous down payments emerge from households seeking better loan terms. We also set the maximum payment-to-income limit to 45%. This limit does not bind in the steady-state of the model. The housing-depreciation rate, δ_h, is calibrated to match the ratio of residential investment to output. The rental-maintenance parameter, κ, is calibrated to match the house-price-to-rent ratio implied by the steady-state pricing relationship: $p_r = \kappa + \frac{r+\delta_h}{1+r} p_h$.[15] The minimum owner-occupied unit size $\underline{h}$ (which is also the maximum rental size) is calibrated to match the homeownership rate. We cannot separately pin down house supply and house prices. We normalize the house supply, $\bar{H} = 1$.

Banking Sector Four banking-sector parameters are calibrated: the bank discount factor, β_L, the fraction of assets that bankers can divert, ξ, the mortgage subsidy rate, τ^d, and the fraction of the wage bill that firms finance through banks, μ. The first two parameters are identified using analytical moments implied by the bank's problem. In the steady state, the spread between the bank lending and borrowing rates satisfies $r_\ell - r = \frac{1-\beta_L(1+r)}{\widehat{\lambda}\beta_L}$, where the leverage ratio and haircut are defined, respectively, as $\widehat{\lambda} = \frac{1+r}{1+r-(1-\phi)(1+r_\ell)}$, $\phi = \xi^{1-\beta_L}\left(\frac{1+r}{1+r_\ell} - 1 + \phi\right)^{\beta_L}$. The two targets—the bank leverage ratio, $\hat{\lambda}$, and the spread between the lending and deposit rates, $r_\ell - r$, identify the bank discount factor β_L and the seizure parameter ξ. The remaining two parameters are identified using simulated model moments. The mortgage-subsidy rate affects the effective mortgage interest rate $\left(\left(1-\tau^d\right) r_\ell\right)$ paid by households and therefore affects the equilibrium level of mortgage debt. We calibrate the mortgage subsidy, τ^d, to match the mortgage-debt-to-GDP ratio. The fraction of the wage bill financed by banks affects the level of corporate debt. We use the share of mortgage loans in total bank lending (mortgage plus corporate loans) to identify this parameter.

In total, we calibrate ten parameters internally: β, $\underline{h}$, τ^d, γ, μ, β_L, ξ, κ, δ_h, and δ_k. They are jointly calibrated to match the key moments in Table II: homeownership rate, mortgage-debt-to-GDP ratio, capital-output ratio, share of mortgage loans in total bank lending (mortgage plus corporate loans), housing-services share of GDP, mortgage premium, bank leverage ratio, house-price-to-rent ratio, nonresidential-investment-to-output ratio, and residential-investment-to-GDP ratio. All moments are computed as averages over the 2015–2020 period. See Appendix B.1 for details on the data sources.

[15] κ is best interpreted as a net operating wedge on rental supply rather than a literal maintenance cost: the small negative calibrated value ($\kappa = -0.006$) means that matching the observed price–rent ratio requires rental companies to supply housing services at slightly below the frictionless user cost, for example because of scale economies in maintenance.

TABLE II – Moments

Statistic	Data	Model
Capital-output ratio	3	3
Homeownership rate	64.0 percent	64.0 percent
Mortgage-debt-to-GDP ratio	60.3 percent	60.3 percent
Share of housing services in GDP	12.5 percent	125 percent
Share of mortgage loans in bank loans (mortgage plus corporate)	52.3 percent	52.3 percent
Mortgage premium	1.7 percent	1.7 percent
Bank leverage ratio	9.1	9.1
House-price-to-rent ratio	16.1	16.1
Residential-investment-to-GDP ratio	4.7 percent	4.7 percent
Nonresidential-investment-to-output ratio	19.3 percent	19.3 percent

Notes: Flow variables and interest rates are annualized.

4 Results

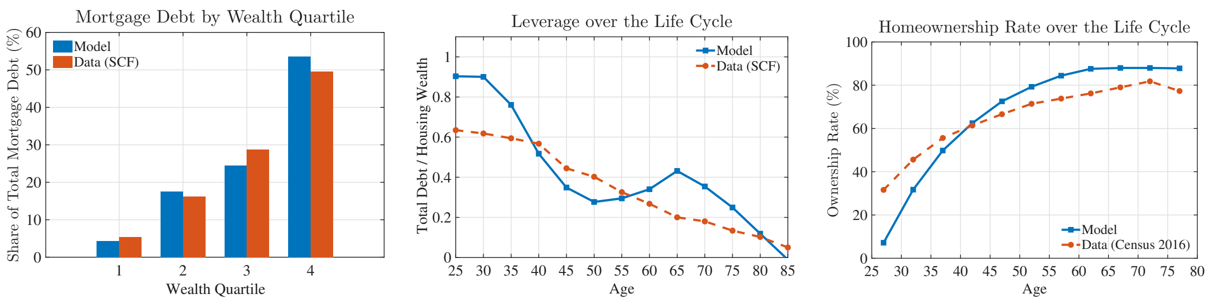
Model Performance: Untargeted Life-Cycle and Cross-Sectional Moments We begin by evaluating the model's ability to match salient cross-sectional and life-cycle patterns that are not targeted in the calibration. Figure 1 reports three such comparisons. The left panel compares the distribution of outstanding mortgage debt across wealth quartiles in the model with the 2016 Survey of Consumer Finances. In both, mortgage debt is concentrated among wealthier households: the top wealth quartile holds about one-half of total mortgage debt, whereas the bottom quartile accounts for less than 10 percent. The model slightly overstates the share held by the bottom quartile, 7.8 percent versus 5.4 percent in the data, but it matches the strong monotonic concentration of mortgage debt across the wealth distribution.

The middle panel plots life-cycle leverage, measured as total mortgage debt relative to total housing wealth within each age bin. The model reproduces the decline in leverage over the life cycle, from nearly one for young households to around 0.3 by retirement. Relative to the Survey of Consumer Finances, leverage is somewhat higher in the model for households below age 40, which is consistent with the assumption that households enter the economy with zero initial wealth, but the two profiles align closely thereafter.

The right panel compares homeownership rates by age in the model with the 2016 U.S. Census. The model tracks the data closely from the mid-30s onward, capturing both the steep increase in homeownership over the working life and the flattening of the profile at older ages. Although the model understates ownership among the youngest households, again due to the assumption that households enter the economy with zero wealth, this gap narrows quickly as households accumulate assets.

Overall, these untargeted moments indicate that the model provides a credible quantitative environment for studying how mortgage structure shapes the transmission of inflation shocks.

FIGURE 1 – Model Performance: Untargeted Life-Cycle and Cross-Sectional Moments



Notes: Model moments computed from the baseline steady state (100 percent LTV). Left: share of total mortgage debt held by each net-worth quartile; data from the 2016 SCF. Middle: ratio of aggregate mortgage debt to aggregate housing wealth within each 5-year age bin; data from the 2016 SCF. Right: homeownership rates by age in the model and the 2016 Census.

Implementation of the 2021–2023 Inflation Shock We next study the model's response to an inflation shock calibrated to the 2021–2023 episode. This episode was marked by a sharp and largely unexpected rise in inflation, whose effects depend critically on mortgage contract structure. In an FRM economy, higher inflation reduces the real value of nominal mortgage liabilities, generating a wealth transfer to borrowers while imposing concentrated valuation losses on banks through the Fisher channel. In an ARM economy, by contrast, nominal mortgage rates reset with inflation, which attenuates the Fisher channel but tightens household cash flows through higher debt-service payments.

In the deterministic steady state, the FRM and ARM economies are identical because, absent shocks, mortgage rates do not vary over time. To isolate the role of mortgage structure, we therefore introduce an unanticipated inflation shock in an environment in which all prices other than those embedded in existing nominal mortgage contracts adjust flexibly. We then compute the full transition dynamics using global solution methods. Notice that in the absence of long-term nominal contracts, an increase in inflation has no effect on the real economy as all prices will adjust at the rate of inflation.[16]

To discipline the experiment, we calibrate the shock to match the broad magnitude and persistence

[16]Consider the budget constraint of an active renter in equation B.1, in nominal terms:

$$Pc + A' + P_r s = Py(j,z) + A\,(1+i)$$

where P is the current price level, A is the current nominal wealth, P_r is the nominal rental price, and i is the nominal of the post-2020 inflation surge. Specifically, we model the episode as an unexpected 7 percentage point increase from an initial zero-inflation steady state, followed by mean reversion governed by an AR(1) process with two-year persistence of 0.4. These values are obtained by first fitting a linear trend to the price level over 2015–2020, which implies trend inflation of about 2 percent, and then measuring the post-2020 deviation of the price level from that trend to infer both the size of the shock and its persistence. We assume perfect foresight regarding the path of the shock after the initial impact.[17]

In the presence of inflation, nominal mortgage payments are calculated using a formula analogous to equation 1:

$$D_t = M + \frac{M}{1+i_t^m} + \frac{M}{\left(1+i_t^m\right)^2} + ... + \frac{M}{\left(1+i_t^m\right)^{T-1}} = M \sum_{\tau=t}^{T-1} \left(\frac{1}{1+i_t^m}\right)^{\tau-t}$$

Here, $\left(1+i_t^m\right) = \left(1+r_t^m\right)\left(1+\pi_t\right)$, where i_t^m is the nominal mortgage interest rate, r_t^m is the real interest rate, and π_t is the inflation rate at time t. D_t is the nominal mortgage debt at time t and M is the constant nominal mortgage payment. This equation gives the nominal mortgage payment as a function of nominal mortgage debt, mortgage interest rate, and maturity:

$$M = \frac{D_t}{\sum_{\tau=t}^{T-1} \left(\frac{1}{1+i_t^m}\right)^{\tau-t}}$$

and nominal mortgage balance evolves according to:

$$D_{t+1} = \left(D_t - M\right)\left(1+i_t^m\right)$$

interest rate. Dividing both sides by P, we get

$$c + \frac{A'}{P} + \frac{P_r}{P}s = y(j,z) + \frac{A}{P}\left(1+i\right)$$

Denoting $\frac{A'}{P} = a'$, $\frac{P_r}{P} = p_r$, and $\frac{1+i}{1+\pi} = 1+r$ where π is the inflation rate between the previous period and the current period ($1+\pi = \frac{P}{P_{-1}}$, P_{-1} is the price level in the previous period), the above equation becomes

$$c + a' + p_r s = y\left(j,z\right) + a\left(1+r\right)$$

which is the same equation as in B.1, and it does not include the price level or the inflation. This implies that changes in the price level or inflation has no impact on the real variables. The same result holds for all other budget constraints except for the homeowner, where real mortgage payment, m and the price of the mortgages, q^m, can be affected from changes in the price level as discussed below.

[17] To maintain tractability in the FRM economy, we assume the risk-free mortgage interest rate, r_m^*, remains constant after the shock. Allowing it to vary would require tracking the vintage of each mortgage, increasing the state space. Changes in the bank lending rate still affect mortgage pricing, however. The ARM economy avoids this complexity as existing mortgage rates adjust periodically.

The real mortgage payment at time t is then given by

$$m_t = \frac{M}{P_t} = \frac{D_t/P_t}{\sum_{\tau=t}^{T-1}\left(\frac{1}{1+i_t^m}\right)^{\tau-t}} = \frac{d_t}{\sum_{\tau=t}^{T-1}\left(\frac{1}{1+i_t^m}\right)^{\tau-t}}$$

and the evolution of real debt balances becomes

$$d_{t+1} = \frac{D_{t+1}}{P_{t+1}} = \frac{(D_t - M)\left(1 + i_t^m\right)}{P_{t+1}} = \frac{(D_t - M)\left(1 + i_t^m\right)}{P_t\left(1 + \pi_t\right)} = \frac{(d_t - m_t)\left(1 + i_t^m\right)}{(1 + \pi_t)}$$

In the ARM economy, the nominal mortgage interest rate, i_t^m, is reset to the current nominal bank lending rate in every period. When inflation rises temporarily, the nominal interest rate also increases, so that $(1 + i_t^m) = \left(1 + r_t^\ell\right)(1 + \pi_t)$. As a result, mortgage payments increase. However, this increase also accelerates the amortization of the real mortgage debt balance. Consequently, the real mortgage payment schedule becomes steeper rather than flat, as in the no-inflation case. In the FRM economy, the nominal mortgage interest rate and the nominal mortgage payment (M) are fixed for existing mortgages and are not affected by inflation. Thus, an unexpected increase in the price level (P_t) immediately reduces the real value of these nominal payments ($m_t = M/P_t$). Furthermore, the real mortgage principal declines at the rate of inflation, accelerating the reduction in the real debt burden over time.

These dynamics are illustrated in Figure 2, which shows the evolution of real mortgage payments, real mortgage balances, and the real market value of mortgage debt in bank assets for a 30-year mortgage with an initial balance of 1, originated in the steady state, when the two-year mortgage interest rate is 9.2 percent and the inflation rate is zero. The solid blue lines depict the case without an inflation shock: real mortgage payments remain constant, the real mortgage debt gradually amortizes, and the book value and market value of the mortgage debt coincide.[18] The dashed red lines and long-dashed black lines show the dynamics for an ARM and an FRM mortgage, respectively, when the two-year inflation rate temporarily rises to 7 percent and then gradually reverts to its steady-state value of zero, with persistence of 0.4 per model period, as in the benchmark economy.

In the ARM economy, real mortgage payments spike before gradually declining to a level below their initial steady-state value. In the FRM economy, by contrast, they drop immediately below their initial steady-state level and continue to decline over time. Despite these differences in the evolution of mortgage payments, the real mortgage debt balance (the book value of real mortgage debt) evolves similarly in both economies. However, the market value of real mortgage debt differs substantially. In the FRM economy, the sharp reduction in real mortgage payments lowers the

[18]With zero inflation, the FRM and ARM economies generate identical paths for mortgage payments and balances.

FIGURE 2 – Inflation Shock and Mortgage Dynamics

Notes: The panels compare the dynamics of real mortgage payments, real mortgage debt, and the real market value of mortgage debt following a 7 percentage point inflation shock in the FRM and ARM economies. The initial debt balance is normalized to 1, and the two-year mortgage interest rate is 9.2 percent. Inflation unexpectedly rises from 0 to 7 percent and then reverts to its initial value with two-year persistence of 0.4. The solid blue line depicts the case without the inflation shock. The red dashed line represents the ARM economy, and the long-dashed black line represents the FRM economy.

present value of mortgages, and thus the market value of the debt. In contrast, in the ARM economy, the effect is smaller, since higher initial mortgage payments offset the reduction in future payments.

The evolution of real mortgage payments and the real market value of mortgage debt show how the inflation shock generates real effects through two primary channels.[19] First, unexpected inflation drives the Fisher effect. In the FRM economy, unexpected inflation immediately erodes the real value of existing fixed-rate mortgage payments and principals. This constitutes a wealth transfer from lenders (banks) to borrowers (households) and generates an immediate valuation shock to

[19] Absent long-term contracts, changes in inflation would have no real effects in this framework.

bank capital. This channel is largely absent in the ARM economy, where nominal interest rates adjust with inflation, stabilizing the real value of the mortgage balance. Second, higher expected inflation increases nominal interest rates. In our benchmark, all prices (other than mortgages) are flexible, so nominal rates rise in parallel with expected inflation. Because standard amortization schedules assume constant nominal payments, positive expected inflation implies that the real value of these payments declines over time. This "tilting effect" front-loads the real payment burden, influencing household consumption and financial decisions. It is present for ARMs, including existing contracts as they reprice. In the tractable FRM experiment, the coupon on newly originated mortgages is held fixed, while changes in bank lending rates affect origination prices.

4.1 Aggregate Dynamics

Figure 3 plots the aggregate effects of the inflation shock, comparing an economy composed entirely of FRMs (red dashed line) with one composed entirely of ARMs (blue solid line). The divergence between the two economies highlights the critical role of mortgage structure in macroeconomic dynamics.[20]

In the ARM economy, the macroeconomic impact of the inflation shock is muted. Since ARM contracts pass payment risk to households, bank balance sheets are largely insulated. The primary transmission mechanism is the tilting effect on real mortgage payments: higher inflation increases current real payments while lowering future real payments. For liquidity-constrained households, this front-loading of real payments reduces consumption. However, the aggregate impact is limited, as most households smooth consumption by reducing savings, given the temporary nature of the shock.

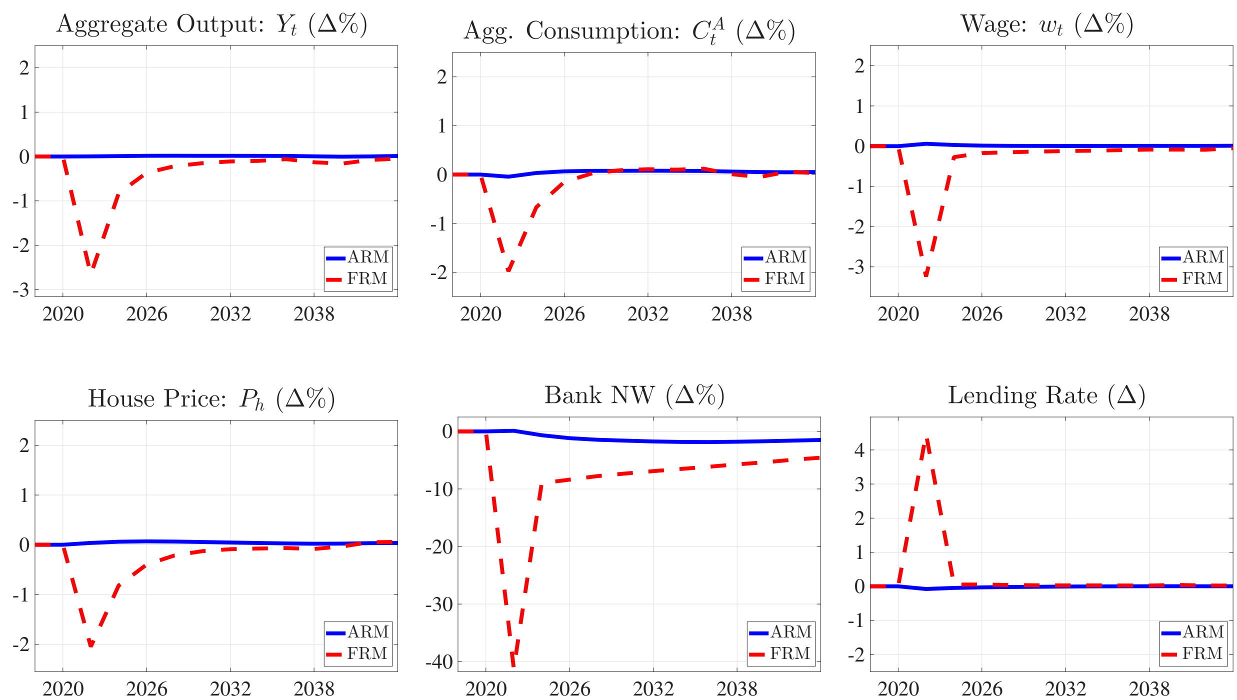
The reduction in mortgage credit demand slightly lowers the bank lending rate. This temporarily reduces firms' financing costs, leading to a brief, small increase in labor demand, wages, and output. Overall, the ARM economy shows significant resilience, with output, consumption, and wages staying almost flat.

