HBANK:
Monetary Policy with Heterogeneous Banks

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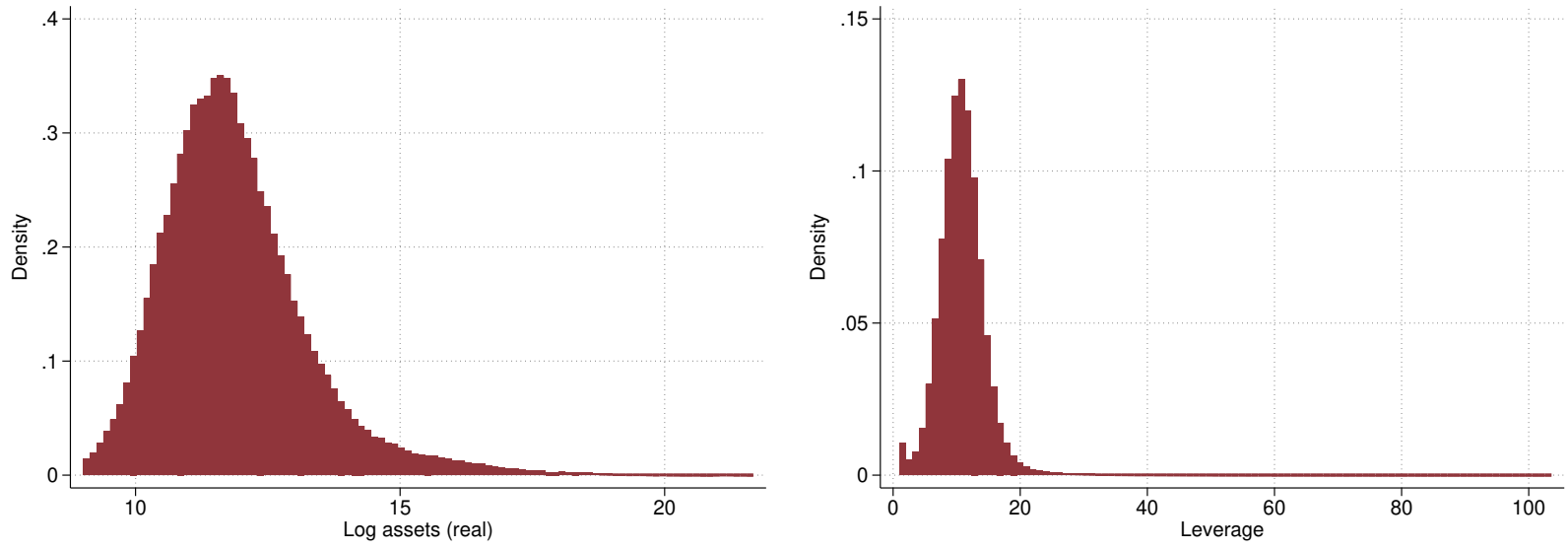
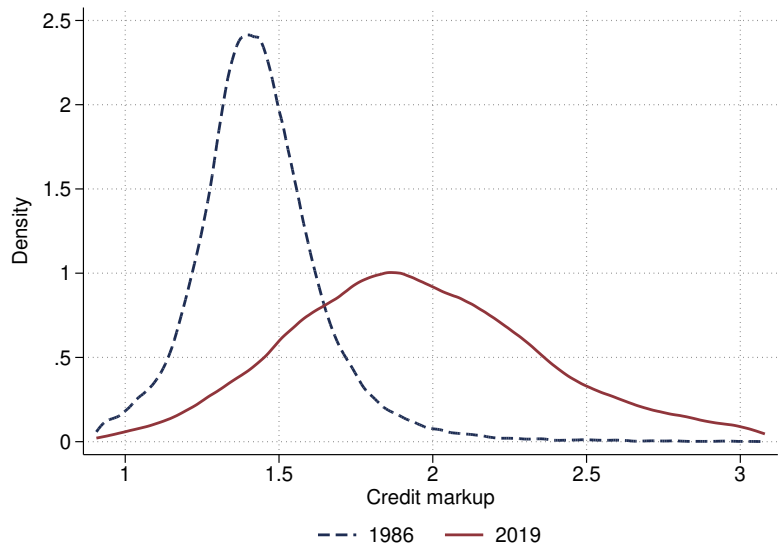
July 22, 2022

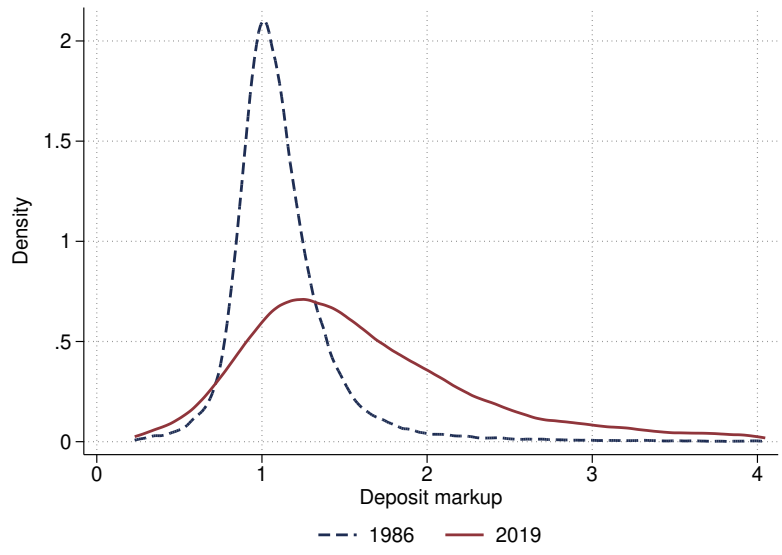
Cross Section of Bank Assets and Leverage



