

The Heterogeneous Bank Lending Channel of Monetary Policy

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Does bank heterogeneity matter for monetary policy transmission?

- Empirical evidence says yes!
 - Liquid assets and size (Kashyap and Stein, 2000)
 - **Leverage** (Jimenez et al., 2012; Dell'Ariccia et al., 2017; Altavilla et al., 2020)
 - **Interest rate risk exposure** (Gomez et al., 2021). Loan rate pricing (Altunok et al., 2023)

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 - **Interest rate risk exposure** (Gomez et al., 2021). Loan rate pricing (Altunok et al., 2023)
- **How do interest-rate risk and leverage affect monetary policy transmission?**
 - ⇒ **Develop a structural model** to go beyond cross-sectional estimates
 - Understand how micro-heterogeneity aggregates to macro responses
 - Quantify the interactions between **interest-rate risk** and **regulatory constraints**
 - Policy counterfactuals

Our contribution

- **Theoretical** benchmark:

Without regulatory constraints, the distribution of interest-rate risk exposure is irrelevant for monetary policy transmission

⇒ Whether IRR exposure matters depends on the empirical distribution of bank leverage and proximity to regulatory constraints (quantitative question)

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- **Quantitative** We build a heterogeneous-banks macro model with:

- Ex-ante heterogeneity in loan-rate fixation (fixed vs. variable rates)
- Ex-post heterogeneity in capital ratios (idiosyncratic credit risk)

⇒ Calibrated to Euro Area: Fixed- (e.g., FR, DE) vs. Variable-rate (e.g., ES, IT) systems

Preview of the results

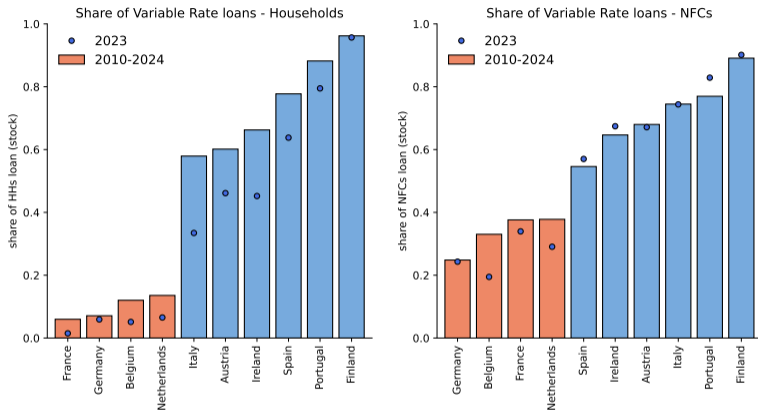
1. Model can replicate long-run distributional features of EA banks
 - Cross-sectional distribution of assets and capital ratios
2. Amplification: Stronger contraction in credit of banks with...
 - Fixed-rate loans
 - ⇒ ex-ante heterogeneity in loan pricing matters for MP transmission
 - Highly levered banks are key margin of transmission
3. Key insight: sources of heterogeneity interact
 - Without heterogeneity in leverage, heterogeneity in loan pricing becomes irrelevant.
4. Implications for financial stability and conduct of monetary & macropru policy

Outline

1. Data: Bank heterogeneity in the Euroarea
2. The Model: Mechanism + Theory
3. Quantitative results
 - Long-term features
 - Dynamic response to MP
 - Policy implications

Data. Euroarea

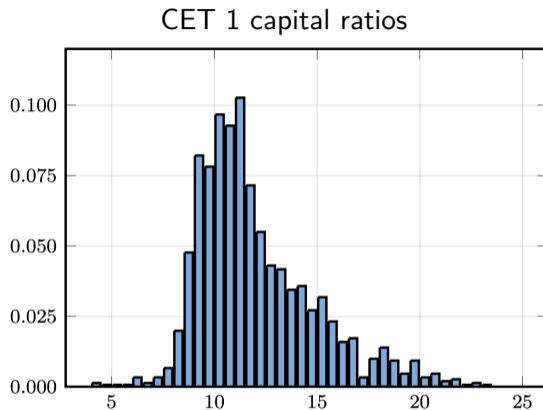
Heterogeneity in loan-rate fixation



Data sources: ECB Statistical Data Warehouse. Lending to households includes mortgage loans, consumer loans, and other loans.

- **FR countries:** Germany, France, Belgium, and Netherlands
- **VR countries:** Spain, Portugal, Italy, Austria, Finland, Ireland
- Loan-rate pricing patterns are highly persistent over time

Heterogeneity in bank leverage



Sources: S&P Global. The sample corresponds to 163 large and medium-sized European banks from 2013 to 2020.