The dynamics in the FRM economy reveal a powerful, recessionary transmission mechanism driven by the vulnerability of the banking sector to inflation. While FRM borrowers experience a wealth windfall as inflation erodes the real value of their fixed nominal debt, the corresponding real losses are concentrated on the balance sheets of the banks holding these assets. The market value of their long-term, fixed-rate mortgage portfolios declines sharply. As shown in the bottom-middle panel of Figure 3, bank net worth declines by more than 40 percent on impact.

This erosion of bank capital triggers a strong financial accelerator effect. Constrained banks contract their credit supply, leading to a spike in the bank lending rate (bottom-right panel), which increases

[20]Notice that the steady-state of an economy entirely composed of FRM or ARM is identical. The differences across these two economies are due to the interaction of different mortgage structures with the aggregate shock.

FIGURE 3 – Model Dynamics with Inflation Shock: ARM versus FRM



Notes: This figure plots the transition dynamics following an unanticipated 7 percentage point inflation shock, comparing an economy with only adjustable-rate mortgages (ARM, solid blue line) to one with only fixed-rate mortgages (FRM, dashed red line). The shock hits an initial zero-inflation steady state and then follows an AR(1) process with two-year persistence of 0.4. The panels report the responses of output, consumption, wages, house prices, bank net worth, and the bank lending rate. Because the model abstracts from nominal rigidities other than mortgage contracts, all other prices adjust flexibly after the shock.

by more than 4 percentage points. This highlights an important insight of our framework: a shock that benefits borrowers can simultaneously trigger a systemic credit crunch when the losses are borne by leveraged financial intermediaries.

The real consequences of this credit contraction dominate the positive wealth effect on households. Facing sharply higher financing costs, firms reduce labor demand. This leads to a recession: output falls by about 2.5 percent, wages decline by 3.2 percent, and household consumption contracts by 2.0 percent. In parallel, house prices fall by more than 2.0 percent. These results imply that the structure of the mortgage market fundamentally alters the transmission of inflation shocks.

The model predicts a recession in the FRM economy driven by a sharp contraction in bank net worth. This contrasts with the actual U.S. experience, where growth slowed but remained positive. This difference reflects forces omitted from the model that buffered the actual economy during this episode. Our framework isolates the structural vulnerability of the FRM system to assess the transmission mechanism. In reality, the negative credit-supply shock was buffered by three policy interventions. First, households entered the tightening cycle with unprecedented excess savings from fiscal transfers (CARES and ARP Acts). Second, regulatory interventions—most notably the Bank Term Funding Program (BTFP)—provided liquidity against eligible collateral valued at par, thereby limiting forced asset sales and the associated contraction in credit. Third, as discussed in Section 5.2, the central bank's initial delay in tightening acted as a form of forbearance, shielding banks from the valuation shock. Our results should therefore be interpreted as a *counterfactual benchmark of financial fragility*: they quantify the financial accelerator that could have materialized in the absence of these fiscal, regulatory, and monetary backstops.

Role of Bank Balance Sheets To isolate and quantify the contribution of the bank balance sheet channel, we conduct a counterfactual experiment. Figure 4 compares the benchmark FRM and ARM economies with counterfactual FRM and ARM economies in which the bank balance-sheet constraint is nonbinding. In these counterfactuals, banks still intermediate credit and price default risk, but their lending rates do not respond to changes in their own net worth. This effectively eliminates the financial accelerator mechanism.[21]

The results show that the constrained banking sector is the primary driver of the recession in the FRM economy. In the absence of the bank channel, the inflation shock is expansionary. The wealth transfer to FRM households boosts demand, leading to a 0.6 percent increase in consumption and 0.3-0.5 percent increases in output, wages, and house prices.

When the bank channel is active, however, this positive demand-side impulse is entirely reversed. The credit crunch induced by the collapse in bank net worth is sufficiently large to push the economy into a significant recession. This exercise confirms that the adverse macroeconomic consequences of an inflation shock in an FRM-dominated economy are attributable to the vulnerabilities it creates within the leveraged financial sector.

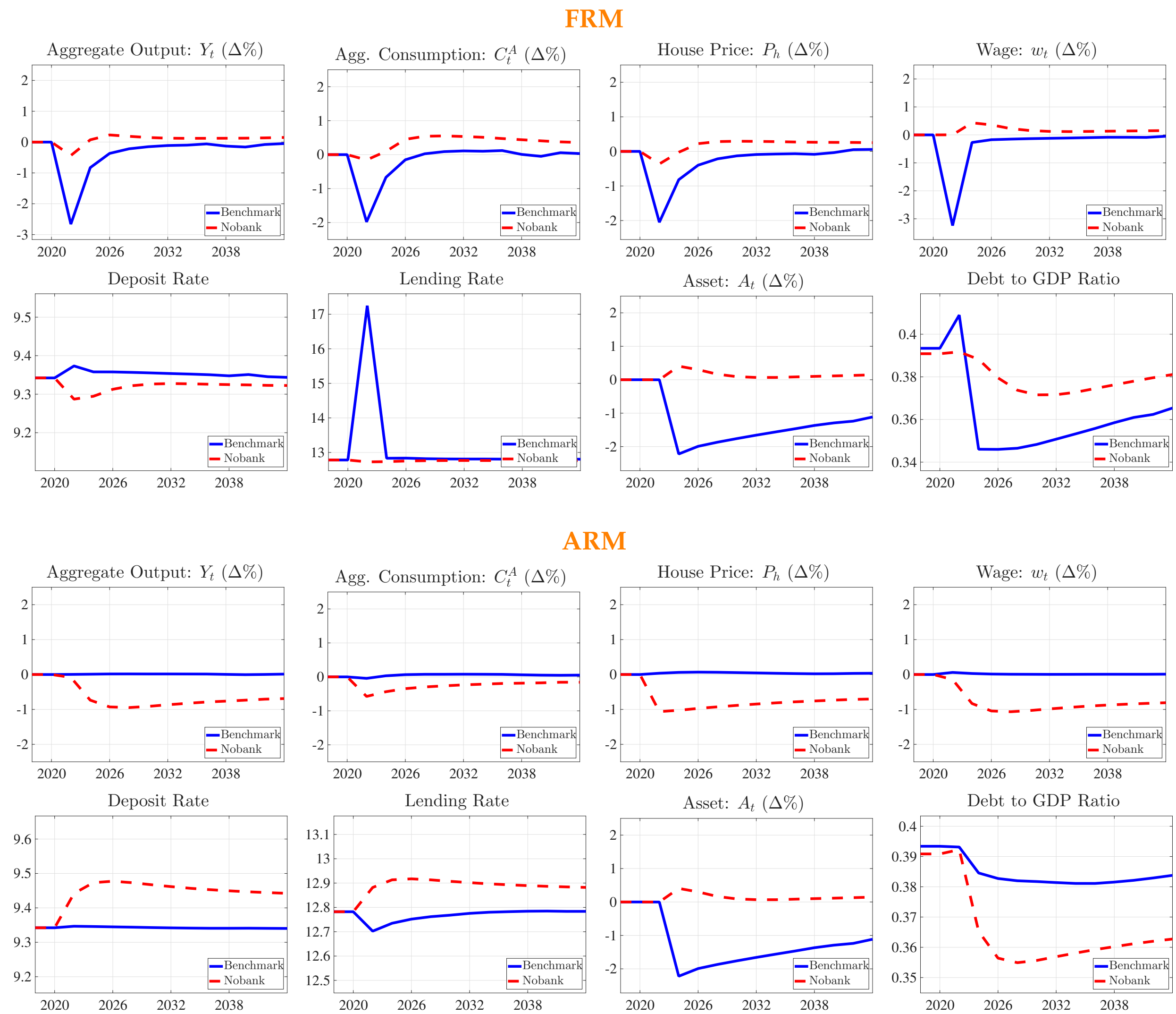
This finding has important implications for the interpretation of empirical research on the Fisher channel. Studies that focus solely on the household wealth gains from inflation often capture only the partial equilibrium demand-side response. Our general equilibrium analysis demonstrates that the offsetting credit-supply contraction from the banking sector is powerful enough to overturn the sign of the aggregate impact. This highlights a fundamental "missing intercept" problem: empirical estimates of the household channel, while potentially internally valid, may provide a misleading guide to the ultimate macroeconomic consequences in an FRM system, where the general equilibrium effects of the bank balance sheet channel dominate.

In contrast to the FRM case, the bank balance sheet channel plays a very different role in the ARM economy. The bottom panels of Figure 4 compare the benchmark ARM economy (solid blue line)

[21] In this economy, the only role of financial intermediaries is to price mortgages. This economy corresponds to the standard heterogeneous-agent model where borrowers are directly financed by the savings of households.

with the counterfactual ARM economy in which the bank constraint is nonbinding (dashed red line). Notably, the benchmark economy performs better than the "no-bank" counterfactual, indicating that the banking channel is actually supportive during this episode.

FIGURE 4 – Model Dynamics with Inflation Shock: The Role of Bank Balance Sheets



Notes: This figure compares the transition dynamics following an unanticipated 7 percentage point inflation shock in the benchmark model and in a counterfactual economy in which the bank balance sheet constraint is shut down. The top two rows report the FRM economy and the bottom two rows report the ARM economy. In each panel, the solid line denotes the benchmark economy and the dashed line denotes the no-bank-balance-sheet counterfactual. The shock hits an initial zero-inflation steady state and then follows an AR(1) process with two-year persistence of 0.4. Because the model abstracts from nominal rigidities other than mortgage contracts, all other prices adjust flexibly after the shock. Output, consumption, house prices, wages, and assets are reported as percent deviations from the initial steady state, while deposit rates, lending rates, and the debt-to-GDP ratio are reported in levels. The debt-to-GDP panel expresses mortgage debt relative to GDP per model period (two years); the annualized steady-state ratio equals the 60.27 percent target in Table II.

This stabilizing effect occurs through a general equilibrium adjustment in the lending rate. In the ARM economy, the inflation shock increases the real burden of current mortgage payments (the "tilting effect"), which causes a decline in the demand for new credit. In the benchmark model, this reduction in loan demand puts downward pressure on the equilibrium lending rate, causing it to fall temporarily. This lower lending rate reduces firms' financing costs for working capital, which slightly boosts labor demand and output. The counterfactual does not generate the same endogenous decline in the lending rate. As a result, output contracts relative to the benchmark, in which the lower lending rate provides a modest buffer.

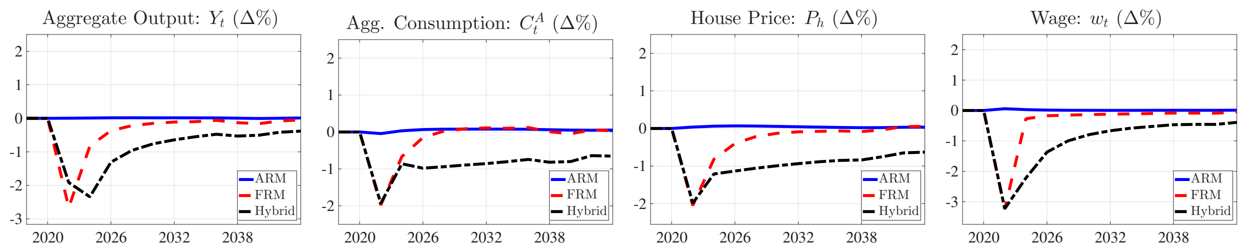
4.2 Decomposition of Household and Bank Balance Sheets

To further disentangle the relative contributions of the household and bank balance sheet channels, Figure 5 presents an analysis comparing three scenarios following the inflation shock: the benchmark FRM economy, the benchmark ARM economy, and a hybrid economy. In the hybrid scenario, households hold ARMs, but the bank lending rate is exogenously set to the path observed in the distressed FRM economy. This scenario isolates the combined effect of ARM payment resets and the exogenously imposed FRM lending-rate path.

The FRM economy experiences the largest impact contraction, whereas the hybrid economy displays the most persistent decline. The hybrid path combines the household cash-flow effect of ARMs with the adverse lending-rate path from the FRM economy, producing a smaller impact decline than under FRMs but a substantially more persistent contraction. Comparing the hybrid and FRM economies shows how replacing FRMs with ARMs changes the timing of the household adjustment when the adverse lending-rate path is held fixed. FRM borrowers receive the Fisher-channel windfall and avoid the ARM payment reset, but the aggregate FRM contraction is sharper on impact; the hybrid contraction is less severe initially and more persistent. The sharper FRM impact reflects the timing of the two forces: the Fisher windfall is a wealth gain spread over borrowers' remaining lifetimes, so it does little to offset the immediate collapse of new mortgage lending and housing demand at sharply higher rates, whereas the hybrid economy's payment resets drain cash flows only gradually—muting the impact response but prolonging the adjustment.

Conversely, comparing the hybrid and ARM economies isolates the impact of the bank balance sheet channel. In both economies, households hold ARMs, implying identical direct exposure. The difference lies in the banking sector: the ARM economy has resilient banks and stable lending rates, while the hybrid economy suffers from a decline in credit supply. The divergence in outcomes, a mild downturn in the ARM economy versus a deep and prolonged recession in the hybrid economy, demonstrates that the health of the banking sector is a primary determinant of macroeconomic stability during an inflation shock.

FIGURE 5 – Decomposition of Household and Bank Effects



Notes: The graph plots the dynamics of the model economy with the inflation shock for key variables. The blue solid line is the benchmark ARM economy, the red dashed line is the benchmark FRM economy, and the black long-dashed line is the hybrid economy with ARMs and the lending-rate path from the benchmark FRM economy. The inflation shock is an unexpected 7 percentage point increase from an initial steady state of zero. The shock follows an AR(1) process with a two-year persistence of 0.4. Since there are no price rigidities other than nominal mortgage contracts, all prices, including the bank deposit rates, adjust nominally.

Overall, this decomposition clarifies that the recession in the FRM economy is the net result of a powerful negative credit-supply shock, which is partially offset by positive household wealth effects.

4.3 Distributional Implications of Mortgage Structure

The choice of mortgage structure alters not only the magnitude of the economic downturn but also the distribution of its costs. We analyze these distributional consequences across two key dimensions: net worth and housing tenure (renters, outright owners, and indebted mortgage holders). We classify households based on their state variables immediately before the shock. We trace these individuals over time, presenting statistics relative to an economy without the inflation shock to eliminate life-cycle effects.

Consumption Figure 6 (top panels) plots the dynamics of consumption across different groups. In the FRM economy, the recession caused by the credit contraction generates consumption declines, particularly among the most vulnerable households. The poorest decile experiences a drop in consumption of close to 1.0 percent. Renters face reductions of approximately 0.5 percent. These groups suffer losses despite not necessarily holding mortgage debt, indicating that the transmission operates primarily through general equilibrium effects, namely, a weak labor market and tight credit conditions. Indebted homeowners increase consumption (by more than 1 percent for high-LTV holders), driven by the erosion of their real debt burden.

The ARM economy shows a different pattern. As we have shown above, the aggregate consumption response is much smaller, reflecting the overall macroeconomic stability. However, the costs of the inflation shock are concentrated on certain groups. The poorest decile and renters maintain stable consumption. High-LTV mortgage holders reduce consumption by about 0.1 percent on impact, reflecting the direct cash-flow effect of increased real mortgage payments. Although consumption among these groups subsequently increases, the rise is much smaller than in the FRM economy.

Homeownership Rate Figure 6 (middle panels) reveals how mortgage structure affects the housing market across different groups in our model economy. In the FRM economy, homeownership rises for all tenure groups but falls by more than 1 percentage point for the poorest decile. This decline occurs primarily through the extensive margin—the inability of new buyers to secure financing due to high lending rates and tighter credit conditions. Existing homeowners, particularly mortgagors, remain homeowners at higher rates than in the no-shock counterfactual because they benefit from lower real debt burdens.

In the ARM economy, the impact of the inflation shock on homeownership is minimal across all groups. While high-LTV owners face increased payment burdens, this translates to only marginal declines in ownership rates. The preservation of credit availability and stable lending rates means that potential new entrants face fewer barriers to homeownership.

Welfare Figure 6 (bottom panels) presents the welfare effects in consumption-equivalent terms. The FRM economy generates a divergence between winners and losers. On the one hand, the poorest households and renters experience significant welfare losses of close to 0.2 percent. These losses reflect the combined impact of wage and consumption declines. On the other hand, existing mortgage holders—particularly highly leveraged borrowers—experience welfare gains of more than 0.6 percent because the benefit of real debt erosion outweighs the adverse macroeconomic environment. This creates a perverse redistribution: those with mortgage debt benefit from the inflation shock, while those without mortgage debt bear the adjustment costs through the recession.