- Distributions of (log) **assets** and bank **leverage** are right-skewed

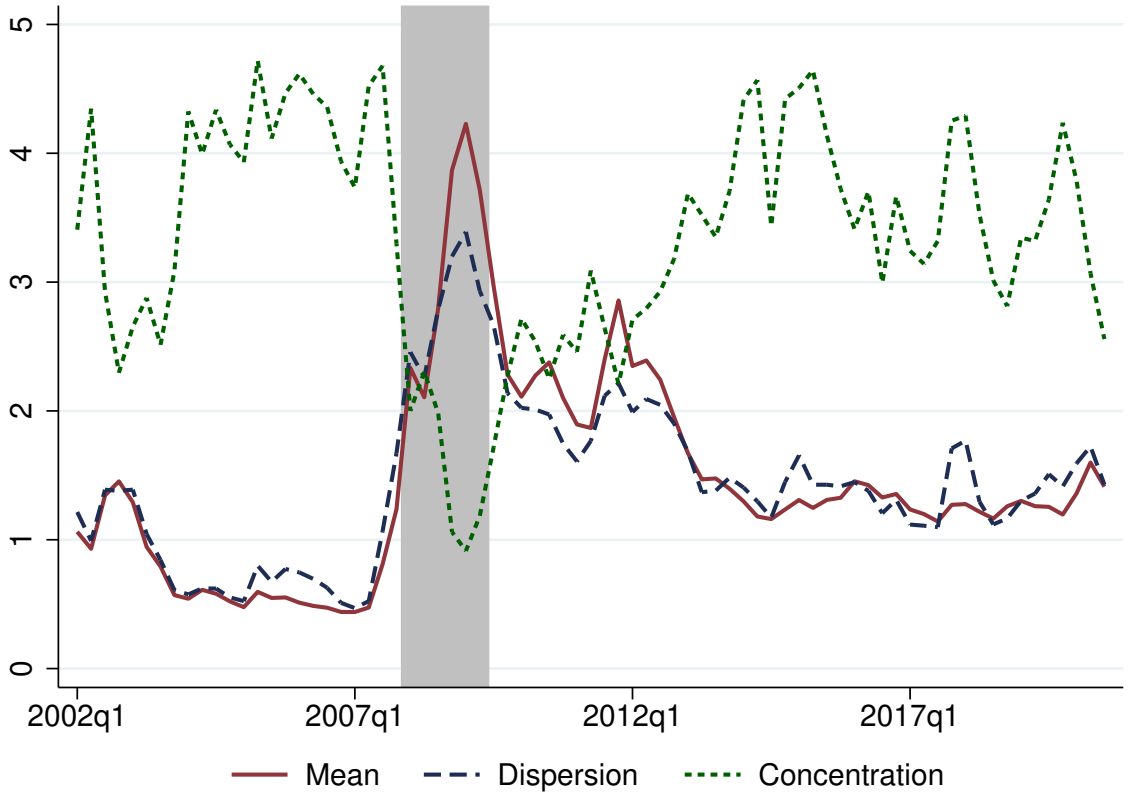
Market Power





- Rising trend in credit and deposit mark-ups
- More dispersed distributions

Default Risk



I Mean, dispersion $\Rightarrow$ counter-cyclical

II Concentration (skewness) $\Rightarrow$ pro-cyclical (more negatively skewed)

Heterogeneity and market power in banking

I. Large degree of cross-sectional heterogeneity.
   - The distribution of bank leverage, assets and default probability features high dispersion and right-skewness

II. Significant degree of market power on both asset and liability sides

III. Increasing over time and with more dispersion

IV. Moments of banking distribution are time-varying

THIS PAPER

- Role of bank heterogeneity and two-sided market power for the transmission of monetary policy
- Unconditional and conditional evidence from disaggregated data
- HBANK model with:
  - I Permanent vs stochastic bank returns heterogeneity
  - II Incomplete insurance
  - III Endogenous & heterogeneous two-sided market power
  - IV Bank default & deposit insurance
  - V Nominal rigidities

This Paper: Empirics

- Bottom-up estimates of credit and deposit mark-ups
- Document $\Uparrow$ trend in mean, dispersion and concentration of credit and deposit mark-ups
- Trilateral correlation:
  - I Credit & deposit mark-ups
  - II Balance sheet size
  - III Profitability

  $\Rightarrow$ Positively correlated
- Conditional response of credit and deposit mark-ups to MP shocks. After tightening:
  - I Average credit mark-up $\Downarrow$ (*conditionally* pro-cyclical)
  - II Average deposit mark-up $\Uparrow$ (*conditionally* counter-cyclical)
  - III Credit mark-up more responsive for *big* banks
  - IV Deposit mark-up more responsive for *small* banks

This Paper: Model

- Transmission of monetary policy in HBANK
  - I Permanent vs stochastic bank returns heterogeneity
  - II Endogenous & heterogeneous two-sided market power
  - III Endogenous bank default & deposit insurance
  - IV Price rigidities
- Sizeable amplification of monetary policy shocks
  - Returns heterogeneity
  - Credit market power
- Deposit market power dampens effects of MP shocks
- Rich heterogeneity in the response of different banks
  - Market power-size interaction $\Rightarrow$ driver of monetary transmission
- Match conditional and unconditional banking moments in the data
  - Cross-sectional relationships
  - Aggregate and cross-sectional responses to monetary shocks