- Large heterogeneity in CET 1 capital ratios
- Most European banks hold substantial capital buffers ⇒

The model

The Model – Environment

Two institutional environments: fixed-rate and variable-rate loans

Banking sector

- Continuum of perfectly competitive banks
- Assets: safe short-term reserves and risky long-term risky loans.
- Liabilities: short-term deposit and equity.
- Regulation: (i) Minimum capital requirement, (ii) Liquidity requirement.

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Non-financial sector

- Entrepreneurs: Rely on bank loans for funding investment projects.
- Households: Save in deposits and gov. bonds, consume, own the banks.
- Government: sets policy rate and runs a deposit insurance scheme.

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Bank – Balance Sheet

- Bank j starts with: legacy loans L_{jt} , accumulated equity E_{jt}
- Chooses: new loans N_{jt} , reserves M_{jt} ,
... (insured) deposits D_{jt} and wholesale debt (uninsured) B_{jt}
- Bank's balance sheet:

$$L_{jt} + N_{jt} + M_{jt} = D_{jt} + B_{jt} + E_{jt}$$

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- Differentiate between short (M_{jt}) and long-term assets ($L_{jt} + N_{jt}$)
 - **maturity transformation** is banks' core function
 - key distinction from classic banking literature:
Gertler&Kiyotaki (2010), Gertler&Karadi (2011), Mendicino et. al. (2021), Coimbra&Rey (2023)

Bank assets

Long-term loan portfolio (L_{jt}): continuum of risky loans

- Principal of 1 and avg. effective **lending rate** r_{jt}^L
- Law of motion:

$$L_{jt+1} = (1 - \delta)(1 - \omega_{jt+1})(L_{jt} + N_{jt}).$$

- δ **fraction matures** with iid prob. (Leland and Toft, 1996)
- $\omega_{jt+1} \sim F(\rho, \rho)$ **stochastic default rate** correlated at the bank level (Vasicek, 2002)
- Loss given default: fraction $\lambda \in (0, 1)$ of the principal
- Technology: new loans N_{jt} incur a convex cost $f\left(\frac{N_{jt}}{L_{jt}}\right) L_{jt}$

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Short-term reserves (M_{jt}): safe assets remunerated at the **policy rate** r_t^M

Loan rate pricing: fixed vs. variable regimes

Fixed-rate (FR) economy:

- Loan rate r_t^N is fixed at origination and constant until maturity.
- Average rate on legacy loans:

$$\bar{r}_{jt+1}^L = \frac{r_{jt}^L L_{jt} + r_t^N N_{jt}}{L_{jt} + N_{jt}}$$

Variable-rate (VR) economy:

- Loan rate $r_t^N = r_t^M + s_t^N$ adjusts with policy rate.
- Average rate on legacy loans:

$$r_{jt+1}^L = r_t^M + s_{jt+1}^L, \text{ with } s_{jt+1}^L = \frac{s_{jt}^L L_{jt} + s_t^N N_{jt}}{L_{jt} + N_{jt}}$$

Key distinction: \Rightarrow in VR, repricing is quick as rates track monetary policy directly;
 \Rightarrow in FR, repricing is gradual as new loans replace old ones.

Bank equity and Capital Regulation

- Equity is accumulated through retained earnings:

$$E_{jt+1} = E_{jt} + (1 - \tau)\Pi_{jt+1},$$

- Profits:

$$\begin{aligned}\Pi_{jt+1} = & (1 - \omega_{jt+1} - \lambda\omega_{jt+1}) \left(r_{jt}^L L_{jt} + r_t^N N_{jt} \right) - r_t^D D_{jt} - r_t^B B_{jt} && \text{(net interest income)} \\ & + r_t^M M_{jt} && \text{(return of reserves)} \\ & - f(N_{jt}/L_{jt}) L_{jt} && \text{(origination costs)}\end{aligned}$$

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- Minimum capital requirement (γ):

$$E_{jt} \geq \gamma L_{jt}$$

- Failure to comply: bank resolution \rightarrow endogenous failure

Taking Stock. Key features

1. Banks maturity transformation

- + heterogeneity in loan pricing (FR vs VR)
- + Deposits structure that captures rate pass-through \Rightarrow Captures NIM dynamics!

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+ idiosyncratic credit risk \Rightarrow generates ex-post heterogeneity in leverage

Taking Stock. Key features

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2. Slow moving leverage, L_{jt}/E_{jt}
 - + idiosyncratic credit risk \Rightarrow generates ex-post heterogeneity in leverage
3. + Capital regulation \Rightarrow endogenous capital buffers!