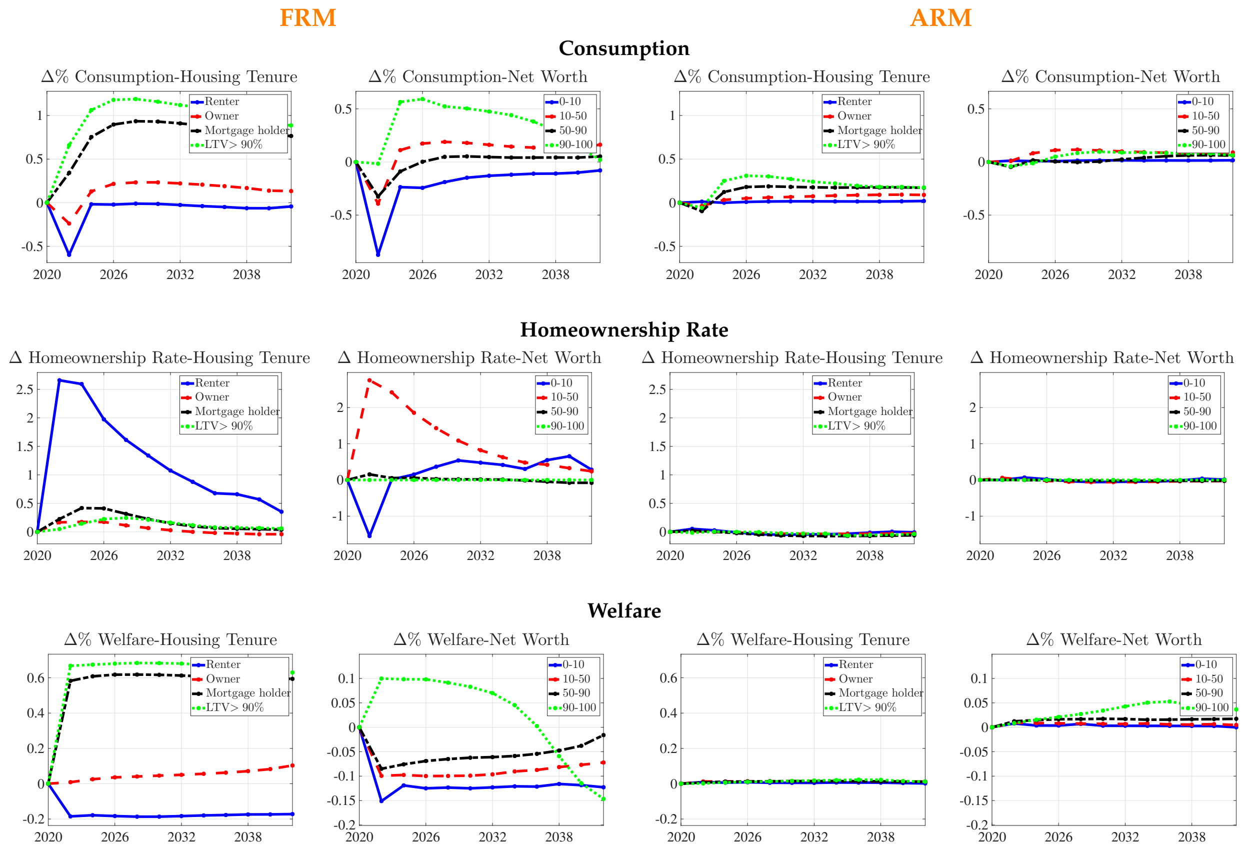
The ARM economy produces muted welfare effects. High-LTV borrowers experience a small welfare gain of about 0.05 percent, while poorer households and renters experience essentially no welfare loss. The preservation of macroeconomic stability, particularly wages and credit availability, means that other groups experience minimal welfare losses.

Balance Sheet Adjustments The mechanisms underlying these welfare dynamics become clearer when examining household balance sheet adjustments. Figure 7 (top panels) reveals different patterns of financial asset depletion across the two regimes.

In the FRM economy (top-left panels), renters face the most severe adjustment, depleting approximately 9 percent of their financial assets to maintain consumption amid the recession. The 10th–50th percentile group reduces its assets by roughly 7 percent. Mortgage holders and high-LTV borrowers both deplete less than 2 percent of their assets.

The ARM economy (top-right panels) shows more modest adjustments. High-LTV mortgage holders experience the largest reduction at approximately 2 percent. Regular mortgage holders see

FIGURE 6 – Distributional Effects of Inflation: FRM versus ARM

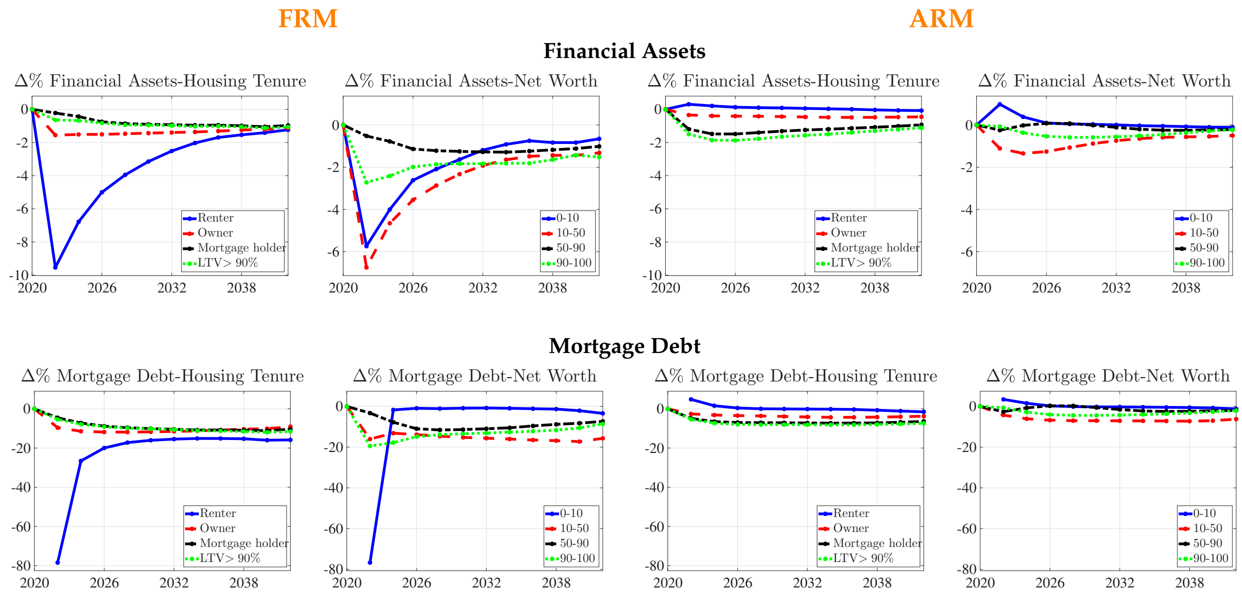


Notes: This figure shows the distributional effects of the inflation shock across household groups in the FRM economy (left panels) and the ARM economy (right panels). The top row reports consumption responses, the middle row reports homeownership responses, and the bottom row reports welfare effects, each relative to an otherwise identical economy without the inflation shock. Within each mortgage regime, the left column groups households by housing tenure status — renters, outright owners, and mortgagors, with a separate series for high-LTV mortgagors — while the right column groups households by the pre-shock net worth distribution. Households are assigned to groups based on their state variables immediately before the shock and are then followed over time. The inflation shock is an unanticipated 7 percentage point increase from an initial zero-inflation steady state and then reverts according to an AR(1) process with two-year persistence of 0.4.

their assets fall by less than 2 percent. Renters and poorer households increase their financial assets, in part to purchase homes later in life. This pattern reflects the preservation of macroeconomic stability—most groups avoid significant dissaving because the economy avoids a deep recession.

Deleveraging Patterns The dynamics of mortgage debt across the population further show the divergent adjustment mechanisms (Figure 7). In the FRM economy (top panels), the poorest decile experiences a reduction of more than 70 percent in mortgage debt—reflecting not voluntary prepayment but exclusion from mortgage markets amid the credit crunch. Even renters, who begin with minimal mortgage exposure, show close to an 80 percent decline from their already-low

FIGURE 7 – Balance Sheet Adjustments after the Inflation Shock: FRM versus ARM



Notes: This figure reports the distributional effects of the inflation shock on household balance sheets in the FRM economy (left panels) and the ARM economy (right panels). The top row shows financial asset holdings, and the bottom row shows mortgage debt, with all series measured relative to an otherwise identical economy without the inflation shock. Within each mortgage regime, the left column groups households by housing tenure status — renters, outright owners, mortgagors, and high-LTV mortgagors — while the right column groups households by their pre-shock position in the net worth distribution. Households are assigned to groups based on their state variables immediately before the shock and are then followed over time. The inflation shock is an unanticipated 7 percentage point increase from an initial zero-inflation steady state and then reverts according to an AR(1) process with two-year persistence of 0.4.

baseline, indicating blocked entry into the mortgage market.

The ARM economy (bottom panels) displays more modest adjustments. High-LTV borrowers deleverage by approximately 9 percent in response to higher payment burdens, while regular mortgage holders reduce debt by about 8 percent. The poorest households and renters, on the other hand, increase their mortgage borrowing by about 3.5 and 4.8 percent, respectively. This pattern—modest deleveraging by constrained borrowers combined with increased borrowing by unconstrained households—stands in sharp contrast to the widespread credit-market exclusion in the FRM economy.

Synthesis of Distributional Implications These distributional patterns reveal a fundamental trade-off inherent in mortgage design. The FRM system effectively socializes the risk of inflation shocks. While it generates significant wealth windfalls for borrowers via the Fisher channel, it does so by concentrating nominal valuation risk in the banking sector. When this risk materializes, the resulting financial instability and credit crunch generate a broad recession whose costs are borne disproportionately by the most vulnerable—the poor and renters—through income losses and exclusion from the housing market.

By contrast, the ARM system privatizes the risk. It protects the financial system and preserves broad macroeconomic stability but concentrates the adjustment on indebted borrowers facing immediate payment shocks. Although this creates distress for affected households, it limits spillovers to the wider economy and avoids the broad, persistent contraction that characterizes the FRM response.

5 Policy Implications

So far we have shown that mortgage market structure is a primary determinant of how economic shocks propagate through the banking system and household balance sheets. This section explores how the macroeconomic transmission is mediated by the regulatory environment and the central bank's policy stance. First, we examine how initial leverage in the banking and household sectors amplifies shocks under different mortgage regimes, highlighting the interaction between mortgage design and macroprudential policy. Second, we investigate how the central bank's reaction function–specifically, the aggressiveness of its response to inflation–interacts with the mortgage structure to influence macroeconomic stability.

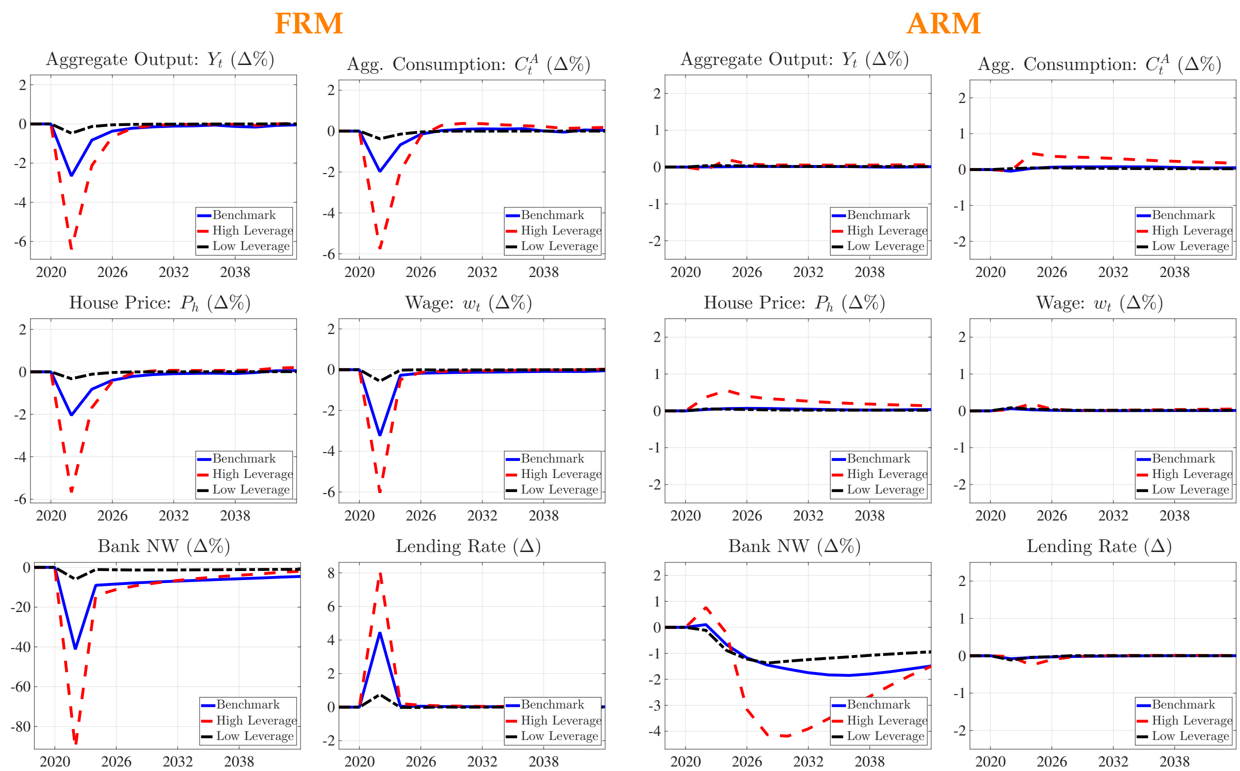
5.1 Macroprudential Policies

We study two main types of macroprudential policies: bank capital requirements and borrower-based loan-to-value and payment-to-income limits. Begenau (2020) provides a general-equilibrium analysis of bank capital requirements, while Bianchi (2011) and Bianchi and Mendoza (2018) motivate borrower-based debt regulation as a correction of pecuniary externalities. We begin with bank-based capital requirements.

The Role of Bank Leverage To assess how the initial capitalization of the banking system affects shock transmission, we conduct a counterfactual exercise varying the steady-state bank leverage ratio. We compare our benchmark calibration (leverage of 9.12) with high-leverage (12.5) and low-leverage (7.5) scenarios.

Figure 8 (left panels) shows the response of the FRM economy to the inflation shock under these three scenarios. The results imply that bank leverage acts as a powerful amplifier of financial instability in an FRM system. When leverage is high, the initial shock to bank net worth—caused by the inflation-induced valuation losses on fixed-rate assets—is magnified, leading to a much deeper and more persistent recession. Output falls by about 6 percent in the high-leverage case, compared with less than 1 percent in the low-leverage case. This occurs because highly leveraged banks operate closer to their borrowing constraints; a given loss of net worth forces a larger contraction in credit supply, resulting in a sharper spike in lending rates and a more severe downturn in wages, consumption, and house prices.

FIGURE 8 – Bank Leverage and Inflation Shock Transmission



Notes: This figure shows how the transmission of the inflation shock depends on the initial leverage of the banking sector under FRMs and ARMs. The left panels report the FRM economy and the right panels report the ARM economy. In each mortgage regime, the figure compares the benchmark calibration with steady-state bank leverage of 9.12 to a high-leverage case of 12.5 and a low-leverage case of 7.5. The panels show the responses of output, consumption, house prices, wages, bank net worth, and the lending rate following an unanticipated 7 percentage point inflation shock. The shock hits an initial zero-inflation steady state and then follows an AR(1) process with two-year persistence of 0.4. Output, consumption, house prices, wages, and bank net worth are reported as percent deviations from the initial steady state, while the lending rate is reported as a deviation in percentage points.

Figure 8 (right panels) repeats the experiment for the ARM economy, revealing a much more stable dynamic. The amplification effect of leverage is substantially muted compared to the FRM economy. This resilience stems from the core mechanism of our dual channel framework: because ARMs insulate bank balance sheets from inflation and interest rate risk, the initial shock has a much smaller impact on bank net worth. Consequently, the credit-supply channel remains largely intact, even when banks are highly leveraged.

These results provide an important policy insight. The ARM structure intrinsically reduces the link between bank leverage and macroeconomic outcomes by mitigating the underlying inflation risk on bank balance sheets. This suggests that macroprudential policies aimed at managing bank leverage are far more critical for ensuring macroeconomic stability in economies dominated by fixed-rate debt.

The Role of Borrower-Based Macroprudential Policies We further explore how borrower-based macroprudential regulations—specifically Loan-to-Value (LTV) and Payment-to-Income (PTI) restrictions—interact with mortgage structure during an inflationary episode. These tools are often deployed to enhance the resilience of both household and financial sector balance sheets.

Tighter LTV and PTI restrictions (Figures C.1 and C.2 in Appendix) prove effective in mitigating the adverse effects of the inflation shock, particularly in the FRM economy. By reducing the initial level of household leverage, stringent LTV and PTI caps decrease the aggregate volume of fixed-rate debt held by the banking sector. This directly limits the banks' exposure to inflation-induced valuation losses. Consequently, when the inflation shock hits, the erosion of bank capital is less severe, dampening the financial accelerator and resulting in a milder recession. In the ARM economy, tighter limits do not have much impact since the economy is already stable even without these restrictions.

5.2 The Role of the Monetary Policy Response to the Inflation Shock

In the benchmark analysis, we assumed passive monetary policy, with nominal interest rates responding one-for-one to the inflation shock, following the rule $i_t = r_t + \phi^m \pi_t$, with $\phi^m = 1$, where i_t is the nominal interest rate and r_t is the real interest rate. We now explore the implications of more or less aggressive monetary policy by setting $\phi^m = 1.15$ (hawkish) and $\phi^m = 0.85$ (dovish).[22]

Figure 9 (left panels) shows the results for the FRM economy. A more aggressive monetary policy response significantly deepens the recession. By raising rates more in response to inflation, the central bank exacerbates the pressure on bank balance sheets. The value of banks' fixed-rate assets falls further, eroding their net worth more severely. The resulting credit crunch is more pronounced, leading to a larger contraction in output—about 3.6 percent under the hawkish rule, compared with about 2.2 percent under the dovish rule.