Related Literature

Four main strands:

I Aggregate effects of bank market power: Corbae and D'Erasmo (2021), Jamilov and Monacelli (2021), Wang et al. (2020), Whited et al. (2021), Drechsler et al. (2017,2021), Egan et al. (2017), Gerali et al. (2010)

II Bank heterogeneity: Coimbra and Rey (2019), Begenau and Landvoigt (2022), Bianchi and Bigio (2022), Rios Rull et al. (2020)

III Macro-banking: Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Brunnermeier and Sannikov (2014), He and Krishnamurthy (2013), Jermann and Quadrini (2013), Nuno and Thomas (2016), Gertler et al. (2016, 2020), Brunnermeier and Pedersen (2009), Adrian and Shin (2010), Adrian and Boyarchenko (2015), Begenau et al. (2021)

IV Monetary policy with heterogeneity and/or financial frictions: Kaplan et al. (2018), Lee at al. (2020), Bigio and Sannikov (2021), Baqaee et al (2021), Ottonello and Winberry (2020), Kaplan et al. (2020)

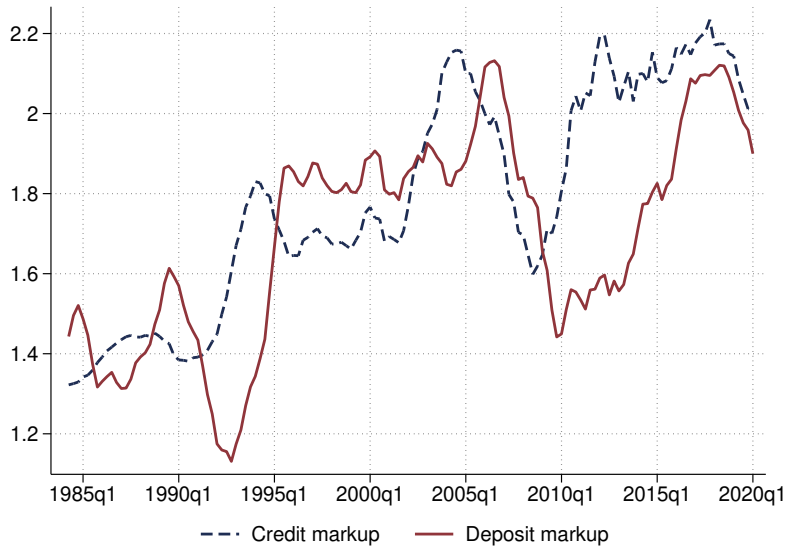
Empirics

Data

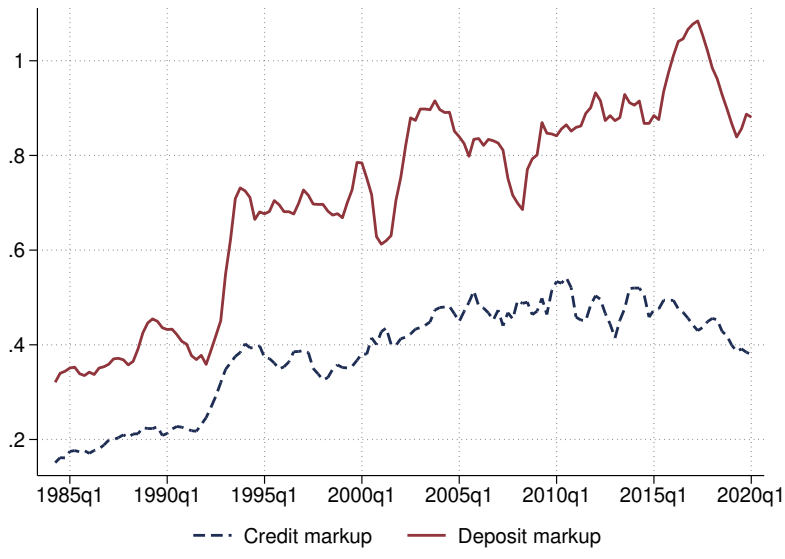
- Call Reports:
  - Quarterly, 1985q1-2020q1
  - All U.S. FDIC-insured banks
  - Income statement and balance sheet data
- Book leverage: $\frac{\text{Assets}}{\text{Net Worth}}$
- **Credit** mark-up: $\frac{\text{Price of loans}}{\text{MC of loans}}$ ▸ Estimation
- **Deposit** mark-up: $\frac{\text{Safe return on funds}}{\text{MC of deposits}}$ ▸ Estimation
- Credit (deposit) mark-ups $\Rightarrow$ asset (deposit) weighted
- Weighting and quintile ranking $\Rightarrow$ average holdings over the last 4 quarters
- Interpolate at monthly frequency
  - Results unchanged if we use original quarterly data