Main Mechanism

Net Profits (simplified):

$$\text{Variable rate: } \Pi_{jt+1} = \underbrace{(r_t^N N_{jt} + r_{jt}^L L_{jt})(1 - \omega_{jt+1}) - \bar{r}_t^D D_{jt}}_{\text{Net Interest Margin (NIM)}} + \bar{r}_t^M M_t$$

$$\text{Fixed rate: } \Pi_{jt+1} = (r_t^N N_{jt} + \bar{r}_{jt}^L L_{jt})(1 - \omega_{jt+1}) - \bar{r}_t^D D_{jt} + r_t^M M_{jt}$$

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- Policy tightening:

$$\uparrow^+ r_t^M \rightarrow \uparrow \bar{r}_t^D \rightarrow \left\{ \begin{array}{l} \uparrow r_{jt}^L L_{jt} + \uparrow r_t^N N_{jt} - \bar{r}_t^D D_{jt}, \quad \uparrow\downarrow \text{ NIM variable rate} \\ \cancel{\uparrow \bar{r}_{jt}^L L_{jt}} + \uparrow r_t^N N_{jt} - \bar{r}_t^D D_{jt}, \quad \downarrow \text{ NIM fixed-rate} \end{array} \right.$$

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- Policy tightening: $\uparrow^+ r_t^M \rightarrow \uparrow \bar{r}_t^D \rightarrow \downarrow \Pi_{t+1}$ (Stronger for fixed-rate)

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- Policy tightening: $\uparrow^+ r_t^M \rightarrow \uparrow \bar{r}_t^D \rightarrow \underbrace{\downarrow E_{t+1} \rightarrow \downarrow \text{New Lending}}_{\text{Due to Capital Constraint}}$ (Stronger for fixed-rate)

Implication: The speed of loan rate adjustment drives differences in profitability, capital ratios, and ultimately the lending response to monetary policy.

The theoretical benchmark: Irrelevance of rate exposure

Proposition 1. In the absence of idiosyncratic risk, the model features identical prices and allocations in the fixed- and variable-rate economies in steady state

- **Intuition:** If banks are unconstrained, they can smoothly adjust their balance sheets and absorb losses/gains via equity without cutting lending
 - No equity constraints → no effect of rate exposure
 - whether exposure matters depends on the empirical distribution of bank leverage:
→ mass of banks near the regulatory constraint

Quantitative Results

Calibration highlights

- Quarterly frequency, period 2013-2023.
- Matches euro area bank balance sheets (capital ratios, liquid assets, loan maturities)
- Many parameters... [what's important?](#)
 - Credit risk process
 - Loan adjustment costs
 - Entrepreneurs demand elasticities

recursive-problem

pre-set parameters

Jointly estimated parameters

	Jointly estimated	Value	Target	Data	Model
β	Subjective discount factor	0.933	Banks' return on equity (%)	6.4	6.4
ρ	Loan default correlation	0.51	Bank failure probability (%)	0.66	0.66
η	Loan origination cost	0.22	Voluntary capital buffer (%)	5.1	4.8
ζ_1	Ent. entry cost (level)	5.78	Avg. lending rates (%)	3.0	3.0
ζ_2	Ent. entry cost (power)	0.50	Response of new lending (%)	-0.38	-0.37
$\bar{\pi}$	Fixed operating cost	0.012	Non-interest expenses to assets (%)	0.34	0.22
χ	Bank's exit rate (pp)	2.00	Slope of log-log asset distribution	-1.56	-1.56

Credit risk process

- Vasicek credit risk model (Basel IRB foundation):

$$F_j(\omega) = \Phi \left(\frac{\sqrt{1-\rho} \Phi^{-1}(\omega) - \Phi^{-1}(p)}{\sqrt{\rho}} \right)$$

Default rate: $p = 2.65\%$;

loan correlation $\rho = 0.51$: targets dispersion in bank failure risk.

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- **Loan origination costs**

$$f\left(\frac{N_{jt}}{L_{jt}}\right) = \eta \left(\frac{N_{jt}}{L_{jt}}\right)^2 \quad \text{with } \eta > 0$$

η targets average voluntary capital buffer (target: 5.1%).