This highlights a critical dilemma for policymakers in an FRM system: a more aggressive nominal-rate response amplifies the financial-instability risks that drive the recession. Because inflation is exogenous in this exercise, the comparison identifies a trade-off between interest-rate aggressiveness and financial stability; Appendix C.2 examines the genuine price-stability trade-off when inflation responds endogenously.

Figure 9 (right panels) shows that in the ARM economy, the central bank's stance also affects the depth of the recession, but the mechanism is different and the trade-off is less severe. A more

[22] In the implementation of the monetary policy, we assume that the monetary policy only affects the funding rate of the banks. That is, while a hawkish policy directly increases the real funding rate of banks, we assume it has no direct effect on the rest of the real interest rates. However, due to general equilibrium effects, it might also have further indirect effects on all real interest rates. This assumption introduces a transitory wedge between the banks' funding rate and the return on households' other assets; the two coincide in the steady state.

aggressive policy leads to a larger downturn compared to a dovish stance. However, the recessions are substantially milder than in the FRM economy across all policy stances. This occurs because the ARM structure preserves bank capital and stabilizes the credit supply. The primary transmission mechanism is the direct household cash-flow channel. Consequently, the central bank in an ARM economy can pursue price stability with less concern for inducing systemic financial instability.

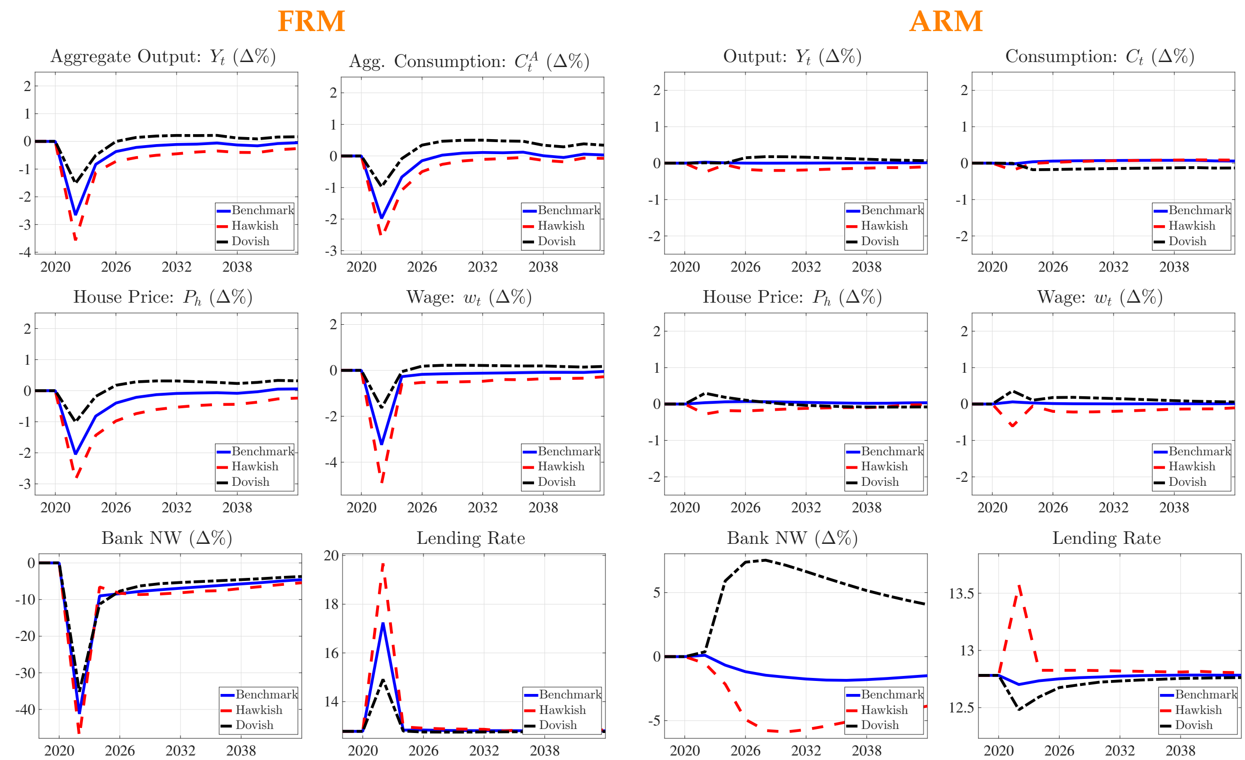
A Financial-Stability Constraint and the Missing Recession These dynamics provide a mechanism that may have limited the contraction during the 2021–2023 inflation episode. In the exogenous-inflation experiment, a less aggressive nominal-rate response reduces the peak output decline from about 3.6 percent to about 2.2 percent by limiting valuation losses on banks' FRM assets. Because the inflation path is held fixed here, this exercise does not show that policy trades higher inflation persistence for financial stability. Appendix C.2 introduces endogenous inflation and demonstrates that trade-off directly. Viewed through that extension, the Federal Reserve's delayed tightening may have provided an unintended financial-stability buffer, although fiscal support and emergency liquidity facilities also played important roles. This interpretation complements Diamond et al. (2025), who emphasize that the Fed's temporary deviation from active inflation targeting was central to transmitting fiscal stimulus into a post-Covid boom; our mechanism adds that this same accommodative stance also served, perhaps unintentionally, as an implicit macroprudential shield for FRM-heavy bank balance sheets.

Robustness to Endogenous Inflation In the benchmark monetary policy analysis above, we assumed an exogenous inflation path to isolate the transmission of the shock through mortgage balance sheets. To ensure our conclusions are not driven by this simplification, in Appendix C.2 we relax this assumption and allow inflation to respond endogenously to the central bank's policy stance via a reduced-form Phillips curve relationship. We find that our core results are robust to this extension.

6 Empirical Evidence

In the preceding quantitative analysis we have shown that the macroeconomic impact of an inflation shock is governed by a "dual channel," where household balance sheet effects (including the Fisher channel) and the bank lending channel operate in opposition. To provide empirical evidence for this mechanism, we leverage the 2021–2023 U.S. monetary tightening cycle as an empirical setting. This episode, characterized by a rapid and substantial increase in inflation and nominal interest rates, generated significant variation in the pressures faced by households and banks depending on their pre-existing mortgage compositions.

FIGURE 9 – Monetary Policy Tightness and Mortgages



Notes: This figure compares the responses of the FRM economy (left panels) and the ARM economy (right panels) to the inflation shock under alternative monetary policy rules. The benchmark rule sets the nominal policy response coefficient to $\phi^m = 1$, while the hawkish and dovish cases set $\phi^m = 1.15$ (hawkish) and $\phi^m = 0.85$ (dovish), respectively. The panels report the paths of output, consumption, house prices, wages, bank net worth, and the lending rate following an unanticipated 7 percentage point inflation shock. The shock hits an initial zero-inflation steady state and then follows an AR(1) process with two-year persistence of 0.4. Output, consumption, house prices, wages, and bank net worth are reported as percent deviations from the initial steady state, while the lending rate is reported in levels.

Our empirical strategy proceeds in three stages. First, we use state-level data and a stacked adjacent-state design with state-border-pair fixed effects to test for the simultaneous presence of the opposing household and bank channels. Second, we utilize granular bank- and bank-county-level data to isolate the credit-supply mechanism, controlling for local demand. Finally, we employ a Rajan-Zingales methodology to trace the real effects of this credit-supply channel on employment in financially dependent sectors. We begin by detailing the construction of our dataset and the key variables used in this analysis.

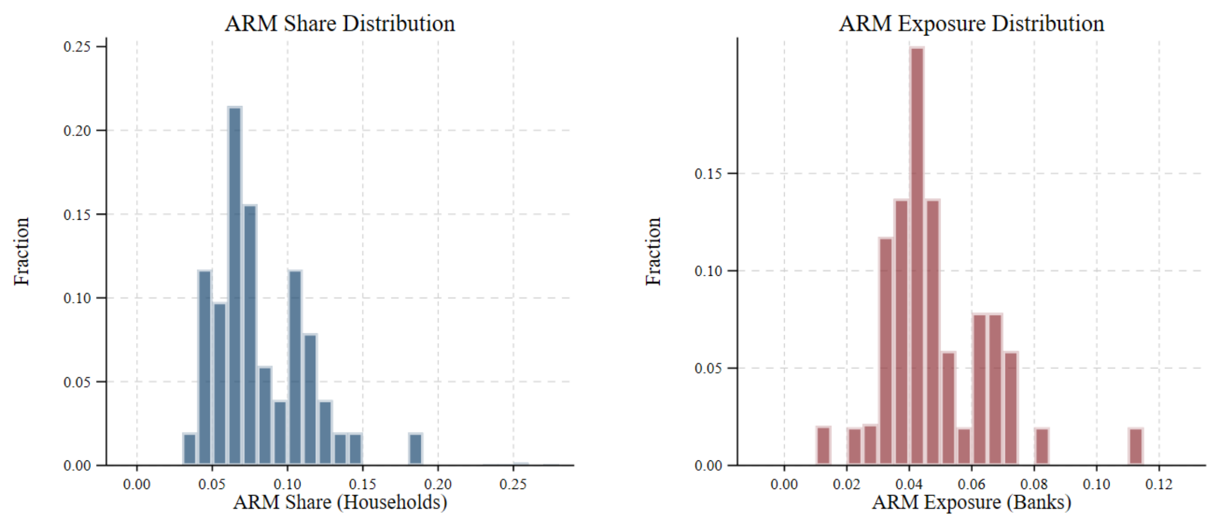
We operationalize this analysis by using the share of ARMs, where a high ARM share implies a low FRM share. The impact of high bank ARM exposure identifies the benefit of banks being insulated from the valuation losses inherent in FRMs (the bank resilience channel). The impact of high household ARM exposure identifies the household vulnerability to rising rates (the cash-flow channel), in contrast to the wealth benefits FRM holders receive via the Fisher channel.

6.1 Data

Our analysis combines multiple datasets covering mortgage composition, bank characteristics, and economic outcomes at different levels of aggregation.

The 2021–2023 Tightening Episode and the Mortgage Market Two features make this episode particularly suitable for our analysis. First, the 30-year mortgage rate increased from 2.8 percent to 7.1 percent, creating one of the largest gaps between market rates and existing mortgage rates in recent history. Second, despite the national shift toward FRMs, substantial regional variation persisted (Figure 10; the construction of these shares is described below).

FIGURE 10 – Mortgage Distributions



Note: The left panel plots the state-level household ARM share, and the right panel plots state exposure to banks with different ARM shares. The construction of both measures is described in the text. Their correlation is 0.12.

Mortgage Data We obtain mortgage data from CoreLogic's Loan-Level Market Analytics (LLMA) database, which covers approximately 75 percent of the U.S. mortgage market. For each loan, we observe a wide array of characteristics. Most importantly for this study, we observe each loan's contract type (ARM or FRM). We aggregate these data to the state and MSA levels and construct annual ARM shares as adjustable-rate balances divided by total outstanding mortgage balances.

Banking Data Bank balance sheet information comes from quarterly Call Reports filed with federal regulators. We primarily use the dataset constructed by Drechsler et al. (2021), which we update with more recent observations and supplement with ARM-loan data from WRDS. We restrict our

TABLE III – Summary Statistics for State-Level Data

	N	Mean	SD	Min	p25	p50	p75	Max
ARM VARIABLES AND MAIN CONTROLS (2019)								
ARM share of mortgages (Households)	51	0.073	0.029	0.029	0.052	0.065	0.097	0.173
Bank ARM exposure (Banks)	51	0.049	0.017	0.005	0.038	0.045	0.061	0.114
Log per capita income	51	10.881	0.106	10.687	10.806	10.863	10.948	11.214
Log median scheduled monthly payment	51	6.800	0.262	6.433	6.561	6.760	6.990	7.448
Log median scheduled principal	51	5.720	0.240	5.371	5.568	5.661	5.863	6.392
Unemployment rate	51	3.6	0.8	2.1	3.0	3.5	4.1	5.6
Debt-to-Income Ratio	51	1.42	0.30	0.75	1.17	1.45	1.66	2.06
MAIN ECONOMIC GROWTH VARIABLES (2021–2023, percent change)								
Real GDP growth	51	0.054	0.021	0.004	0.039	0.050	0.070	0.116
Personal income growth	51	0.098	0.025	0.052	0.077	0.100	0.114	0.165
Employment growth	51	0.062	0.014	0.038	0.051	0.060	0.070	0.110
Consumption growth	51	0.162	0.018	0.129	0.147	0.160	0.174	0.216
House price growth	51	0.270	0.086	-0.003	0.233	0.278	0.321	0.454
STATE WEALTH AND DEBT VARIABLES (LOG, 2019)								
Median Net Worth	49	11.683	0.531	10.086	11.346	11.612	12.114	12.830
Median Net Worth Excl. Home	49	10.626	0.633	8.897	10.171	10.686	11.055	11.788
Median Assets at Financial Inst.	49	8.718	0.521	6.932	8.412	8.711	9.105	9.680
Median Checking Account Balance	49	7.645	0.403	6.397	7.378	7.619	8.006	8.294
Median Other Interest Accounts	47	8.389	0.496	7.170	8.055	8.294	8.700	9.668
Median Home Equity	44	11.725	0.426	11.082	11.406	11.657	11.928	12.848
Median Vehicle Equity	47	8.921	0.199	8.568	8.781	8.905	9.066	9.543
Median IRA or Keogh Accounts	36	10.868	0.285	10.130	10.757	10.847	11.014	11.408
Median 401(k) & Thrift Savings Plan	40	10.692	0.274	10.135	10.563	10.703	10.839	11.350

This table presents summary statistics for the state-level analysis. ARM variables and control variables are measured as of 2019. ARM Share (Households) is the fraction of outstanding mortgage balances that are adjustable-rate, sourced from CoreLogic LLMA. Bank ARM exposure is the deposit-weighted average ARM share of banks operating in the state, constructed using Call Reports and FDIC SOD data. Main economic growth variables measure the cumulative percentage change from 2021 to 2023, sourced from the BEA Regional Economic Accounts and Zillow. State wealth and debt variables are sourced from SIPP summary tables.

sample to commercial banks with assets exceeding $50 million as of 2019 to exclude institutions too small to have meaningful lending operations.

Our key variables include: (i) ARM holdings: "Adjustable rate closed-end loans secured by first liens on 1-4 family residential properties" (RCON5370), (ii) total assets, loans, deposits, and equity, (iii) securities holdings by maturity bucket, and (iv) various loan categories including commercial and industrial loans, consumer loans, and real estate loans by maturity.

To identify the credit-supply channel, we merge the Call Reports data with the Community Reinvestment Act (CRA) annual bank-county-level small business loan data. The CRA data provide granular information on small-business lending at the county level, allowing us to account for local loan demand through county fixed effects. We focus on the total dollar amount of loans

TABLE IV – Summary Statistics for Banking and Credit Analysis Data

	N	Mean	SD	Min	p25	p50	p75	Max
ARM VARIABLES AND MAIN CONTROLS (2019)								
ARM Share (fraction of total assets)	4895	0.064	0.087	0.000	0.004	0.029	0.089	0.749
Log Total Assets	4936	12.725	1.367	10.562	11.771	12.477	13.328	21.574
Equity to Assets Ratio	4936	0.127	0.070	0.022	0.101	0.115	0.134	0.998
Loans to Deposits Ratio	4915	0.804	0.315	0.000	0.692	0.831	0.932	17.300
Personal Loans/Assets	4931	0.033	0.067	0.000	0.006	0.016	0.035	0.993
C&I Loans/Assets	4931	0.085	0.071	0.000	0.040	0.070	0.111	0.816
RE Loans >15yr/Assets	4931	0.047	0.085	0.000	0.001	0.010	0.052	0.833
Loans & Leases >15yr/Assets	4931	0.073	0.103	0.000	0.006	0.027	0.097	0.835
Demand Deposits/Assets	4931	0.164	0.109	0.000	0.077	0.154	0.224	0.886
Savings Deposits/Assets	4931	0.316	0.168	0.000	0.199	0.276	0.405	1.183
Time Deposits/Assets	4931	0.255	0.131	0.000	0.163	0.243	0.331	0.843
1-Year Interest Income Gap	4931	0.207	0.123	-0.523	0.128	0.195	0.271	0.848
DEPENDENCE ON EXTERNAL FINANCE (2011–2019 average)								
$DoEF_i$	97	-4.553	56.414	-342.528	-4.530	0.751	10.016	193.297
DEPENDENT VARIABLES (2021–2023, percent change)								
C&I Loan Growth	4078	-2.274	66.982	-96.409	-40.065	-15.159	16.930	389.697
Total Loan Growth	4078	27.396	32.704	-29.902	9.023	21.691	38.278	193.841
Other Individual Loan Growth	4010	57.482	232.947	-95.169	-10.915	14.379	45.442	1936.544
Small Business Lending	52204	-0.169	1.413	-1.0	-1.0	-0.616	0.077	8.696

This table presents summary statistics for the bank-level and bank-county-level analyses. The bank-level sample includes commercial banks with assets exceeding \$50 million in 2019. Bank characteristics and ARM shares are measured as of year-end 2019, sourced from Call Reports. ARM Share is defined as adjustable-rate closed-end loans secured by first liens on 1-4 family residential properties (RCON5370) scaled by total assets. Dependence on External Finance ($DoEF_i$) is the industry-level average reliance on external financing $(CAPX - CashFlow)/CAPX$, calculated using Compustat data from 2011–2019. Dependent variables measure the cumulative percentage change in lending from 2021 to 2023. Small Business Lending growth is based on the bank-county CRA dataset.

originated to small businesses with gross annual revenues less than \$1 million.