Credit and Deposit Market Power over Time

(A) Mean

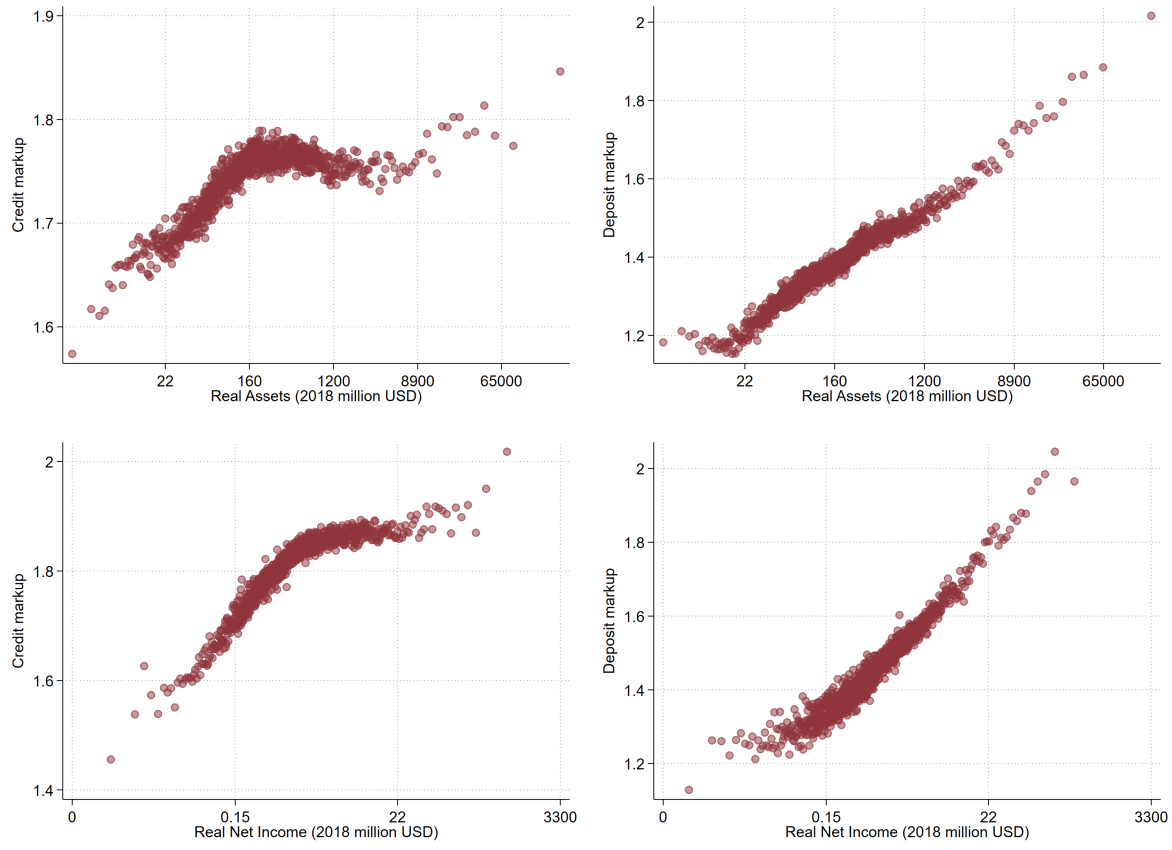


(B) Standard deviation



- Average credit and deposit mark-up ⇑
  - Average deposit *spread* ⇓ (Drechsler et al. (2017))
- Dispersion of credit and deposit mark-ups ⇑

Credit and Deposit Market Power in the Cross-Section



- Larger banks $\Rightarrow$ larger **credit** (left) and **deposit** (right) mark-ups
- More profitable banks $\Rightarrow$ larger credit and deposit mark-ups
- $\Rightarrow$ Trilateral positive correlation: credit & deposit market power, assets, profits

Proxy-SVAR Estimation

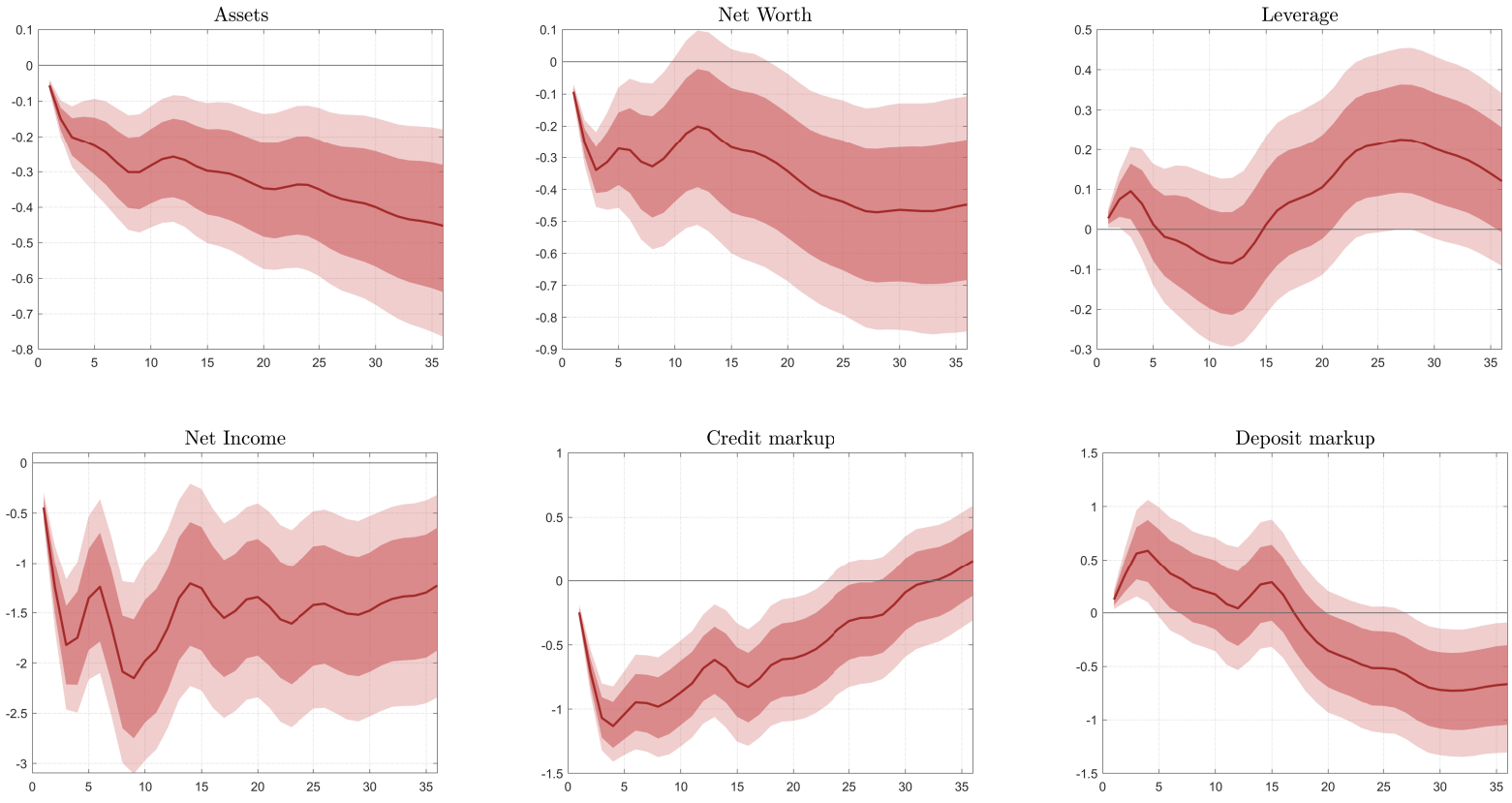
- Instrument for **MP shocks**: change in the 3-month ahead Fed Funds futures around FOMC announcements
  - Robust to controlling for information content as in Jarociński and Karadi (2020)
- Reduced-form VAR:

$$X_t = \mu + \sum_{j=1}^{12} A_j X_{t-j} + u_t$$

- X_t includes:
  I. Fed Funds rate
  II. CPI
  III. Industrial production index
  IV. S&P 500 index monthly return
  V. Selected banking variable

Monetary Contraction: Aggregate Response

▶ Macro ▶ F-Stat

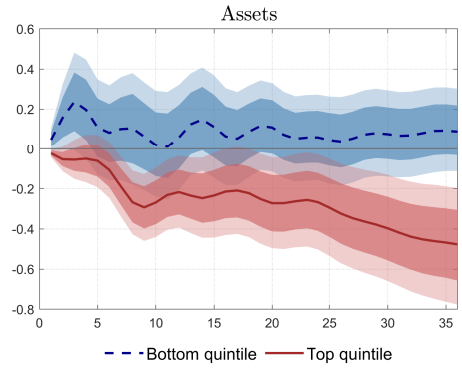


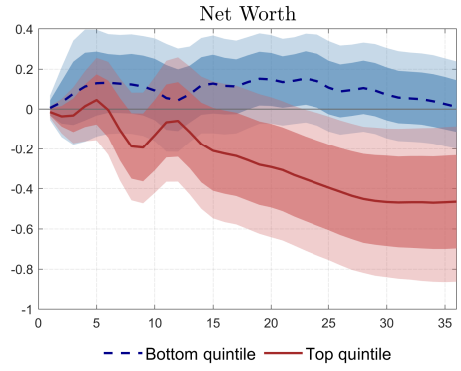
- **Bank balance sheet** channel : total assets, net worth, net income ⇓
- Average credit mark-up ⇓
- Average deposit mark-up ⇑

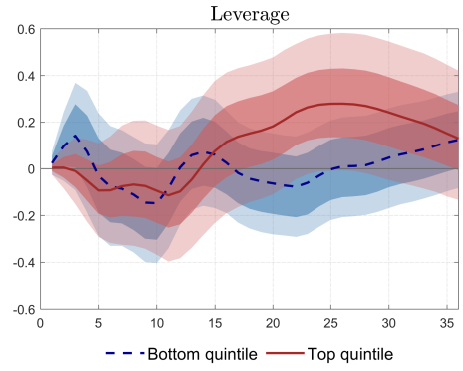
} **Bank market power** channel: imperfect pass-through

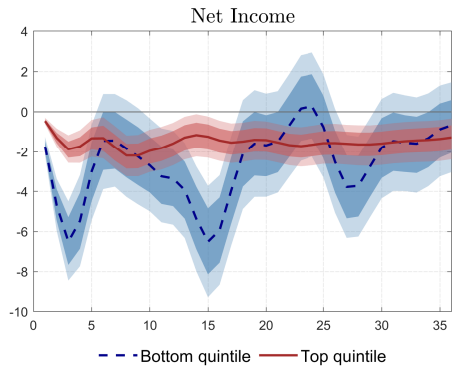
Monetary Contraction: Cross-Section

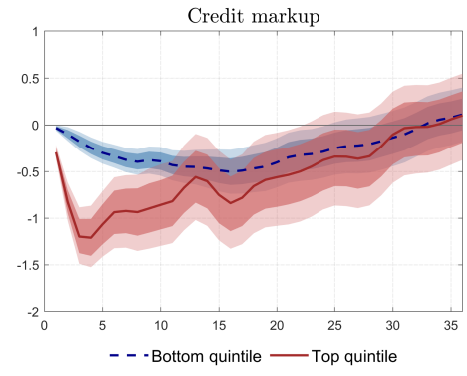
▶ Rob. ▶ Mom.