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- Entrepreneur entry cost: Rising and convex in credit volume

$$a(N_t) = \zeta_1 N_t^{\zeta_2} \quad \text{with } \zeta_1, \zeta_2 > 0$$

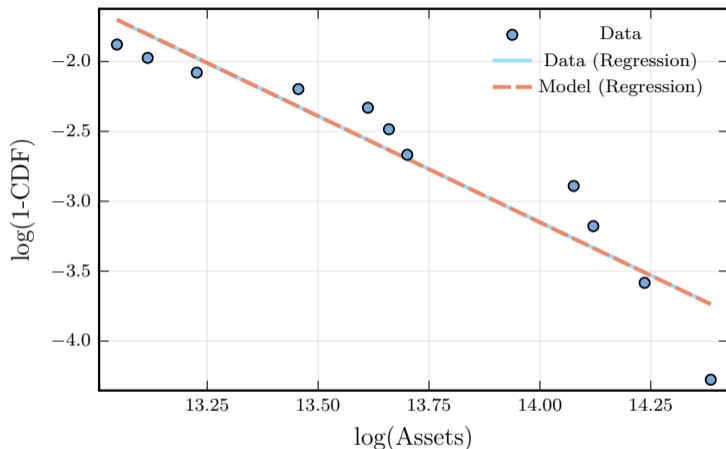
Level (ζ_1) targets average lending rates (3%).

Curvature ($\zeta_2 = 0.50$) governs responsiveness of lending to policy.

matches semi-elasticity of new lending: -0.38 for 100bp shock.

Quantitative results

Steady-state. Asset size distribution



- The model's steady-state distribution of assets follows a Power Law
⇒ Common empirical feature in the banking (Janicki and Prescott, 2006, Bremus et al. 2018)

Steady-state. Distribution of capital ratios

Table 1: Bank capital ratios: Data vs. Model

	All Banks	Large Banks	Model
1st Percentile	9.36	9.68	9.71
5th Percentile	11.22	10.91	11.10
10th Percentile	11.68	11.28	11.66
20th Percentile	12.31	11.67	12.18
30th Percentile	13.03	12.00	12.46
40th Percentile	13.54	12.41	12.65
Avg. Top 50%	18.71	14.73	13.13

- The model reproduces the left tail of the CR distribution well
⇒ banks near the constraints are more sensitive to equity losses

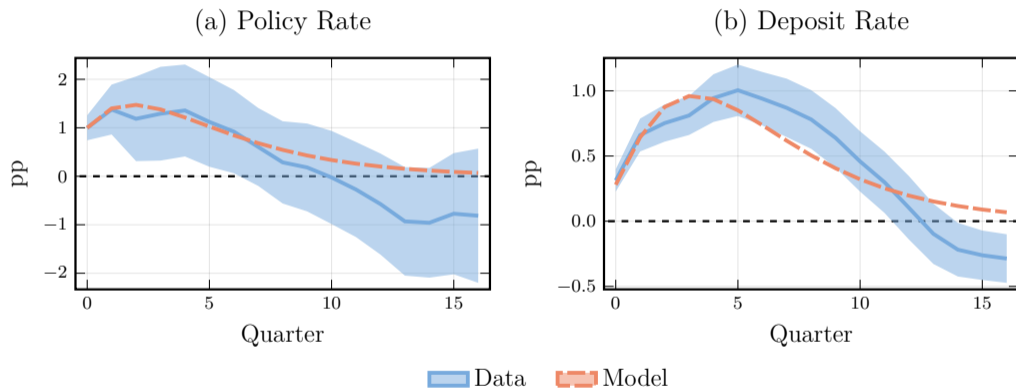
Dynamics. Model Simulations

MIT shock: Responses to a monetary tightening $\Delta^+ r^M$ (100 bps)

1. Aggregate responses: Model vs data IRFs.
2. Cross-sectional responses.
3. Turning off heterogeneity.

Targeted IRFs

Figure 1: Targeted impulse responses



solid blue lines: empirical impulse responses to a monetary policy shock

dashed red lines: sequences fed to the model

Heterogeneity in responses to monetary shocks

- Panel Local Projections with country fixed effects (Jordà, 2015)

$$y_{c,t+h}^{\ell} = \alpha_{c,h} + \beta_{1,h} \varepsilon_t^{MP} + \beta_{2,h} \left[\varepsilon_t^{MP} \times I_c^{FR} \right] + \Gamma_h X_{c,t}(L) + e_{c,t+h}$$

ε_t^{MP} : Δ ECB deposits facility rate instrumented (Jarocinski and Karadi, 2020)