We further restrict the sample to bank-county pairs where the bank originated at least \$50,000 in small business loans (to firms with revenues less than \$1 million) in 2021. This filter ensures that we analyze economically meaningful lending relationships rather than sporadic or negligible activity, and it helps reduce the influence of zeros and extreme growth rates. The final bank-county sample contains over 50,000 observations, providing substantial variation to identify the credit-supply channel while controlling for local demand conditions.

We use daily bank-level stock prices from the Center for Research in Security Prices (CRSP) at the University of Chicago. To link the Call Reports data with CRSP data, we use the link file maintained by the Federal Reserve Bank of New York.

Mortgage Exposure via Banks We measure a region's (state or MSA) exposure to ARMs through the banking sector by linking bank balance-sheet data containing ARM information to banks' branch-level deposit data from the FDIC's Summary of Deposits (SOD). We then construct region-level exposure to bank ARM shares as:

$$\text{Region's ARM Exposure}_{i,2019} = \sum_{b} \omega_{b,i,2019} \times \text{Bank ARM Share}_{b,2019} \tag{12}$$

where $\omega_{b,i,2019}$ is bank b's share of deposits in region i. This measure captures the exposure of residents in region i to banks with different mortgage portfolios.

Regional Data For state-level consumption, GDP, employment, and income, we use the Regional Economic Accounts of the Bureau of Economic Analysis. We use the Quarterly Census of Employment and Wages (QCEW), which provides employment by state, county, and industry at the sectoral level. For house prices we use Zillow data. We use Census data and SIPP state-level summary tables to control for demographics, assets, and debt.

Dependence on External Finance

We construct three-digit industry-level measures of external-finance dependence following the methodology of Rajan and Zingales (1998), adapted to our sample period. Using Compustat data from 2011–2019, we calculate each firm's reliance on external financing as the share of capital expenditures not funded through internally generated cash flow: $(CAPX - CashFlow)/CAPX$. We then aggregate these firm-level ratios to the three-digit NAICS industry level by taking within-industry means across all firm-years in our sample period. This approach captures the structural financing needs of different industries during the period immediately preceding our analysis, providing plausibly exogenous variation in credit dependence that we use to identify the bank-lending channel. Industries with higher values rely more heavily on external financing and should therefore be more sensitive to credit-supply shocks transmitted through the banking sector.

Institutional Context The U.S. mortgage market presents unique institutional features, notably the role of Government-Sponsored Enterprises (GSEs). It is therefore important to clarify how this feature interacts with our identification of the bank-lending channel.

While GSEs facilitate the securitization of conforming FRMs, allowing originators to offload interest rate risk, this risk transfer is far from complete. Banks retain significant portfolios of mortgages on their balance sheets. According to Federal Reserve Z.1 data (Table L.218), as of Q4 2019, commercial banks held approximately \$2.3 trillion in one-to-four-family residential mortgages directly on their books, out of \$11.1 trillion total outstanding. These retained portfolios often include non-conforming Jumbo loans, which exceed conforming limits and are ineligible for GSE purchase, as well as loans held for portfolio lending strategies. Our empirical analysis, based on Call Report data (specifically RCON5370 for ARMs), explicitly measures the composition of these on-balance-sheet portfolios. Thus, our measure of bank ARM exposure captures the interest rate risk directly borne by the banks themselves, net of securitization.

Moreover, the 2023 banking turmoil showed that unrealized losses on long-duration fixed-rate assets can erode a bank's economic capital and constrain its behavior even when regulatory capital ratios appear adequate under held-to-maturity accounting. Our analysis captures the realized impact of this fundamental interest rate exposure on the banking sector during the tightening cycle.

6.2 Empirical Analysis

We measure pre-period characteristics as of 2019 to avoid contamination from pandemic-related disruptions and to mitigate endogeneity concerns related to ARM shares and bank ARM exposures. The key assumption is that mortgage portfolio composition as of 2019 is uncorrelated with unobserved factors driving differential economic outcomes during the 2021–2023 tightening cycle. We first examine the dual channel at the state level in U.S. data and then provide more granular evidence on the banking and credit-supply mechanism using bank-, bank-county-, and sector-level data.

6.2.1 Regional Analysis

At the state level, we estimate:

$$\Delta Y_{s,21-23} = \beta_1 \text{ARM Share}^{HH}_{s,19} + \beta_2 \text{ARM Exposure}^{Bank}_{s,19} + \Gamma X_{s,19} + \mu_{s-b} + \epsilon_{s,b} \tag{13}$$

where ΔY_{21-23} represents changes in consumption, GDP, employment, income, and several other variables from 2021 to 2023. ARM Share^{HH}_{19} is the household ARM share in a state, capturing demand effects, while ARM $\text{Exposure}^{Bank}_{19}$ measures a state's exposure to ARMs through the banks operating in that region, capturing credit-supply effects.

For our identification strategy it is important that the cross-sectional correlation between the household ARM share and the bank ARM exposure is very low (0.12, as shown in Figure 10). This indicates that the composition of household demand for mortgage types is largely independent of the portfolio choices of the banks operating in the same region. This low correlation helps limit multicollinearity and allows the two exposure measures to enter the same regression. It does not, by itself, establish that either exposure is exogenous.

To identify the effects of mortgage structure while accounting for unobserved regional heterogeneity, we employ a stacked adjacent-state design with state-border-pair fixed effects (μ_{s-b}). This approach restricts the comparison to contiguous states, leveraging their geographic proximity to control for localized confounders. This strategy is particularly important for the 2021–2023 period, which was characterized by spatially correlated shocks related to pandemic recovery, extreme weather events, and supply chain disruptions. The state-border-pair fixed effects, μ_{s-b}, absorb unobserved factors common to each adjacent-state region.

To mitigate potential state-specific omitted variable bias, we include a comprehensive set of predetermined controls, $X_{s,19}$, measured in 2019. First, to isolate the household vulnerability channel, we must account for differences in households' pre-existing capacity to absorb payment shocks. We therefore include detailed measures of household balance sheet strength: net worth, holdings of liquid assets (checking and other interest-bearing accounts), and retirement savings. We also control for leverage, including the state-level debt-to-income ratio and non-mortgage debt levels. These variables mitigate the concern that that the estimated effect of the ARM share is not confounded by underlying differences in household financial resilience.

Second, we control for baseline macroeconomic conditions, including the log of per capita income and the unemployment rate. Finally, we include initial mortgage market characteristics, such as average mortgage payment levels and foreclosure rates. This allows us to disentangle the effect of the contract type (ARM vs. FRM) from the initial level of mortgage burden in the state.

While our stacked adjacent-state design and rich set of controls mitigate many standard endogeneity concerns, we acknowledge that the allocation of ARMs is not random. We argue that the 2019 ARM shares are plausibly exogenous to the subsequent tightening cycle because the magnitude and speed of the 2021–2023 rate hikes were largely unanticipated. Furthermore, regional variation in mortgage structure tends to be highly persistent, driven by historical borrower preferences and local banking conventions. Nonetheless, our identification strategy relies on the assumption that unobserved differences between high- and low-ARM regions do not systematically correlate with the economic response to the 2021–2023 tightening, conditional on our controls and fixed effects.

Table V presents the results of this "horse-race" estimation. Across multiple measures of economic activity during the 2021–2023 tightening cycle, we find strong evidence for the dual-channel mechanism, with the two exposures operating simultaneously and in opposition. Across all key macroeconomic outcomes—consumption, GDP, and personal income—the coefficient on the household ARM share (ARM Share^{HH}) is negative and statistically significant. This reflects the strong household cash-flow channel, where ARM borrowers face immediate payment shocks (consistent with prior literature such as Di Maggio et al. (2017) and Cloyne et al. (2020)), and the absence of the Fisher channel windfall that benefits FRM households.

However, we simultaneously identify the bank supply channel. The coefficient on bank ARM exposure (ARM Exposure^{Bank}) is positive and statistically significant across these same specifications. This is consistent with the bank resilience channel predicted by our model: states served by a banking sector with higher concentrations of ARMs were insulated from the valuation risk that impaired FRM-heavy banks. This positive association is consistent with the systemic vulnerability

TABLE V – The Effect of Mortgage Structure on State Economies

Dependent Variables: State (percent change)				
	(1)	(2)	(3)	(4)
Variables	Consumption	Real GDP	Personal Income	Per-capita Personal Income
ARM Share$^{HH}_{s,19}$	-0.440***	-0.599***	-0.666***	-0.464***
Std. Error	(0.155)	(0.181)	(0.207)	(0.135)
ARM Exposure$^{Bank}_{s,19}$	0.453**	0.585***	0.448**	0.321**
Std. Error	(0.187)	(0.212)	(0.218)	(0.143)
Observations	126	126	126	126
R-squared	0.509	0.635	0.683	0.702
All Controls	Yes	Yes	Yes	Yes
State-Border FE	Yes	Yes	Yes	Yes

Notes: This table examines the relationship between adjustable-rate mortgages (ARMs) and state-level economic outcomes. ARM Share (via households) captures the state-level proportion of ARMs held by households, while ARM Exposure (via banks) measures the state's exposure to ARMs through bank lending patterns. All models include: loan characteristics (payment, principal, balance, interest), economic controls (income, unemployment), asset controls (net worth, home equity, retirement accounts, liquid assets), DTI ratio, vehicle equity, and foreclosure rates. Fixed effects: border-pair. Standard errors are clustered at the state level. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

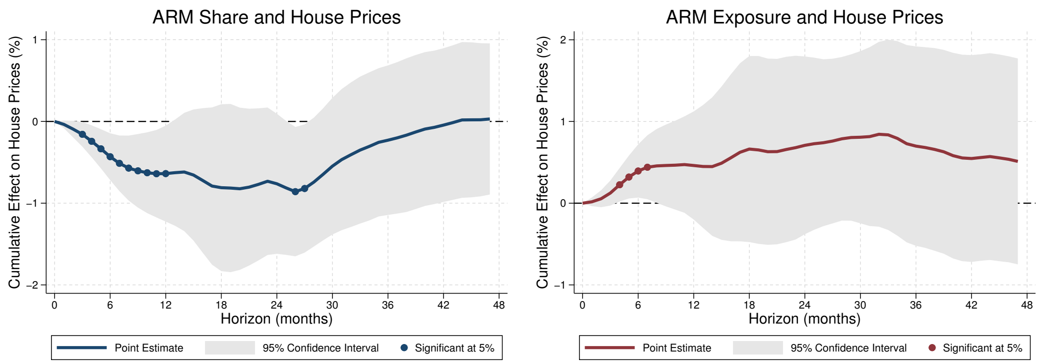
created by FRMs. As demonstrated in the model, the inflation-induced valuation losses on FRM portfolios erode bank capital, triggering a credit crunch. Consequently, states with higher exposure to these FRM-heavy banks experienced significantly worse economic performance.

This finding provides direct evidence for the bank resilience channel, highlighting the positive credit-supply effect discussed in Altunok et al. (2025). Our analysis is the first to simultaneously identify and quantify these two opposing mechanisms within a single empirical framework during a tightening cycle.

These results are economically meaningful. For personal income, a 1-percentage point increase in the household ARM share is associated with about 0.66 percentage points lower income growth. In contrast, a 1-percentage point increase in ARM exposure through banks is associated with approximately 0.45 percentage points higher consumption or personal-income growth. These results illustrate the opposing forces at work: household ARM exposure is associated with a negative impulse, whereas bank ARM exposure provides substantial support. The net effect on a state's economy therefore depends critically on this trade-off between the household wealth effects generated by FRMs (the Fisher channel) and the financial stability risks they introduce.

Because house prices respond relatively slowly to economic shocks, we use a dynamic specification

FIGURE 11 – Mortgage Structure and State House Prices



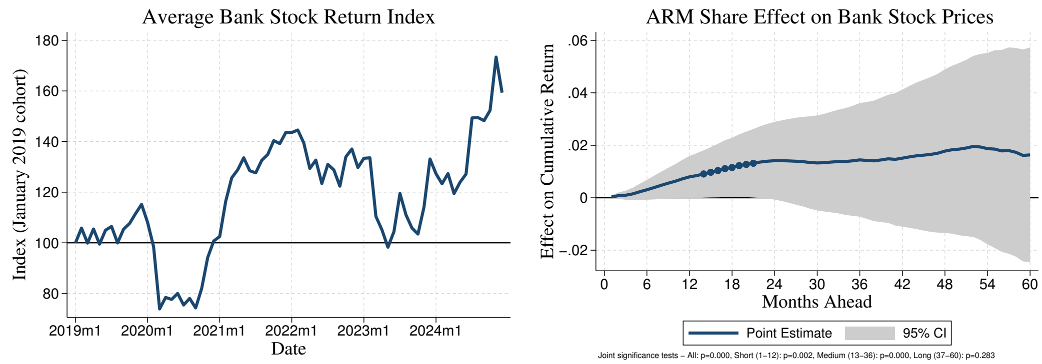
Notes: These figures present dynamic local-projection estimates following Jordà (2005) to examine the dynamic effects of adjustable-rate mortgage prevalence on house prices. The specification follows:$y_{s,t+h} - y_{s,t-1} = \alpha^h + \beta_1^h \text{ARM Share}_{s,19}^{HH} + \beta_2^h \text{ARM Exposure}_{s,19}^{Bank} + \gamma^h X_{s,t} + \mu_{s-b,h} + \varepsilon_{s,t+h}$, where $y_{s,t+h} - y_{s,t-1}$ represents the cumulative percentage change in house prices from the base period $(t-1)$ to horizon h, measured monthly for up to 48 months. ARM Share$_{s,19}^{HH}$ captures the state-level proportion of ARMs held by households, while ARM Exposure$_{s,19}^{Bank}$ measures the state's exposure to ARMs through bank lending patterns. $X_{s,t}$ includes predetermined state-level controls: loan characteristics (scheduled monthly payment, scheduled principal), economic conditions (per capita income, unemployment rate), household balance sheet variables (net worth excluding home, home equity, motor vehicle equity, retirement accounts, liquid assets), debt measures (credit card debt), debt-to-income ratio, homeownership rate, and foreclosure rates. $\mu_{s-b,h}$ represents border-pair $\times$ horizon fixed effects to control for time-invariant unobserved heterogeneity between neighboring states and horizon-specific shocks. Standard errors are clustered at the border-pair level to account for spatial correlation. The shaded areas represent 95% confidence intervals, with solid markers indicating statistical significance at the 5% level. The identification strategy exploits cross-state variation in ARM prevalence at state borders, controlling for local economic conditions that might affect both mortgage choice and house price dynamics.

that relates cumulative monthly house-price growth to the 2021 baseline. Figure 11 plots the results. The results are consistent with our earlier findings. States with higher household ARM shares experience lower house-price growth, whereas states with greater bank ARM exposure experience stronger house-price growth. Although most horizon-specific estimates for bank ARM exposure are not statistically significant, their signs are consistent with the proposed mechanism. The dynamic evidence is therefore suggestive rather than definitive.

6.2.2 Banking and the Credit Supply Channel

Our regional results point to the simultaneous operation of the dual-channel mechanism: household ARM exposure depressed economic activity, while bank ARM exposure supported it. However, more directly identifying the credit-supply mechanism requires separating bank behavior from local demand conditions. We now turn to granular bank-level data to achieve this isolation. Specifically, we investigate how the concentration of valuation risk via FRMs impaired bank lending capacity during the recent rise in inflation. We hypothesize that banks with higher ARM shares (and thus lower FRM exposure) were better positioned to maintain credit supply.

FIGURE 12 – Bank Equity Prices: 2019–2024



Notes: This figure examines the relationship between bank mortgage composition and equity market performance during the 2019–2024 period, using data from CRSP for publicly traded U.S. bank holding companies. The left panel plots the cross-sectional average of bank stock prices over time. The right panel presents dynamic local-projection estimates following Jordà (2005) and estimates the effect of a bank's pre-period (2019) ARM share—as a percentage of total assets—on cumulative stock returns over horizons of 1 to 60 months. The specification is: $\triangle BankStockPrice_{i,t+h} = \beta_h \times ARMShare_{i,2019} + \gamma' X_{i,2019} + \delta_t + \varepsilon_{i,t+h}$. Controls ($X_{i,2019}$) include bank size (log assets), risk measures (equity, cash, and liquidity ratios), detailed asset maturity structure, liability composition, and securities holdings. The regressions include time (year-month) fixed effects (δ_t). Standard errors are clustered at the bank holding company level. The shaded area represents the 95% confidence interval.

Bank-Level Evidence: Equity Valuations To provide market-based evidence for the bank balance sheet channel, we first examine how banks' mortgage portfolio composition has influenced their equity valuations during the 2021–2023 monetary tightening cycle. If ARMs indeed shield banks from interest rate risk as we predict, we should observe superior stock price performance among banks with higher ARM shares.

We first examine banking-sector equity prices in the U.S., where FRMs dominate the mortgage market. Using daily stock price data from CRSP for all publicly traded bank holding companies in our sample, we calculate monthly average prices for each bank. We then compute the cross-sectional average of these individual bank indices for each month, providing a sector-wide view of performance. Following a pandemic-induced decline in early 2020, bank equities recovered steadily, but the recovery slowed as inflation and nominal interest rates rose. Beginning in early 2022, average bank stock prices declined by about 30 percent.

To quantify the relationship between ARM exposure and bank stock returns, we employ a Jordà-style local-projection framework. For each horizon h from 1 to 60 months, we estimate:

$$\triangle BankStockPrice_{i,t+h} = \beta_h \text{Bank ARM Share}_{i,19} + \gamma' X_{i,2019} + \delta_t + \varepsilon_{i,t+h}$$

where $\triangle BankStockPrice_{i,t+h}$ is the percentage change in bank i's stock price index from month t to $t+h$, $ARMShare_{i,2019}$ is the bank's pre-period share of ARMs, and $X_{i,2019}$ includes bank-level controls (log assets, equity ratio, liquidity ratios, and other balance sheet characteristics). We include year-month fixed effects, δ_t, and cluster standard errors at the bank level. The coefficient β_h traces out the dynamic effect of a one percentage point increase in ARM share on cumulative returns at each horizon. The results reveal a positive relationship: banks with higher ARM shares outperformed their FRM-heavy counterparts throughout the tightening cycle.