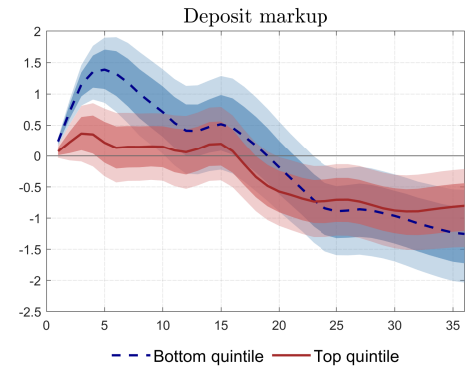












- Large banks shrink size relatively more ⇒ larger Marginal Propensity to Lend
- Large banks ⇒ larger credit mark-up elasticity
- Small banks ⇒ larger deposit mark-up elasticity

Model

Overview

- Agents: representative household, banks, capital good producer, intermediate good producers, final good producer
- Banks:
  - Continuum of banks $j \in [0, 1]$
  - Demand deposits from households d_j
  - Supply equity-type claims to capital producers k_j
- Deposits:
  - Provide liquidity services to households
  - Imperfect substitutes across banks j

  $\Rightarrow$ Endogenous & heterogeneous **deposit mark-up**
- Equity claims:
  - Imperfect substitutes across banks j

  $\Rightarrow$ endogenous & heterogeneous **credit mark-ups** and **MPL**
- New Keynesian block

HOUSEHOLD

- Utility from consumption and liquidity services from deposits:

$$U(C_t, B_t) = \frac{C_t^{1-\psi}}{1-\psi} + \frac{B_t^{1-\nu}}{1-\nu}$$

- Deposit imperfect substitutes across banks $j \Rightarrow$ aggregate deposit supply:

$$\int_0^1 \Upsilon\left(\frac{b_{j,t}}{B_t}\right) dj = 1$$ ▸ Specific.

- Can invest in mutual fund M_t or in deposits $b_{j,t} \Rightarrow$ budget constraint:

$$C_t + \int_0^1 b_{j,t} dj + M_t \leq R_t M_{t-1} + \int_0^1 R_{j,t}^b b_{j,t-1} + W_t + \text{Div}_t + T_t$$

  - R_t risk-free rate
  - $R_{j,t}^b$ deposit rate

Deposit Mark-ups

- FOC for deposits:

$$R^b_{j,t+1} = R_{t+1}\left(1 - \underbrace{\left[\frac{C_t^{\psi}}{B_t^{\nu}} \frac{\Upsilon'\left(\frac{b_{j,t}}{B_t}\right)}{\int_0^1 \Upsilon'\left(\frac{b_{j,t}}{B_t}\right)\frac{b_{j,t}}{B_t}dj}\right]}_{\text{deposit spread} \geq 0}\right)$$

- $\Upsilon(\cdot)$ convex $\Rightarrow$ deposit spread increasing in relative size $\frac{b_{j,t}}{B_t}$
- Deposit mark-up:

$$\mu^b_{j,t} = \frac{R_{t+1}}{R^b_{j,t+1}} \geq 1$$

- Two channels affect $\mu^b_{j,t}$:
  - I Real rigidity channel
  - II Liquidity preference channel

Capital Producers

- Require bank financing in the form of equity-type claims
- Aggregate capital:

$$\int_0^1 \Phi\left(\frac{k_{j,t}}{K_t}\right) dj = 1$$

▸ Specific.

- Capital producers solve:

$$\max_{k_{j,t}} \left[Q_t K_t - \int_0^1 q_{j,t} k_{j,t} dj \right] \text{ s.t. technology}$$

- Inverse demand function for assets:

$$\frac{q_{j,t}}{Q_t} \mathcal{A}_t^k = \Phi'\left(\frac{k_{j,t}}{K_t}\right)$$

  - $Q_t = \int_0^1 q_{j,t} \frac{k_{j,t}}{K_t} dj$ aggregate price index
  - $\mathcal{A}_t^k := \int_0^1 \Phi'\left(\frac{k_{j,t}}{K_t}\right) \frac{k_{j,t}}{K_t} dj$

BANKS

- Intermediate funds between households and capital producers $\Rightarrow$ balance sheet:

$$d_{j,t} + n_{j,t} = k_{j,t}$$

- Law of motion of net worth:

$$n_{j,t+1} = R^T_{j,t+1} q_{j,t} k_{j,t} - R^b_{j,t+1} d_{j,t} - \underbrace{\zeta_1 k^{\zeta_2}_{j,t}}_{\text{Non-int. cost}}$$

- $\zeta_2 \Rightarrow$ non-linearity and scale-variance
- Incomplete financial markets $\Rightarrow$ bank-specific total return on assets $R^T_{j,t}$

$$R^T_{j,t} = \underbrace{\eta_j}_{\text{permanent}} + \underbrace{\rho_\xi \xi_{j,t-1} + \sigma_\xi \epsilon_{j,t}}_{\text{stochastic}}$$

- Permanent (skill) vs stochastic (luck) heterogeneity in returns
- Involountary exit with probability $1 - \sigma$

BANKS (CONT'D)

- Moral hazard friction$\Rightarrow$ bank can divert up to λ of assets
- No sanction for diversion, but default in next period
- In equilibrium indifference between diverting or not $\Rightarrow$ incentive constraint:

$$\lambda q_{j,t} k_{j,t} \leq V_{j,t}$$

- Bank-specific leverage constraint $\Rightarrow$ non-linearities
- Banks default with probability:

$$s_{j,t} = \Pr\left(n_{j,t+1} \leq 0\right)$$

- After default, households recover fraction $x_{j,t} \leq 1$ of promised payments
- Deposit insurance:
  - Ex-ante households perceive $s_j = 0 \; \forall j$
  - Banks can still default ex-post $\Rightarrow$ disconnect between insolvency risk and deposit prices

BANKS (CONT'D)