I_c^{FR} : 1 if country c operates with fixed-rate pricing

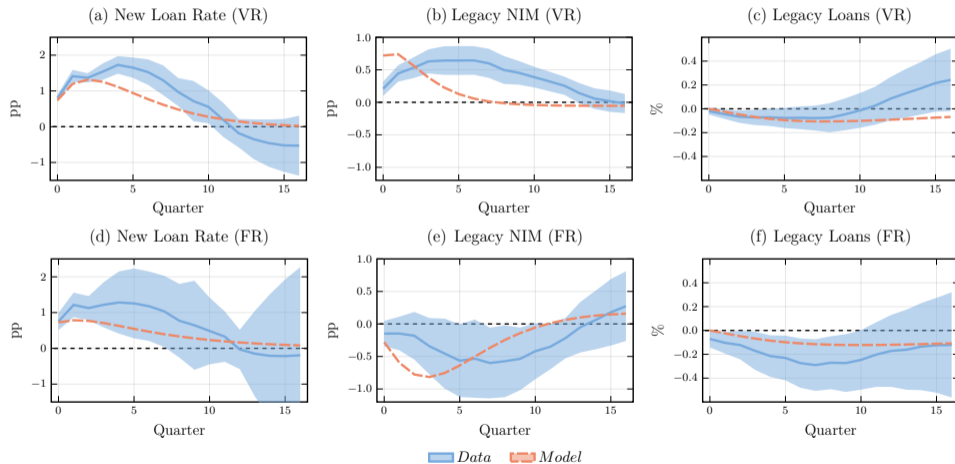
$X_{c,t}$: GDP growth, inflation, BBB corporate yield, 1y DE bond yield.

- Recover responses across FR and VR economies

$$\begin{aligned} \{\beta_{1,h}\}_{h=0}^{16Q} &\Rightarrow \text{avg impact on variable-raters} \\ \{\beta_{1,h} + \beta_{2,h}\}_{h=0}^{16Q} &\Rightarrow \text{avg impact on fixed-raters} \end{aligned}$$

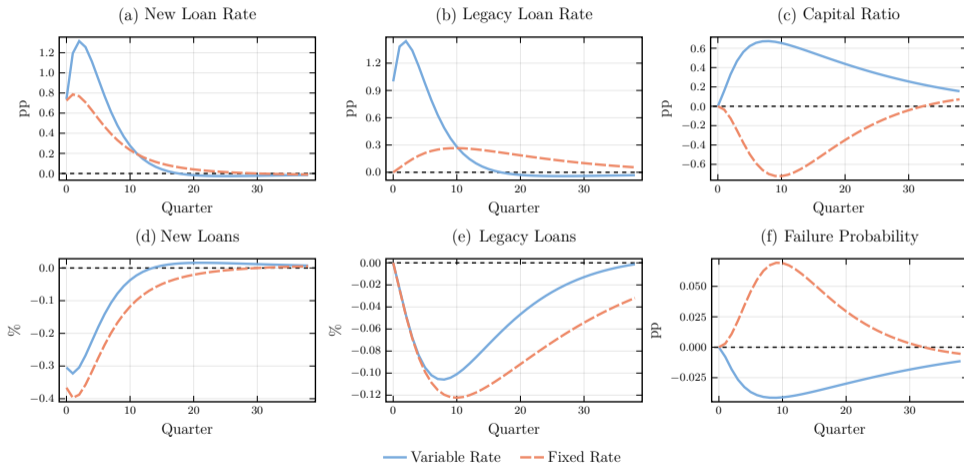
Untargeted IRFs to a monetary tightening

Figure 2: Untargeted impulse responses



Ex-ante heterogeneity matters for monetary transmission

Figure 3: Aggregate impulse response functions



⇒ Amplification Panel d: Model predicts that new lending response is about 1/3 stronger in FR economies

Fixed-rate vs. Variable-rate banks: key differences

Variable-rate (VR) banks:

- Loan rates adjust quickly → NIM improves after rate hike
- Higher profitability → rising equity & capital ratios
- Lending expands & bank stability improves

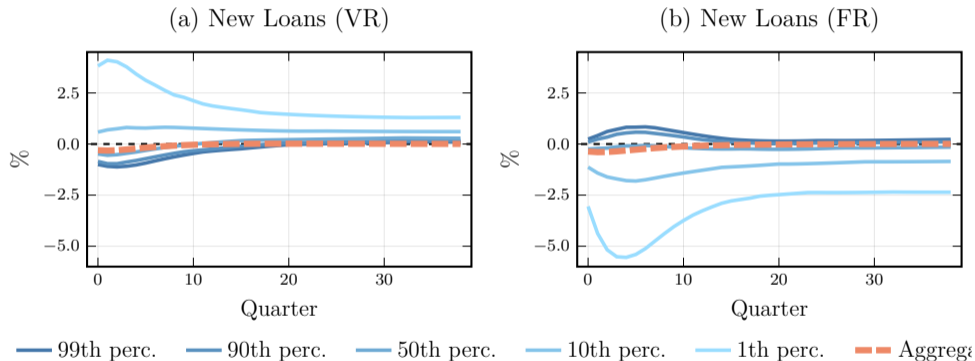
Fixed-rate (FR) banks:

- Income on legacy loans remains fixed → NIM compresses
- Funding costs rise → equity erosion & capital deterioration
- Lending contracts sharply, failure risk increases

Conclusion: Loan rate fixation patterns shape both the strength of the lending channel and financial stability outcomes

The cross-sectional mechanism

Figure 4: Individual impulse response functions



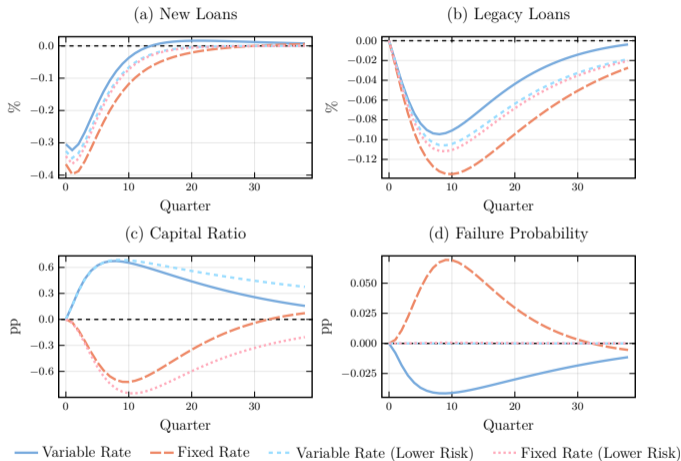
Note: Dashed red lines show the aggregate impulse response. The lightest shade corresponds to the 1st percentile (banks closest to the regulatory constraint in the steady state); darker shades correspond to higher percentiles.

The cross-sectional mechanism

- Why do VR and FR banks respond differently?
- **Proximity to regulatory constraints:** Banks closer to the capital requirement act more cautiously to avoid violating the constraint and being liquidated.
- **Interacting with interest-rate risk:**
 - **Variable-rate (VR):** Rate hikes expand margins and build equity. This moves constrained banks away from the liquidation threshold, freeing them to lend
 - **Fixed-rate (FR):** Rate hikes compress margins and erode equity. Banks already near the constraint must severely cut lending to survive

vs. No Ex-post heterogeneity

Figure 5: Impulse response functions — Lower idiosyncratic risk



Note: “Variable Rate (Lower Risk)” and “Fixed Rate (Lower Risk)” correspond to alternative parameterizations with $\rho = 0.1$ (versus $\rho = 0.51$ in the baseline).

Ex-ante vs. ex-post heterogeneity: role of idiosyncratic risk

- Ex-ante heterogeneity (e.g., VR vs. FR) matters **only if** banks face ex-post risk
- Without idiosyncratic shocks:
 - Capital ratios still diverge (due to NIM dynamics)
 - But no bank fails → lending depends only on marginal profitability
- Heterogeneity in capital constraints disappears when risk is muted

Conclusion: Ex-ante heterogeneity amplifies responses *only* because ex-post heterogeneity pushes some banks close to their constraints

Policy implications and robustness

- **Macroprudential policy interactions** Appendix
 - Releasing Countercyclical Capital Buffers (CCyB) during tightening relieves constrained banks, narrowing the FR/VR credit contraction gap
- **Monetary policy gradualism** Appendix
 - More gradual implementation of policy rate hikes allows for more gradual deleveraging, substantially reducing bank failure rates in FR economies
- **Robustness: Endogenous borrower credit risk** Appendix
 - Extending the model to allow borrower default to rise in VR economies when rates hike does not overturn the main results for moderate shocks