The point estimates indicate that a 10 percentage point increase in the ARM share is associated with approximately 2 percentage points higher cumulative returns by month 60. The 95 percent confidence bands, shown as shaded areas, widen over time, reflecting increasing dispersion: the point estimates remain positive throughout, although the long-horizon estimates are imprecise. Taken together, these positive coefficients imply that banks with higher ARM shares performed better in the equity market.[23]

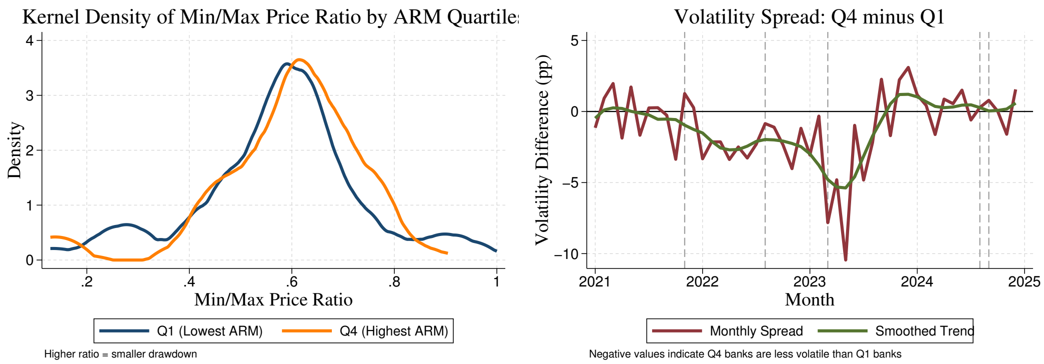
To examine downside price variation, we calculate each bank's minimum-to-maximum price ratio over the 2022–2024 period. This ratio, bounded between 0 and 1, summarizes the range of prices during the sample: a ratio of 0.60 indicates that the minimum observed price was 60 percent of the maximum observed price. We sort banks into quartiles based on their 2019 ARM share and plot kernel density distributions of the min/max ratio for each quartile. Banks in the highest ARM quartile (Q4) experience a rightward-shifted distribution relative to the lowest quartile (Q1), indicating that minimum prices were closer to maximum prices. The median bank in Q4 maintained a min/max ratio of approximately 0.62, compared to 0.54 for Q1 banks. This 8 percentage point difference indicates a narrower minimum-to-maximum price range among high-ARM banks.

To examine the time-varying nature of risk differentials, for each bank-month, we calculate the standard deviation of daily returns within that month, then annualize. Banks are sorted into quartiles based on their pre-period (2019) ARM share weighted by assets, with Q1 representing the bottom 25 percent (lowest ARM exposure) and Q4 the top 25 percent (highest ARM exposure). For each month, we compute the average volatility within each quartile, then calculate the spread as the difference between Q4 and Q1 average volatilities.

The figure supports our bank balance sheet channel hypothesis. Beginning in 2021, the volatility spread becomes increasingly negative, indicating that high-ARM banks became less volatile than low-ARM banks. During the March 2023 banking turmoil, the difference between low- and high-ARM banks became much larger. The spread declines to approximately -10 percentage points, meaning that Q1 banks (with predominantly FRMs) became significantly more volatile than their Q4 (ARM-heavy) counterparts. This divergence is consistent with greater stress at FRM-heavy banks,

[23] To formally assess the overall significance of these findings, we conduct a Wald test for the joint significance of the coefficients (β_h) across all horizons. Utilizing a fully saturated stacked regression approach, which rigorously accounts for the cross-horizon covariance of the estimates, we strongly reject the null hypothesis that the ARM share has no effect over the 60-month horizon ($F(60, 324) = 2.27$, $p < 0.0001$).

FIGURE 13 – Bank Equity Price Distribution by ARM Quartiles



Notes: This figure analyzes the relationship between bank ARM exposure and equity-market price variation and volatility, comparing banks in the lowest (Q1) and highest (Q4) quartiles of 2019 ARM share (weighted by assets). Data is sourced from CRSP. The left panel plots the kernel density distribution of the minimum-to-maximum price ratio during the 2022–2024 period. A higher ratio indicates a narrower gap between the minimum and maximum observed prices. The right panel plots the time series of the volatility spread between Q4 and Q1 banks from 2021 onwards. For each bank-month, annualized volatility is calculated as the standard deviation of daily returns within the month, multiplied by $\sqrt{252}$. The spread is the difference between the average volatility of Q4 banks and Q1 banks (Q4-Q1). A negative spread indicates Q1 (low ARM/high FRM) banks are more volatile.

reflecting valuation losses on fixed-rate assets and concerns about deposit outflows, while ARM-heavy banks remained relatively stable. As the acute phase of the crisis passed and extraordinary policy support was provided, the volatility spread gradually normalized.

This volatility evidence also supports our hypothesized mechanism. The equity market priced the differential exposure to inflation and interest rate risk embedded in the mortgage portfolios. Market participants understood that FRM-heavy banks faced substantial valuation losses on their long-duration assets as inflation surged, eroding their capital base. In contrast, ARM-heavy banks were insulated from this valuation shock, preserving their financial stability.

Bank-Level Lending Evidence Having provided evidence that the market recognized the differential impact of mortgage structure on bank valuations, we now turn to bank-level data to study the credit-supply mechanism. Specifically, we investigate how the concentration of interest rate risk via FRMs impaired bank lending capacity during the recent tightening cycle. We hypothesize that banks with higher ARM shares (and thus lower FRM exposure) were better positioned to maintain credit supply. To study bank-level credit-supply effects, we estimate:

$$\Delta L_{b,21-23} = \gamma \text{Bank ARM Share}_{b,19} + \Psi Z_{b,19} + \epsilon_b \tag{14}$$

where $\Delta L_{b,21-23}$ denotes one of several measures of loan growth, including C&I loan growth.

To isolate the effect of a bank's ARM share on its lending growth, we control for a comprehensive set of predetermined bank characteristics, $Z_{b,19}$, that could otherwise confound the relationship.

All control variables are measured as of year-end 2019 to mitigate endogeneity concerns and capture the bank's condition immediately prior to the monetary tightening cycle. First, we include standard size and risk controls, such as the logarithm of total assets to account for scale effects, and the equity-to-assets ratio, cash-to-assets ratio, and loan-to-deposit ratio to capture the bank's capitalization, liquidity, and overall risk posture. Second, we incorporate detailed measures of balance sheet composition, including the maturity structure of both the asset side (real estate loans, other loans, and securities) and the liability side (demand deposits, savings deposits, and time deposits of varying maturities). These controls are necessary for distinguishing the effect of ARM holdings from broader maturity mismatch exposures. Finally, we include a set of controls designed to capture other sources of interest rate sensitivity that are distinct from the mortgage portfolio. These include the bank's holdings of trading assets and derivatives, as well as standard measures of interest rate exposure like the one-year "income gap" (the difference between rate-sensitive assets and rate-sensitive liabilities maturing within one year, scaled by assets).

Table VI presents the results. Column 1 shows that for total loans, a 1-percentage point increase in a bank's ARM share is associated with 0.14 percent higher loan growth. Column 2 focuses on commercial and industrial (C&I) loans, where the association is stronger: a 1 percentage point increase in the ARM share is associated with 0.26 percent higher C&I loan growth. Column 3 examines individual loans—consumer loans to individuals that are not secured by real estate—and shows the largest association, at 1.12 percent.

These results provide strong support for the bank balance sheet channel identified in our model. The stronger loan growth among high-ARM banks is consistent with valuation risk constraining the lending capacity of FRM-heavy banks. Consistent with the model's financial accelerator mechanism, banks that heavily invested in long-duration FRMs faced substantial balance sheet pressure as inflation eroded the real value of their assets, depleting their capital and forcing them to contract credit supply.

Bank-County Small Business Lending Evidence To distinguish credit-supply effects from local demand conditions, we examine bank lending at the bank-county level using CRA data. We estimate bank-county regressions with county fixed effects (μ_{county}) and compare lending by banks with different ARM shares within the same county. Specifically, we estimate the following regression using the CRA data:

$$\Delta L_{b,county,21-23} = \gamma \text{Bank ARM Share}_{b,19} + \Psi Z_{b,19} + \mu_{county} + \epsilon_{b,county}. \tag{15}$$

Table VII presents the results of this analysis. The coefficient on a bank's ARM share is positive and highly statistically significant across all columns, even as we progressively saturate the model with a comprehensive set of bank-level controls. In our most stringent specification (Column 4),

TABLE VI – The Effect of Bank ARM Share on Total Lending

Dependent Variable: Percent Change in Bank Loans			
Variables	Total Loans	C&I Loans	Individual Loans
Bank's ARM Share	0.137**	0.265*	1.122***
Std. Error	(0.062)	(0.157)	(0.385)
Observations	3,931	3,931	3,931
R-squared	0.038	0.041	0.028
All Bank Controls	Yes	Yes	Yes

Notes: This table estimates the relationship between banks' ARM exposure and percentage changes in various measures of bank lending from 2021 to 2023. The main explanatory variable is ARM Share, defined as adjustable-rate closed-end loans secured by first liens on one-to-four-family residential properties (RCON5370) divided by total assets, measured as of 2019. All specifications include comprehensive bank-level controls measured in 2019: size controls (log assets), bank risk controls (equity ratio, liquidity ratio, cash ratio), interest rate sensitivity measures (trading assets ratio, maturity gap, income gap), asset maturity controls (various loan and securities maturity buckets), securities portfolio controls (securities by maturity), and liability structure controls (deposit composition by type and maturity). Standard errors are clustered at the bank holding company level. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

which includes controls for bank size, risk, interest rate sensitivity, and the full maturity structure of assets and liabilities, we find that a 1-percentage point increase in a bank's pre-period ARM share is associated with a 1.23 percent increase in its lending to small businesses.

This finding provides more direct evidence on the credit-supply channel. Within the same local market, banks with a higher share of ARMs significantly expanded their supply of credit. Equivalently, the result is consistent with FRMs concentrating valuation risk on bank balance sheets and reducing small-business credit supply at more exposed banks during the inflationary episode.

6.2.3 Evidence on the Credit Supply Channel: A Rajan-Zingales Approach

Having established that FRM exposure directly curtails banks' credit supply, we now investigate the real economic consequences of this contraction. We employ a difference-in-differences strategy inspired by Rajan and Zingales (1998) to test whether this credit-supply shock disproportionately affected industries dependent on external finance. The core idea is that if the bank resilience channel operates by easing credit constraints, its positive effects should be most pronounced in industries that are structurally more dependent on external finance. We test this by interacting our state-level measures of household and bank ARM exposure with a predetermined industry-level measure of external financial dependence (DoEF). This specification, which includes state-border-pair and

Table VII – The Effect of Bank ARM Share on CRA Lending

Dependent Variable: Percent Change in CRA Loans				
Variables	(1)	(2)	(3)	(4)
Bank's ARM Share	0.818***	1.360***	0.939***	1.230***
Std. Error	(0.192)	(0.274)	(0.282)	(0.284)
Observations	52,204	51,626	51,626	51,626
R-squared	0.064	0.088	0.101	0.122
Controls:				
Size Controls	Yes	Yes	Yes	Yes
Bank Risk Controls	Yes	Yes	Yes	Yes
Interest Rate Sensitivity Controls	No	Yes	Yes	Yes
Asset Maturity Controls	No	Yes	Yes	Yes
Securities Controls	No	No	Yes	Yes
Liability Controls	No	No	No	Yes
County FE	Yes	Yes	Yes	Yes

Notes: This table estimates the relationship between banks' adjustable-rate mortgage (ARM) share and the percent change in dollar amounts of loans to small businesses with gross annual revenues less than $1 million from 2021 to 2023. The main explanatory variable is ARM Share, defined as adjustable-rate closed-end first-lien residential mortgage balances divided by total assets as of 2019. All specifications include county fixed effects to control for local loan demand. Column (1) includes size controls (log assets) and basic risk controls (equity ratio, liquidity ratio, cash ratio). Column (2) adds interest rate sensitivity measures (trading assets ratio, maturity gap, 1-year income gap) and asset maturity controls (personal loans ratio, C&I loans ratio, real estate loans by maturity, loans and leases by maturity, MBS ratio). Column (3) incorporates securities portfolio controls (securities holdings by maturity buckets). Column (4) presents the full specification with liability structure controls (demand deposits, savings deposits, time deposits, brokered deposits, and time deposits by maturity). Standard errors are clustered at the county level. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Standard errors are reported in parentheses.

industry fixed effects, isolates whether financially dependent industries performed differentially better in states served by more resilient, high-ARM banks. We estimate:

$$\Delta Y_{s,i,21-23} = \gamma_1 \text{ARM Exposure}^{Bank}_{s,19} \times DoEF_i + \gamma_2 \text{ARM Share}^{HH}_{s,19} \times DoEF_i + \Gamma X_{s,19} + \mu_{s-b} + \mu_i + \epsilon_{s,i} \tag{16}$$

where $\Delta Y_{s,i,21-23}$ denotes one of several labor-market outcomes, and $DoEF_i$is the external-finance-dependence measure for three-digit industry i. Other regional controls include income, unemployment rate, household balance sheets, and regional mortgage characteristics (same controls in the regional analysis above). We also include industry and state-border-pair fixed effects.

Table VIII presents the results. Our primary variable of interest is the interaction between

TABLE VIII – The Effect of Mortgage Structure on State Labor Markets: Evidence from Dependence on External Finance

Dependent Variables: State-sector-level labor-market outcomes (percent change)			
Variables	Establishments	Employment	Total Wages
ARM Share (via Households) $\times DoEF_i$	0.412	0.144	0.149
	(0.256)	(0.119)	(0.192)
ARM Exposure (via Banks) $\times DoEF_i$	1.762***	0.642***	0.701**
	(0.503)	(0.193)	(0.284)
Observations	9,732	9,732	9,732
R-squared	0.531	0.494	0.546
All Regional Controls	Yes	Yes	Yes
State-Border and Industry Fixed Effects	Yes	Yes	Yes
All Regional Controls$\times DoEF_i$	Yes	Yes	Yes

Notes: This table examines the effect of mortgage structure on labor-market outcomes at the sectoral level. The coefficient of interest is the coefficient on the interaction term: ARM Exposure (via Banks) $\times DoEF_i$. $DoEF_i$captures the external-finance dependence of three-digit industries. A positive coefficient indicates that industries with greater external-finance dependence performed better in regions with high ARM exposure through banks. All models include: loan characteristics (payment, principal, balance, interest), economic controls (income, unemployment), asset controls (net worth, home equity, retirement accounts, liquid assets), DTI ratio, vehicle equity, and foreclosure rates. All specifications include state-border-pair and industry fixed effects. Standard errors are clustered at the state level. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

ARM Exposure$^{Bank}_{s,19}$ and external finance dependence, $DoEF_i$. For both Employment and Total Wages, this interaction is positive and highly statistically significant.

This is our key finding: industries with a greater structural reliance on external finance experienced significantly stronger employment and wage growth in states where the banking sector was less exposed to the risks of long-duration FRMs (i.e., more ARM-heavy). The economic magnitude is meaningful: a 1-percentage point increase in ARM exposure via banks is associated with approximately 0.35 percent higher employment growth for a one-standard-deviation increase in financial dependence.

6.3 Synthesis of Empirical Findings

Our empirical analysis of the 2021–2023 U.S. inflation and tightening cycle provides evidence consistent with the "dual-channel" hypothesis derived from our quantitative model. At the aggregate state level, we find that these channels operate simultaneously and in opposite directions. Consistent with the household demand channel, regions with higher household ARM exposure—where borrowers faced payment shocks and lacked the Fisher channel windfall of FRMs—experienced significantly slower growth in consumption, GDP, and income. Crucially, however, we identify a powerful countervailing force: regions exposed to banking sectors with higher ARM shares—and thus insulated from the valuation risk inherent in FRMs—performed significantly better. This divergence is consistent with mortgage structure generating opposing demand- and supply-side (credit) forces during the inflationary episode.

Our banking analysis provides more granular evidence on the mechanisms underlying this bank-resilience channel, aligning with the model's predictions regarding the systemic risks posed by FRMs. By utilizing bank-county data to control for local demand, we show that banks heavily exposed to long-duration FRMs were forced to contract their credit supply significantly more than their ARM-heavy counterparts. This behavior is consistent with the model's financial-accelerator mechanism, where rising inflation erodes the capital of FRM-heavy banks, triggering a credit crunch. Furthermore, the Rajan-Zingales analysis points to the real consequences of this instability, as employment in credit-dependent sectors suffered significantly more in areas served by these vulnerable, FRM-exposed banks. The empirical evidence is thus consistent with the central trade-off highlighted by the model: the household wealth gains provided by FRMs (the Fisher channel) come at the macroeconomic cost of increased financial instability and a potent credit-supply contraction during inflationary episodes.

7 Conclusion

In this paper, we study how mortgage market structure shapes the transmission of inflation shocks. We challenge the conventional view that the Fisher channel—wealth redistribution from lenders to borrowers—is necessarily expansionary by documenting a powerful countervailing force when the lender is a leveraged intermediary. Our central contribution is the identification of a "dual channel" where household wealth effects compete with bank credit supply. In FRM economies, the Fisher channel windfall for borrowers is mirrored by concentrated losses for banks, eroding capital and triggering a credit crunch. Conversely, ARM economies mute this systemic risk. This "dual channel" framework fundamentally reframes how we understand the macroeconomic role of mortgage contracts.