- Bank's dynamic problem (*drop index j*):

$$\max_{\{k_t, q_t, d_t, R_t^b\}} V_t(n_t, \eta_t, \xi_t) = \mathbb{E}_t \left[\Lambda_{t+1} \left((1-\sigma) n_{t+1} + \sigma V_{t+1} \right) \right]$$

subject to:

$$n_{t+1} = R_{t+1}^T q_t k_t - R_{t+1}^b d_t - \zeta_1 k_t^{\zeta_2}$$

$$d_t + n_t = k_t$$

$$R_{t+1}^T = \eta + \xi_{t+1}$$

$$\lambda q_t k_t \leq V_t$$

$$R_t^b = R_t \left(1 - \left[\frac{C_t^\psi}{B_t^\nu} \frac{\Upsilon' \left(\frac{b_t}{B_t} \right)}{\mathcal{A}_t^b} \right] \right)$$

$$\frac{q_t}{Q_t} \mathcal{A}_t^k = \Phi' \left(\frac{k_t}{K_t} \right)$$

- Internalize monopolistic two-sided market power

Credit Mark-ups

- Lerner-type decomposition of the price of assets

$$q_{j,t} = \underbrace{\frac{\sigma_{j,t}}{\sigma_{j,t}-1}}_{\substack{\text{credit mark-up} \\ \mu^k_{j,t}}} \underbrace{\frac{R^b_{j,t} + \zeta_1\zeta_2 k_j^{\zeta_2 - 1}}{R^T_{j,t+1}}}_{\substack{\text{marginal cost} \\ mc_{j,t}}}$$

- $\sigma_{j,t}$: heterogeneous & endogenous credit demand elasticity
- Three components of **marginal cost**:
  - I Cost of deposit financing $R^b_{j,t}$
  - II Non-interest cost of balance sheet expansion $\zeta_1\zeta_2 k_j^{\zeta_2 - 1}$
  - III Heterogeneous return $R^T_{j,t}$

Marginal Propensity to Lend

- Elasticity of bank j credit supply to marginal costs $\Rightarrow$ MPL$_j := \frac{\partial k_j}{\partial mc_j}$
- MPL is increasing in total returns:

$$\frac{\partial k_j}{\partial log\, R_j^T} = \underbrace{-\sigma_j \frac{k_j}{mc_j} \frac{1}{1+\Omega_j}}_{MPL_j} \left(-\frac{1}{R_j^T}\right) > 0$$

- $\Rightarrow$ More profitable banks have larger MPL
- Permanent profitability η_j matters
- Highly profitable banks raise the aggregate credit supply elasticity in the economy

New Keynesian Block

- Final good producer:
  - Aggregates differentiated good produced by retailers according to:

$$\Upsilon_t = \left(\int_0^1 y_{i,t}^{\frac{\gamma-1}{\gamma}} di \right)^{\frac{\gamma}{\gamma-1}}$$

  - Demand for variety i: $y_{i,t} = \left(\frac{p_{i,t}}{P_t} \right)^{-\gamma} \Upsilon_t$
- Continuum of retailers $i \in [0,1]$:
  - Produce intermediate goods according to $y_{i,t} = A_t K_{i,t}^{\alpha} L_{i,t}^{1-\alpha}$
  - Set relative price $p_{i,t}$ paying quadratic adjustment cost $\frac{\varphi}{2} \left(\frac{p_{i,t}}{p_{i,t-1}} - 1 \right)^2 \Upsilon_t$
- Phillips curve:

$$log\,\Pi_t = \frac{\gamma - 1}{\varphi} (logMC_t - logMC^*) + E_t \left[\Lambda_{t+1} log\,\Pi_{t+1} \right]$$

- Monetary authority:

$$i_t = \bar{R} + \phi_\pi \Pi_t + \epsilon_{m,t}$$

Equilibrium

▸ Numerical Algorithm

- Banker's idiosyncratic state vector: $\mathbf{s} = \{n, \eta, \xi\}$
- Banker's aggregate state vector: $\mathbf{S} = \{\Lambda, K, B, \Pi\}$
- A stationary equilibrium is a set of aggregate $\{w, R\}$ and bank-level prices $\{q_j, R_j^b\}$ such that:
  - A Given prices policy functions of the bankers and households solve their respective decision problems
  - B Aggregates are consistent with stationary distributions
  - C All markets clear
- Fully non-linear model solution
- Compute transitional dynamics to unexpected "MIT" monetary policy shocks

Calibration

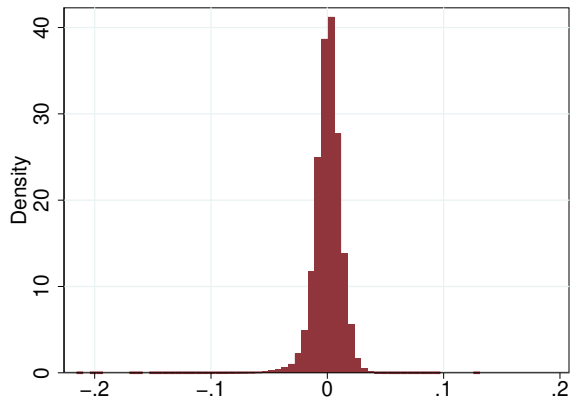
Taking the Model to the Data

▸ Calibration

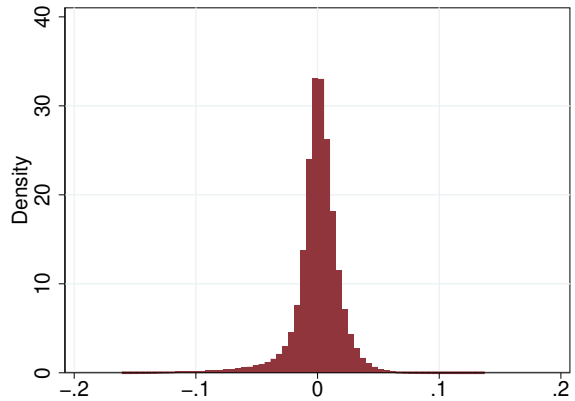
- Returns heterogeneity:

$$R^T_{j,t} = \eta_j + \xi_{j,t}$$
$$\xi_{j,t} = \rho_\xi \xi_{j,t-1} + \sigma_\xi \epsilon_{j,t}$$