Conclusion

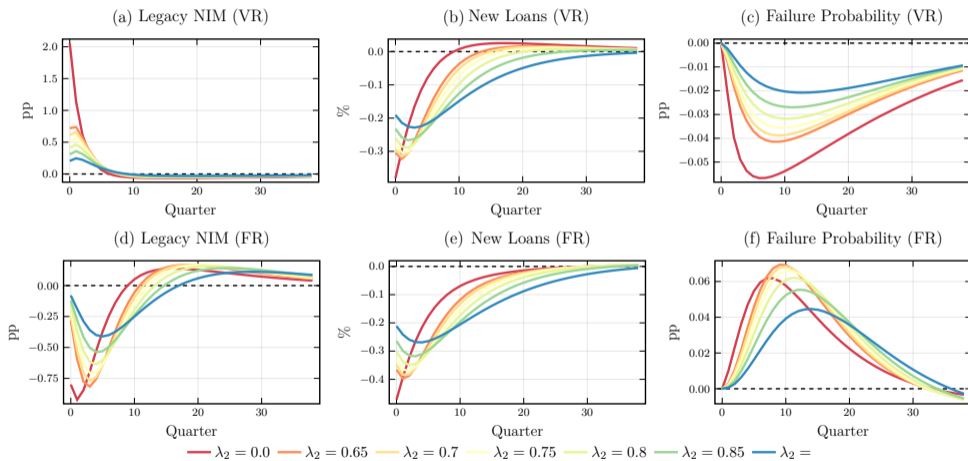
Concluding remarks

- Heterogeneous-banks quantitative macro model with
 - Ex-post heterogeneity in capital ratios
 - Ex-ante heterogeneity in loan-rate fixation: fixed vs. variable rates
- Aggregate and individual IRFs to monetary policy shocks depend on bank characteristics
 - Stronger contraction in credit for banks with...
 - Fixed-rate loans
 - Lower capital ratios
 - Also: implications for financial stability
- Sources of heterogeneity interact: Without heterogeneity in leverage, heterogeneity in loan pricing becomes irrelevant

Appendix

Monetary policy gradualism

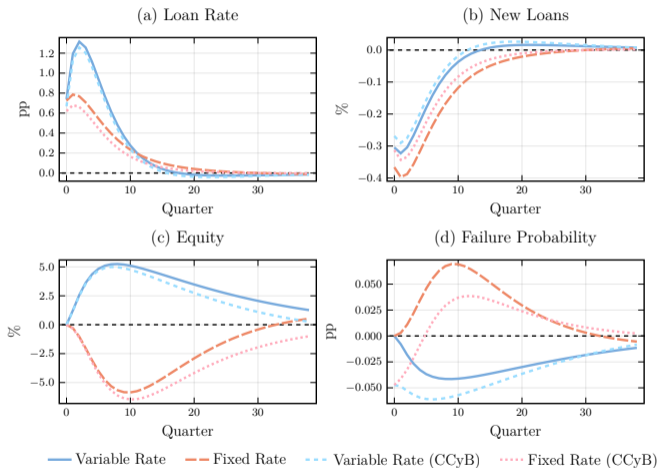
Figure 6: Effects of gradualism



Note: Panels a and b show the response of the legacy NIM; panels c and d show the response of new loans; panels e and (f) show failure probabilities. Left panels correspond to VR economies; right panels correspond to FR economies. Colors from red to blue correspond to increasing degrees of gradualism, captured by $\mu_2 \in \{0.0, 0.65, 0.7, 0.75, 0.85, 0.9\}$. Red corresponds to an AR(1) process ($\mu_2 = 0$); blue corresponds to the most gradual AR(2) process.

Macprudential policy interactions

Figure 7: Impulse response functions — Interest rate increase + CCyB release

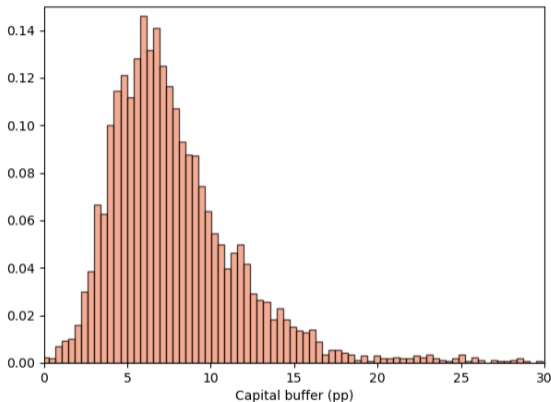


Robustness: Endogenous borrower default

- In VR economies, rate hikes pass directly to borrowers, potentially increasing their default risk and feeding back onto bank balance sheets
- In an extension, we allow the borrower's default probability to increase with the loan rate
 - Borrower default increases in the VR economy following a rate hike, dampening the positive effect on bank equity
 - However, for small to moderate monetary policy shocks, the direct effect of NIM expansion dominates
 - The result that VR economies experience a milder credit contraction than FR economies remains robust

Heterogeneity in bank leverage: capital buffers

CET1 capital buffer distribution across European banks



- Most European banks hold capital buffers around 6pp.
- 1/7 banks hold capital buffers greater than 10pp.