Our quantitative model shows why these aggregate patterns emerge and uncovers important distributional consequences. Under fixed-rate contracts, inflation shocks trigger systemic banking distress that translates into an economy-wide recession. The resulting credit contraction disproportionately harms those without assets—renters and the poor—who bear adjustment costs through income losses and exclusion from homeownership. FRMs thus protect incumbent fixed-rate borrowers, while the associated bank-capital losses fall on renters, prospective buyers, and low-wealth households. Adjustable-rate systems concentrate the adjustment on exposed borrowers through immediate payment shocks but preserve broader economic stability by maintaining functional credit markets.

Our empirical investigation of the 2021–2023 monetary tightening provides evidence that both channels operated simultaneously. The multi-tiered analysis reveals that ARM prevalence among households is associated with weak local economic activity, yet ARM concentration in bank portfolios supports it. These opposing effects manifest across multiple levels of aggregation—from state-level consumption to bank-specific lending decisions to employment in credit-dependent industries. The robustness of these patterns across different identification strategies strengthens confidence in the underlying mechanism.

These results challenge conventional wisdom about optimal mortgage design. Rather than simply focusing on the expansionary effects of the Fisher channel, mortgage structure determines the distribution of macroeconomic risk across society. Fixed-rate systems generate individual wealth gains by creating collective vulnerability—transforming nominal valuation risk into systemic banking fragility with regressive incidence. This trade-off suggests that monetary authorities face an uncomfortable reality: in FRM-heavy economies, the response to inflation shocks is dominated by financial instability rather than the stimulative effects of the Fisher channel.

Several research priorities emerge from our findings. Most pressing is whether regulatory frameworks can decouple household insurance from systemic risk, perhaps through mandatory hedging requirements or countercyclical mortgage regulations that preserve FRM benefits while limiting banking sector exposure. Furthermore, exploring innovative mortgage designs that incorporate automatic stabilization features—such as options to switch rates or adjust payments during recessions (e.g., Eberly and Krishnamurthy (2014), Campbell et al. (2021))—warrants further investigation within a general equilibrium framework that fully accounts for the dual channel highlighted here. We leave this for future research.

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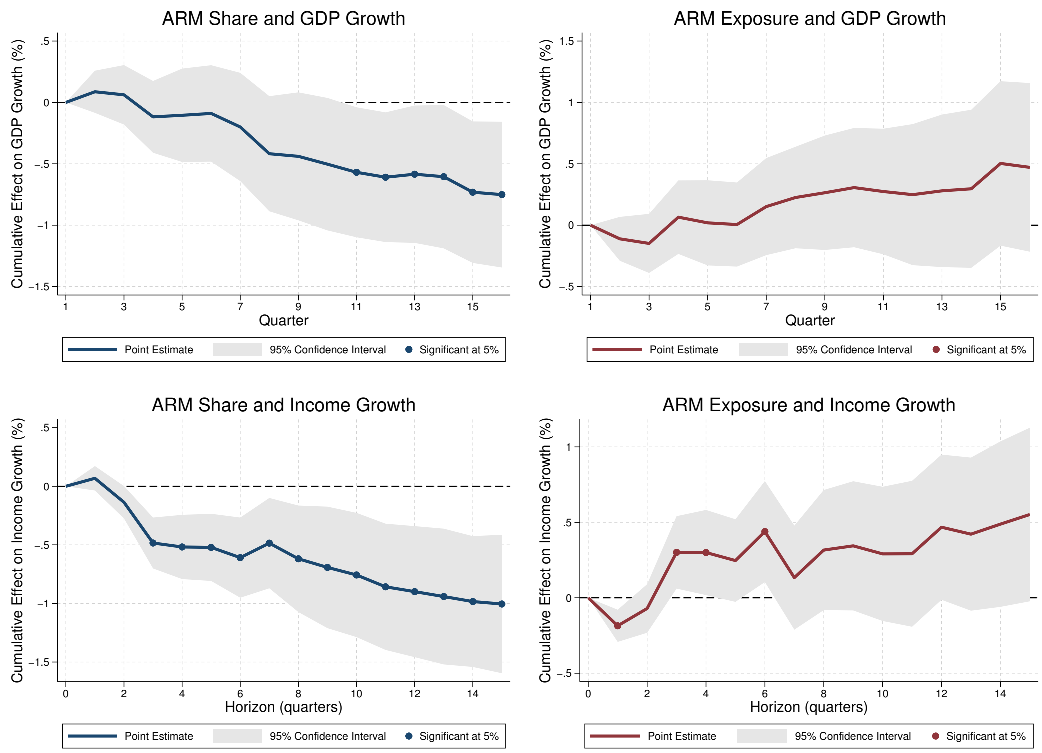
A Further Empirical Evidence

A.1 Further state-level results

FIGURE A.1 – Mortgage Structure and State Economies



Notes: These figures present dynamic local-projection estimates following Jordà (2005) to examine the dynamic effects of adjustable-rate mortgage prevalence on state economies. The specification follows:$y_{s,t+h} - y_{s,t-1} = \alpha^h + \beta_1^h \text{ARM Share}^{HH}_{s,19} + \beta_2^h \text{ARM Exposure}^{Bank}_{s,19} + \gamma^h X_{s,t} + \mu_{s-b,h} + \varepsilon_{s,t+h}$, where $y_{s,t+h} - y_{s,t-1}$ represents the cumulative percentage change in each dependent variable from the base period $(t-1)$ to horizon h, measured quarterly for up to 15 quarters. ARM $\text{Share}^{HH}_{s,19}$ captures the state-level proportion of ARMs held by households, while ARM $\text{Exposure}^{Bank}_{s,19}$ measures the state's exposure to ARMs through bank lending patterns. $X_{s,t}$ includes predetermined state-level controls: loan characteristics (scheduled monthly payment, scheduled principal), economic conditions (per capita income, unemployment rate), household balance sheet variables (net worth excluding home, home equity, motor vehicle equity, retirement accounts, liquid assets), debt measures (credit card debt), debt-to-income ratio, homeownership rate, and foreclosure rates. $\mu_{s-b,h}$ represents border-pair $\times$ horizon fixed effects to control for time-invariant unobserved heterogeneity between neighboring states and horizon-specific shocks. Standard errors are clustered at the border-pair level to account for spatial correlation. The shaded areas represent 95% confidence intervals, with solid markers indicating statistical significance at the 5% level. The identification strategy exploits cross-state variation in ARM prevalence at state borders, controlling for local economic conditions that might affect both mortgage choice and state economic outcomes.

A.2 MSA-level evidence

To provide further support for the dual-channel mechanism and to provide further evidence that our state-level findings are not driven by unobserved regional shocks, we conduct a more granular analysis at the Metropolitan Statistical Area (MSA) level. We employ a stacked adjacent-state design with state-border-pair fixed effects. This approach compares MSAs assigned to the same adjacent-state border pair and controls for economic conditions common to that border region. We estimate the following specification:

$$\Delta Y_{m,s,b,21-23} = \beta_1 \text{ARM Share}^{HH}_{m,19} + \beta_2 \text{ARM Exposure}^{Bank}_{m,19} + \Gamma X_{m,19} + \mu_{s-b} + \epsilon_{m,s,b} \tag{A.1}$$

where $\Delta Y_{m,s,b,21-23}$ represents the log change in economic outcomes for MSA m in state s belonging to border pair b. ARM Share$^{HH}_{m,19}$ and ARM Exposure$^{Bank}_{m,19}$ are the MSA-level exposures measured in 2019. $X_{m,19}$ includes a detailed set of MSA-level controls, including loan characteristics, economic indicators, market concentration measures, and detailed household income distribution data (see table notes). μ_{s-b} denotes the state-border pair fixed effects. The regressions are weighted by the inverse of the number of borders the MSA's state shares.

TABLE A.1 – The Effect of Mortgage Structure on MSA Economies

Dependent Variables: MSA-level Growth (2021–2023)			
	(1)	(2)	(3)
Variables	Per-capita Personal Income	Personal Income	GDP
ARM Share 2019 (HH)	-0.210***	-0.268***	-0.224*
	(0.077)	(0.102)	(0.134)
Bank ARM Exposure 2019	0.0788**	0.068**	0.080**
	(0.033)	(0.029)	(0.032)
Observations	1575	1575	1575
R-squared	0.487	0.5047	0.307
MSA Controls	Yes	Yes	Yes
State-Border Pair FE	Yes	Yes	Yes

Notes: This table examines the relationship between adjustable-rate mortgages (ARMs) and MSA-level economic outcomes using a border-pair fixed effects design. The dependent variables are the log changes in Per Capita Income, Total Income, and GDP (2021–2023). All models include the following MSA-level controls measured pre-period: loan characteristics (log average balance, principal, monthly payment, FICO score), economic/wealth controls (log income 2021, log deposits 2021, pension share), labor market and concentration controls (employment, HHI, number of banks), and detailed household income distribution brackets. All specifications include State-Border Pair Fixed Effects. Regressions are weighted by the inverse of the number of borders the MSA's state shares. Standard errors (in parentheses) are clustered at the border-pair level. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table A.1 presents the results. The MSA-level findings corroborate the state-level evidence and show that the dual-channel pattern persists after controlling for fine-grained local shocks.

The coefficient on the household ARM share (ARM Share^{HH}) is negative and highly statistically significant across all measures of economic activity: Per Capita Income Growth (Column 1), Total Income Growth (Column 2), and GDP Growth (Column 3). This indicates that MSAs with greater household exposure to adjustable rates experienced significantly weaker economic performance. For instance, a 1-percentage point increase in the household ARM share is associated with an approximate 0.21 percentage point decrease in per capita income growth.

Conversely, the coefficient on bank ARM exposure (ARM Exposure^{Bank}) is positive and statistically significant across all specifications ($p<0.05$). This indicates that MSAs served by banking sectors with higher ARM concentration—and thus greater insulation from interest rate risk—performed significantly better. A 1-percentage point increase in bank ARM exposure is associated with an approximate 0.08 percentage point increase in both per capita income and GDP growth.

The consistency of these results in the state-border-pair design reinforces our main findings: the household demand channel (via ARM exposure) acts as a drag on the local economy, while the bank resilience channel (via ARM exposure) provides significant support during an inflationary period.

B Model Appendix

In this section, we provide data sources that we use for numerical calibration. We also give the detailed formulations of all optimization problems.

B.1 Data Sources for the Model Moments

All data come from the Federal Reserve Economic Data (FRED). All data moments are calculated as averages over the 2015–2020 period. In our model, output is denoted by Y_g, and GDP is the sum of output and housing services, with owner-occupied housing services imputed at the rental price as in the data. Thus, GDP is $Y_A = Y_g + p_r \bar{H}$ in the steady state. The data counterpart of model GDP is total GDP less government spending and net exports; equivalently, it is the sum of personal consumption expenditures and gross private domestic investment. We obtain this measure by summing Personal Consumption Expenditures (PCE) and Gross Private Domestic Investment (GPDI) in the FRED database. Output, Y_g, is obtained by subtracting housing services from GDP. Housing services are the sum of Personal consumption expenditures: Services: Housing: Rental of tenant-occupied nonfarm housing (DTENRC1A027NBEA) and Personal consumption expenditures: Services: Housing: Imputed rental of owner-occupied nonfarm housing (DOWNRC1A027NBEA) in FRED.

Mortgage Debt-GDP Ratio The mortgage-debt-to-GDP ratio is obtained by dividing One-to-Four-Family Residential Mortgages; Liability of Households and Nonprofit Organizations (HHMSDODNS) by GDP. The average over 2015–2020 is 60.27 percent.

Homeownership Rate The homeownership rate is obtained from the series RSAHORUSQ156S labeled as Homeownership Rate in the United States. The average rate over 2015–2020 is 64.03 percent.

Housing Services Share in GDP The housing-services share of GDP is calculated by dividing the sum of Personal consumption expenditures: Services: Housing: Rental of tenant-occupied nonfarm housing (DTENRC1A027NBEA) and Personal consumption expenditures: Services: Housing: Imputed rental of owner-occupied nonfarm housing (DOWNRC1A027NBEA) by GDP. The average over 2015–2020 is 12.49 percent.

Non-residential Investment-Output Ratio The nonresidential-investment-to-output ratio is calculated by dividing Private Nonresidential Fixed Investment (PNFI) by output, Y. The average of this series over 2015–2020 is 19.32 percent.

Residential Investment-GDP Ratio The residential-investment-to-GDP ratio is calculated by dividing Private Residential Fixed Investment (PRFI) by GDP. The average of this series over 2015–2020 is 4.72 percent.

House Price-Rent Ratio The house-price-to-rent ratio is calculated by dividing Households; Owner-Occupied Real Estate at Market Value (BOGZ1FL155035013Q) by Imputed Rental of Owner-Occupied Housing (A2013C1A027NBEA). The average of this series over 2015–2020 is 16.14.

Mortgage Share in Bank Assets The mortgage share of bank assets is calculated by dividing Households and Nonprofit Organizations; One-to-Four-Family Residential Mortgages; Liability (BOGZ1FL153165105A) by the sum of Households and Nonprofit Organizations; One-to-Four-Family Residential Mortgages; Liability (BOGZ1FL153165105A) and Nonfinancial Business; Loans; Liability (BOGZ1FL144123005A), representing corporate debt in bank balance sheets. The average of this series over 2015–2020 is 52.29 percent.

Bank Leverage Bank leverage is calculated by dividing Total Assets, All Commercial Banks (TLAACBM027SBOG) by Residual (Assets Less Liabilities), All Commercial Banks (RALACBM027SBOG). The average of this series over 2015–2020 is 9.12.

Mortgage Premium The mortgage premium is calculated as the difference between 30-Year Fixed Rate Mortgage Average in the United States (MORTGAGE30US) and Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity (WGS10YR). The average of this series over 2015–2020 is 1.72 percent.

Capital-Output Ratio This ratio is set to 3, a standard value in the literature.

Inflation Inflation data is obtained using the series Consumer Price Index for All Urban Consumers: All Items Less Food and Energy in U.S. City Average (CPILFESL). We first fit a linear trend to the data over 2015–2020, remove the trend from the actual series, and compute the deviation from the trend after 2020 to obtain the shock fed to the model.

B.2 Value Functions for Households

B.2.1 Active Renters

An active renter has two choices: continue renting or purchase a house. Thus, $V^r = \max\left\{V^{rr}, V^{rh}\right\}$, where V^{rr} is the value function if she decides to continue renting and V^{rh} is the value function if she decides to purchase a house. If she decides to continue to rent, she chooses rental unit size s at price p_r per unit, makes her consumption and saving choices, and remains as an active renter in the next period. After purchasing a house, she begins the next period as a homeowner. The value function of an active renter who decides to remain as a renter is given by

$$V_j^{rr}(a,z) = \max_{c,s\leq \underline{\mathrm{h}},a'\geq 0}\left\{\left(u(c,s)+\beta E\left(V_{j+1}^{r}(a',z')^{1-\sigma}\right)^{\frac{1-\rho}{1-\sigma}}\right)^{\frac{1}{1-\rho}}\right\} \tag{B.1}$$

subject to

$$c + a' + p_r s = y(j,z) + a\,(1+r)\,,$$

where a is the beginning-of-period financial wealth, $p_r s$ is the rental payment, r is the return to savings, and w is the wage rate per efficiency unit of labor. The expectation operator is over the income shock z'.

B.2.2 Inactive Renters

Inactive renters are not allowed to purchase a house because of their default in previous periods. However, they can become active renters with probability χ. Because they cannot purchase a house, they choose only rental size, consumption, and savings. The value function of an inactive renter is given by

$$V_j^{e}(a,z) = \max_{c,s\leq \underline{\mathrm{h}},a'\geq 0}\left\{\left(u(c,s)+\beta\left[\chi E V_{j+1}^{r}(a',z')^{1-\sigma}+(1-\chi)E V_{j+1}^{e}(a',z')^{1-\sigma}\right]^{\frac{1-\rho}{1-\sigma}}\right)^{\frac{1}{1-\rho}}\right\} \tag{B.2}$$

subject to

$$c + a' + p_r s \quad = \quad y(j,z) + a(1+r).$$

B.2.3 Homeowners

A homeowner has four options: (1) remain in the current home, (2) refinance, (3) sell the current house and either rent or buy another house, or (4) default. The homeowner's value function is the maximum of these four option values; that is, $V^h = \max\left\{V^{hh}, V^{hf}, V^{hr}, V^{hd}\right\}$, where V^{hh} is the value of staying as a homeowner, V^{hf} is the value of refinancing, V^{hr} is the value of selling, and V^{hd} is the value of defaulting (being excluded from the ownership option).

A stayer chooses consumption and savings given their income shock, housing stock, mortgage debt, and assets. Therefore, the problem of the stayer can be formulated as follows:

$$V_j^{hh}(a,h,d,z) = \max_{c,a' \geq 0} \left\{ \left(u(c,h) + \beta \left(EV_{j+1}^h(a',h,d',z')^{1-\sigma} \right)^{\frac{1-\rho}{1-\sigma}} \right)^{\frac{1}{1-\rho}} \right\} \tag{B.3}$$

subject to

$$\begin{aligned} c + \delta_h p_h h + a' + m(d, r_m^*, j) - \tau^d r_m^* d &= y(j,z) + a(1+r) \\ d' &= (d-m)(1+r_m^*), \end{aligned}$$

where m is the mortgage payment following the standard amortization schedule computed at the mortgage interest rate r_m^*.