Bank liabilities

Retail deposits (D_{jt}): short-term insured liabilities

- Pay a deposit rate $r_t^D < r_t^M$
- Imperfect policy rate pass-through (sticky deposit rates/deposit beta < 1)
- Deposit base is linked to size of the overall portfolio: $D_{jt} \leq \alpha L_{jt}$
 - Deposit funding cannot be scaled up quickly
 - Deposit rates affect average funding cost, but not the marginal cost of new loans

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Wholesale debt (B_{jt}): short-term uninsured liabilities

- Perfect policy rate pass-through ($r_t^B = r_t^M$)
- r_t^B is the relevant marginal cost of new lending

Recursive Problem

The Recursive Problem of the Bank

$$V_t^B(L_{jt}, E_{jt}, x_{jt}^L) = \mathbf{1}_{\{E_{jt} \geq \gamma L_{jt}\}} \left[\max_{\{N_{jt}, M_{jt}, D_{jt}, B_{jt}\}} \beta \int_0^{\bar{\omega}_{jt+1}} [(1 - \chi)V_{t+1}^B(L_{jt+1}, E_{jt+1}, x_{jt+1}^L) + \chi E_{jt+1}] dF(\omega_{jt+1}) \right]$$

$$\text{s.t. } B_{jt} = L_{jt} + N_{jt} + M_{jt} - D_{jt} - E_{jt}, \quad (\text{Balance sheet identity})$$

$$D_{jt} \leq \alpha L_{jt}, \quad (\text{Deposits constraint})$$

$$L_{jt+1} = (1 - \omega_{jt+1})(1 - \delta)(L_{jt} + N_{jt}), \quad (\text{Loan LOM})$$

$$E_{jt+1} = E_{jt} + (1 - \tau)\Pi_{jt+1}, \quad (\text{Equity LOM})$$

$$E_{jt} \geq \gamma(L_{jt} + N_{jt}), \quad (\text{Capital requirement})$$

$$M_{jt} \geq \theta(D_{jt} + B_{jt}), \quad (\text{Reserve requirement})$$

Pre-set parameters

	Parameter	Value	Target/Source
ρ	Loan default rate, mean (%)	2.65	Mendicino et al. (2020)
λ	Loan loss-given-default	0.30	Mendicino et al. (2020)
δ	Loan maturity	0.20	Cortina et al. (2018)
τ	Corporate tax rate	0.20	Damodaran database.
γ	Min. capital requirement (%)	7.0	Basel III CET1 + Buffer requirement.
α	Deposits-to-loans ratio	0.78	Consolidated EA banks balance sheet.
θ	Liquidity requirement (%)	11.8	Liquid asset to total deposit ratio.
r^M	Steady-state policy rate (pp)	1.0	Avg. EA deposit facility rate, 1999-2019.
r^D	Steady-state deposit rate (pp)	0.5	Avg. EA overnight deposit rate, 2003-2023.

◀ calibration

Calibrated parameters

	Parameter	Value	Target	Data	Model
β	Subjective discount factor	0.933	Banks' return on equity (%)	6.4	6.4
ρ	Loan default correlation	0.51	Bank failure probability (%)	0.66	0.66
η	Loan origination cost	0.22	Voluntary capital buffer (%)	5.1	4.8
ζ_1	Ent. entry cost (level)	5.78	Avg. lending rates (%)	3.0	3.0
ζ_2	Ent. entry cost (power)	0.50	Response of new lending (%)	-0.38	-0.37
$\bar{\pi}$	Fixed operating cost	0.012	Non-interest expenses to assets (%)	0.34	0.22
χ	Bank's exit rate (pp)	2.00	Slope of log-log asset distribution	-1.56	-1.56

◀ calibration

Balance sheet ratios

Table 2: Consolidated bank balance sheet: euro area 2013–2023 vs. model

Assets			Liabilities		
	Model	Data		Model	Data
Loans	88%	89%	Deposits	81%	78%
ST securities and reserves	12%	11%	Wholesale funding	9%	14%
			Equity capital	10%	8%

Source: European Central Bank, Statistical Data Warehouse (SDW). *Note:* The composition is expressed as percentages of total assets. Model counterparts in steady-state. Data corresponds to the consolidated balance sheet of euro area Monetary Financial Institutions (MFIs), excluding the Eurosystem, reported by the European Central Bank. *Loans* include loans to the private sector, to the general government, and other risky assets. *ST securities and reserves* include short-term securities holdings, operations with national central banks (repos and securities lending), and other short-term external assets. *Deposits* include retail deposits of different maturities, external and other liabilities. *Wholesale funding* corresponds to debt securities issued. *Equity capital* comprises capital and reserves.