The second choice for the homeowner is to refinance, which also includes prepayment. Refinancing requires repaying the full balance of any existing debt and originating a new mortgage. We assume that refinancing is subject to the same transaction costs as new mortgage originations. The refinancing problem is:

$$V_j^{hf}(a,h,d,z) = \max_{c,d',a' \geq 0} \left\{ \left(u(c,h) + \beta \left(EV_{j+1}^h(a',h,d',z')^{1-\sigma} \right)^{\frac{1-\rho}{1-\sigma}} \right)^{\frac{1}{1-\rho}} \right\} \tag{B.4}$$

subject to

$$c + d + \delta_h p_h h + a' + m\left(d', r_m^*, j\right) \quad = \quad y(j,z) + a(1+r) + d'\left(q^m(d'; a', h, z, j) - \varphi_m + \tau^d r_m^*\right) - \varphi_f I\left(d' > 0\right).$$

The third choice for the homeowner is to sell the current house and either stay as a renter or buy a new house. Selling a house incurs a transaction cost equal to a fraction φ_s of the sale price. Moreover, a seller has to pay the outstanding mortgage debt, d, in full to the lender. After the sale, the household may either rent or purchase another house; the resulting problem is identical to the renter's problem:

$$V_j^{hr}(a,h,d,z) = V_j^r\left(a + p_h h(1-\varphi_s-\delta_h) - d, z\right).$$

The fourth possible choice for a homeowner is to default on the mortgage, if she has one. A defaulter has no obligation to the bank. The bank seizes the house, sells it on the market, and returns any positive amount from the sale of the house, net of the outstanding mortgage debt and transaction costs, back to the defaulter. For the lender, the sale price of the house is assumed to be $(1-\varphi_e)\,p_h h$. Therefore, the defaulter receives $\max\{(1-\varphi_e)\,p_h h - d, 0\}$ from the lender. The defaulter starts the next period as an active renter with probability χ. With probability $(1-\chi)$, she stays as an inactive renter. The problem of a defaulter becomes the following:

$$V_j^{hd}(a,h,d,z) = \max_{c,s\leq \underline{h},a'\geq 0}\left\{\left(u(c,s)+\beta E\left[\chi V_{j+1}^r(a',z')^{1-\sigma}+(1-\chi)V_{j+1}^d(a',z')^{1-\sigma}\right]^{\frac{1-\rho}{1-\sigma}}\right)^{\frac{1}{1-\rho}}\right\} \tag{B.5}$$

subject to

$$c+a'+p_r s = a(1+r)+y(j,z)+\max\{(1-\varphi_e)p_h h-d,0\}.$$

The problem of a defaulter is different from the problem of a seller in two ways. First, the defaulter receives $\max\{(1-\varphi_e)p_h h-d,0\}$ from the housing transaction, whereas a seller receives $(1-\varphi_s)p_h h-d$. We assume that the default cost is higher than the sale transaction cost, that is, $\varphi_e > \varphi_s$, and the defaulter receives less than the seller as long as $(1-\varphi_s)p_h h-d \geq 0$ (i.e., the home equity net of the transaction costs for the homeowner is positive). Second, a defaulter may be excluded from mortgage credit in the next period. Such an exclusion lowers the continuation utility for a defaulter. In sum, since defaulting is costly, a homeowner will choose to sell the house instead of defaulting as long as $(1-\varphi_s)p_h h-d \geq 0$ (i.e., net home equity is positive). Hence, negative equity is a necessary condition for default in the model. Therefore, in equilibrium, a defaulter receives nothing from the lender.

B.3 Firm's Problem

The firm's first-order conditions are:

$$\begin{aligned}
\alpha\mathbb{Z}\left(\frac{K}{N_g u}\right)^{\alpha-1} &= r+\delta_k\\
(1-\alpha)\mathbb{Z}u\left(\frac{K}{N_g u}\right)^{\alpha} &= (1+\mu r'_\ell)\left(\varpi+\vartheta\frac{u^{1+\psi}}{1+\psi}\right)\\
(1-\alpha)\mathbb{Z}\left(\frac{K}{N_g u}\right)^{\alpha} &= (1+\mu r'_\ell)\,\vartheta u^{\psi}.
\end{aligned}$$

C Additional Model Results

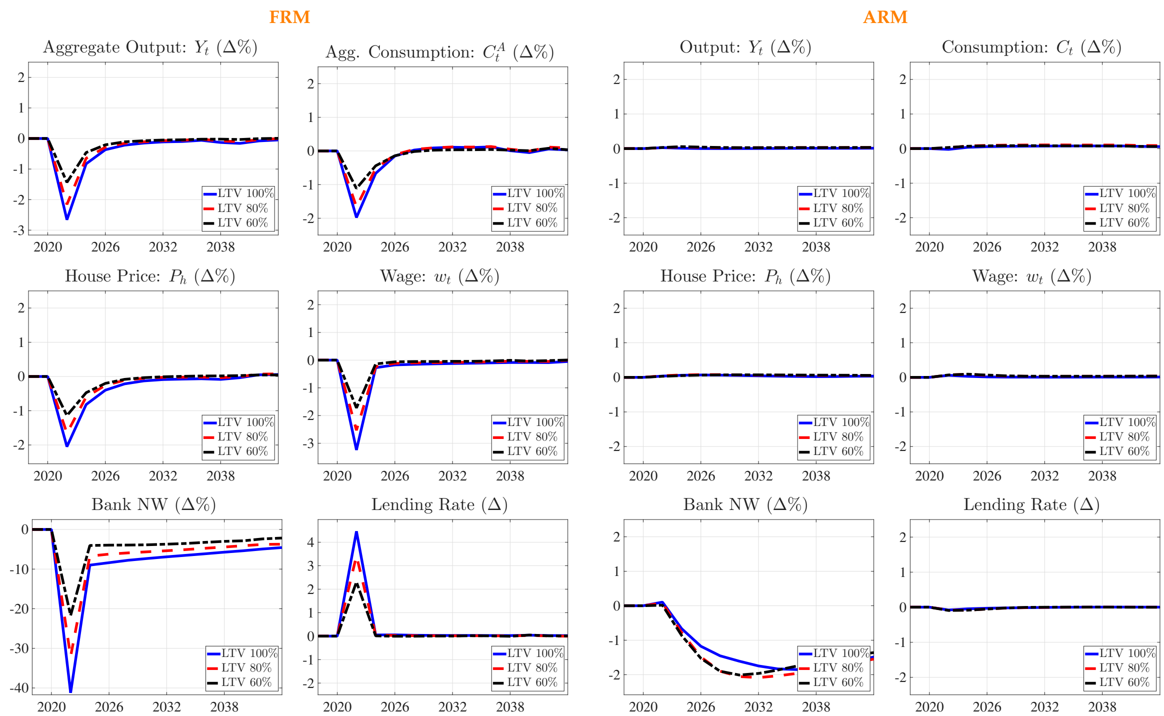
C.1 Alternative Macroprudential Policies: LTV and PTI

We explore how ex ante borrower-based macroprudential regulations mediate the transmission of the inflation shock.

Loan-to-Value (LTV) Restrictions Figure C.1 illustrates the economy's response under varying LTV caps (100%, 80%, and 60%). Tighter LTV limits dampen the recessionary dynamics in the FRM economy. By enforcing lower initial household leverage, these policies reduce the aggregate stock of nominal assets held by the banking sector. This lower exposure reduces the magnitude of the valuation loss banks suffer when inflation spikes, thereby preserving bank capital and mitigating the severity of the credit crunch.

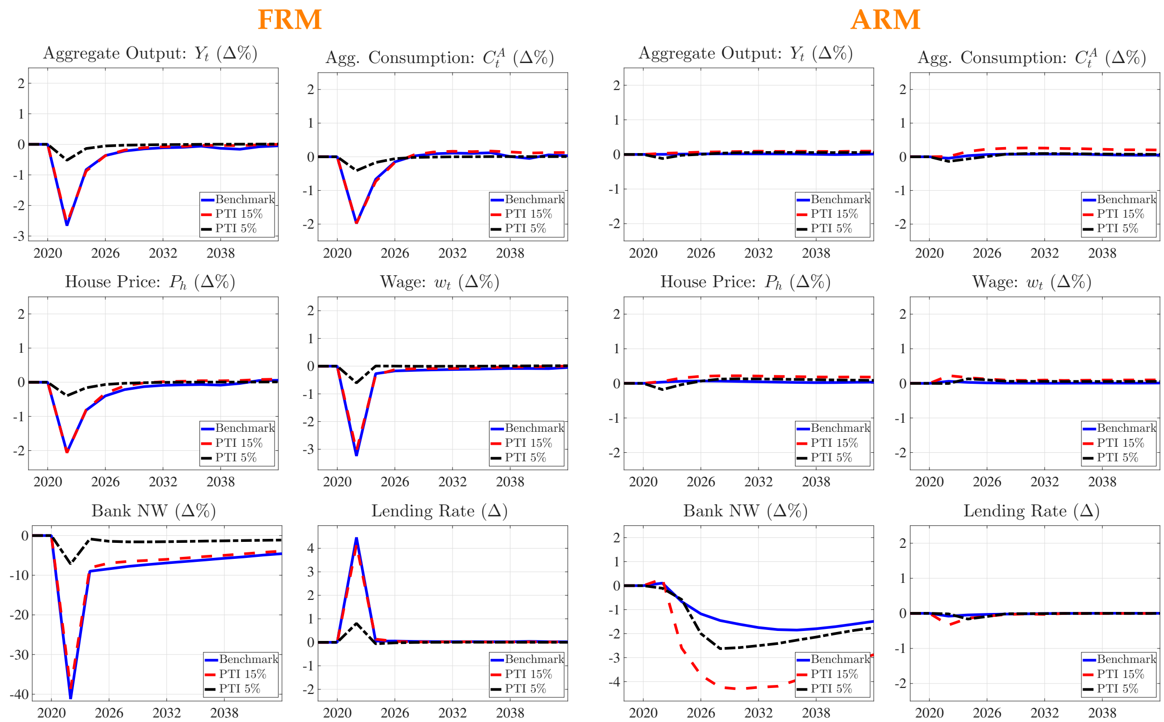
Payment-to-Income (PTI) Restrictions Figure C.2 presents the dynamics under different Payment-to-Income restrictions (45%, 15%, and 5%). In the FRM economy, PTI limits stabilize the economy by limiting total indebtedness, although the constraint bites only when it is very tight: the 15 percent cap leaves the dynamics close to the benchmark, while the 5 percent cap substantially reduces leveraged borrowing, bank losses, and the depth of the recession. In the ARM economy, aggregate dynamics remain essentially stable under all caps. PTI constraints bind on current cash flows, and the inflation shock triggers the "tilting effect" in ARMs, front-loading real payments and tightening the constraint exactly at impact. This produces a small additional consumption dip for constrained borrowers and a somewhat larger decline in bank net worth, but these effects are an order of magnitude smaller than the stabilization the same caps deliver in the FRM economy.

FIGURE C.1 – Loan-to-Value Restrictions and the Model Dynamics



Notes: This figure shows how tighter loan-to-value (LTV) restrictions affect the transmission of the inflation shock in the FRM and ARM economies. The figure compares the benchmark economy with a counterfactual economy that imposes a tighter LTV cap, thereby reducing the initial leverage of new borrowers and the aggregate stock of mortgage debt held by banks. The inflation shock is an unanticipated 7 percentage point increase from an initial zero-inflation steady state and then reverts according to an AR(1) process with two-year persistence of 0.4. The panels report the responses of key macroeconomic variables following the shock. By lowering household leverage ex ante, tighter LTV limits reduce banks' exposure to inflation-induced valuation losses on fixed-rate mortgage assets, thereby dampening the financial accelerator, especially in the FRM economy.

FIGURE C.2 – Payment-to-Income Restrictions and the Model Dynamics



Notes: This figure shows how tighter payment-to-income (PTI) restrictions affect the transmission of the inflation shock in the FRM and ARM economies. The figure compares the benchmark economy with a counterfactual economy that imposes a tighter PTI cap, which restricts debt service burdens at origination and lowers the effective leverage of indebted households. The inflation shock is an unanticipated 7 percentage point increase from an initial zero-inflation steady state and then reverts according to an AR(1) process with two-year persistence of 0.4. The panels report the responses of key macroeconomic variables following the shock. Tighter PTI limits reduce the volume of highly leveraged mortgage borrowing and therefore mitigate the erosion of bank capital after the shock in the FRM economy; effects in the ARM economy are small.

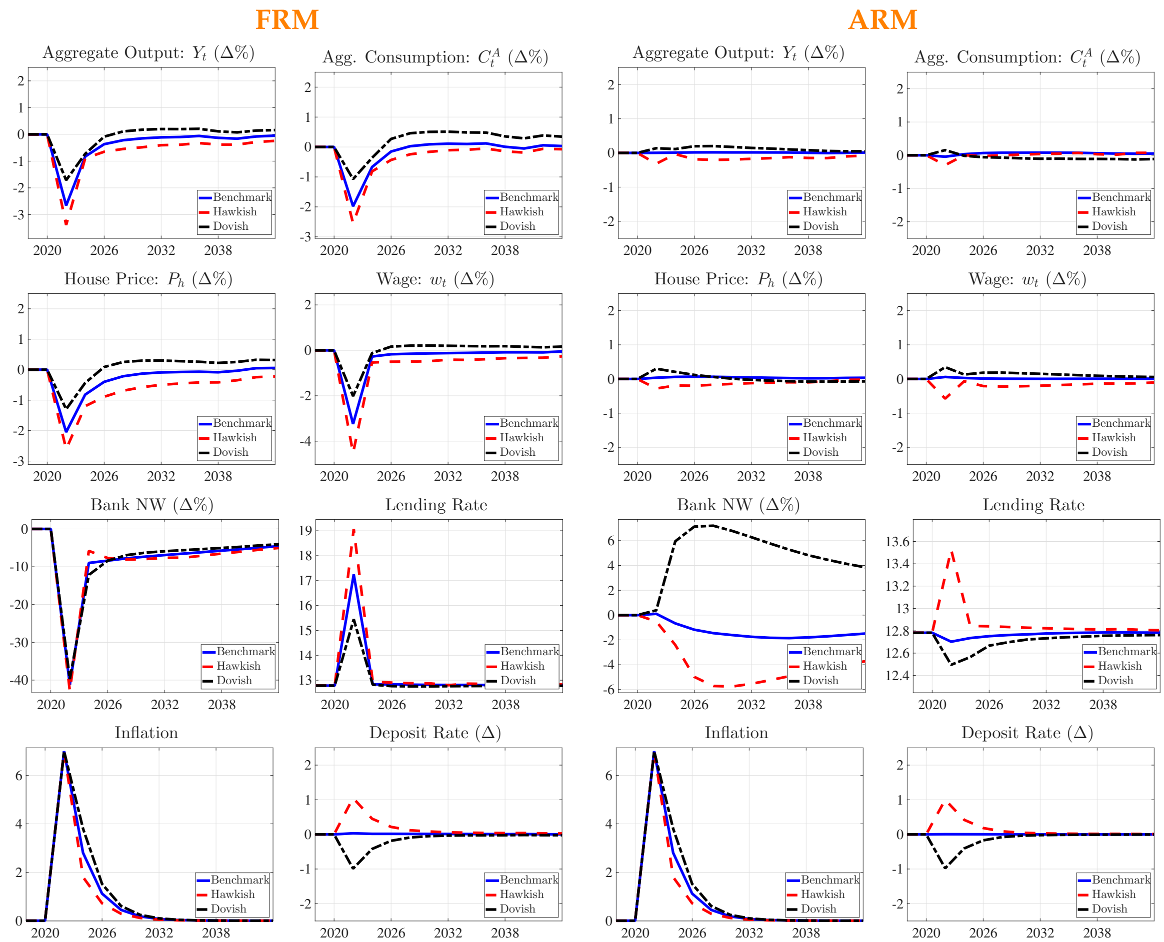
C.2 Monetary Policy with Endogenous Inflation

In the main text, we assumed an exogenous inflation path to isolate transmission channels. Figure C.3 relaxes this assumption, allowing inflation to respond endogenously to the central bank's policy stance via a reduced-form Phillips curve relationship. The implied inflation response to policy is modest, in line with empirical estimates of the effects of monetary policy shocks (Coibion, 2012) and with evidence that the U.S. Phillips curve is flat (Hazell et al., 2022). We compare the benchmark response to a "hawkish" rule (reacting more aggressively to inflation) and a "dovish" rule (reacting less aggressively).

The results indicate that the conflict between price stability and financial stability is structural. In this sense, bank balance sheets create a financial-stability constraint on disinflation in FRM economies. The constraint is analogous to the fiscal limit in Bianchi and Melosi (2022), though here it operates through intermediary net worth rather than fiscal backing. The hawkish policy (red dashed line) compresses inflation but induces a deeper decline in bank net worth. This triggers a larger spike in lending rates and a deeper recession. Conversely, the dovish policy (black dashed line) moderates the decline in output and bank capital, albeit at the cost of more persistent inflation. This pattern is consistent with the financial-stability constraint on monetary tightening identified in our main analysis remaining present under endogenous price determination.

Figure C.3 (right panels) shows the corresponding results for the ARM economy. As in the exogenous-inflation experiment of Section 5.2, the downturn remains substantially milder than under FRMs for every policy stance: bank capital is preserved, credit supply is stable, and the transmission runs mainly through the household cash-flow channel, so the conflict between price stability and financial stability is far less severe.

FIGURE C.3 – Monetary Policy Tightness and Mortgages: When Inflation Responds



Notes: This figure shows the responses of the FRM economy (left panels) and the ARM economy (right panels) to the inflation shock under alternative monetary policy rules when inflation is allowed to respond endogenously to policy. The benchmark rule sets the nominal policy response coefficient to $\phi^m = 1$, while the hawkish and dovish cases set $\phi^m = 1.15$ (hawkish) and $\phi^m = 0.85$ (dovish), respectively. The panels report the paths of output, consumption, house prices, wages, bank net worth, the lending rate, inflation, and the deposit rate. In this appendix exercise, inflation in the next period responds to monetary policy through a reduced-form Phillips-curve-type relationship, with a modest response in line with the monetary policy shock estimates of Coibion (2012) and the flat Phillips curve estimated by Hazell et al. (2022). The figure is designed to show that the main trade-off between price stability and financial stability remains present when inflation is endogenous rather than imposed exogenously.