  - Call Report data $\Rightarrow$ return on equity: $\frac{\text{Net Income}}{\text{Equity}}$
  - Baltagi and Wu (1999) linear panel FEs with AR(1) disturbances on de-meaned series



(A) Permanent, η_j

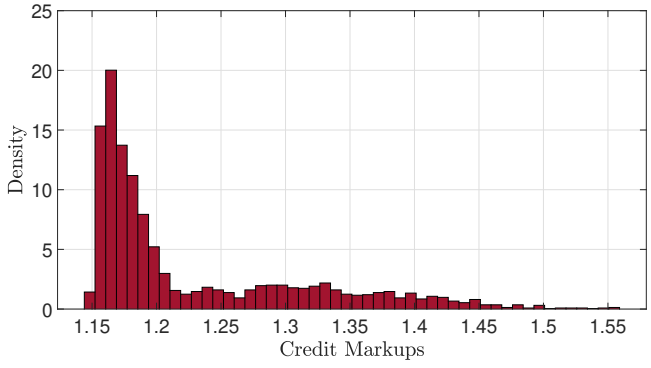


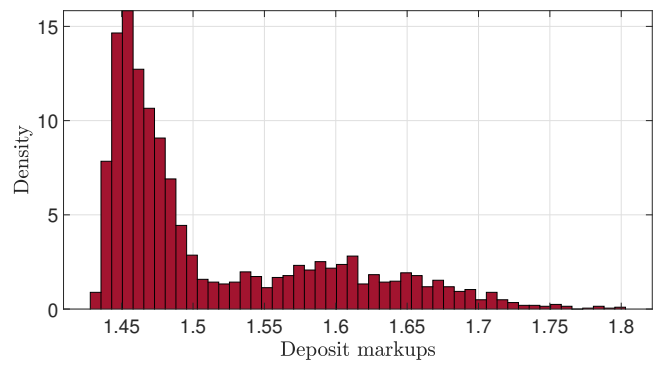
(B) Stochastic, ξ_j

Taking the Model to the Data (cont'd)

Calibration

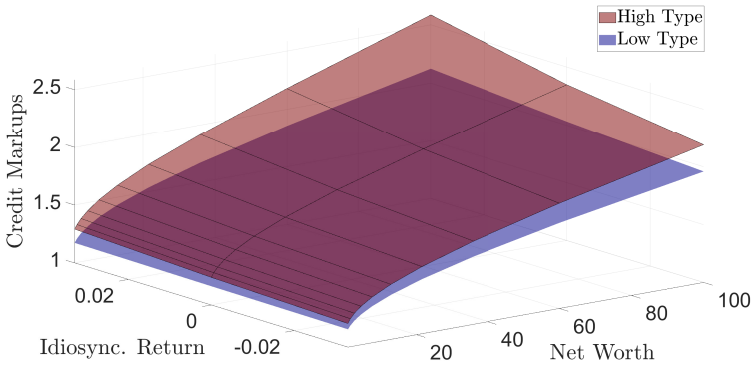
- Market power:
  - $\theta_k, \theta_b \Rightarrow$ govern mean of the mark-up distributions under Kimball
  - $\epsilon_k, \epsilon_b \Rightarrow$ control mark-up-size relation and mark-up elasticity to marginal cost
  - Deposit supply elasticity $\nu \Rightarrow$ governs average deposit mark-up
- Deposit mark-up:
  - Ranges from 1.4 to 1.8 $\Rightarrow$ 1.2 to 2 in the data
- Credit mark-up:
  - Ranges from 1.15 to 1.55 $\Rightarrow$ dispersion in line with data, but lower average
  - Kimball $\Rightarrow$ equilibrium maximum relative size $k_{max} = \theta_k^{\frac{\theta_k}{\epsilon_k}}$
  - Average credit mark-up vs size concentration trade-off



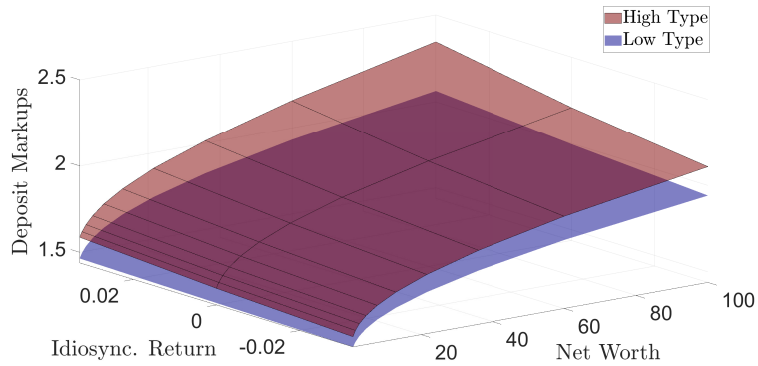


Policy Functions

(A) Credit mark-ups



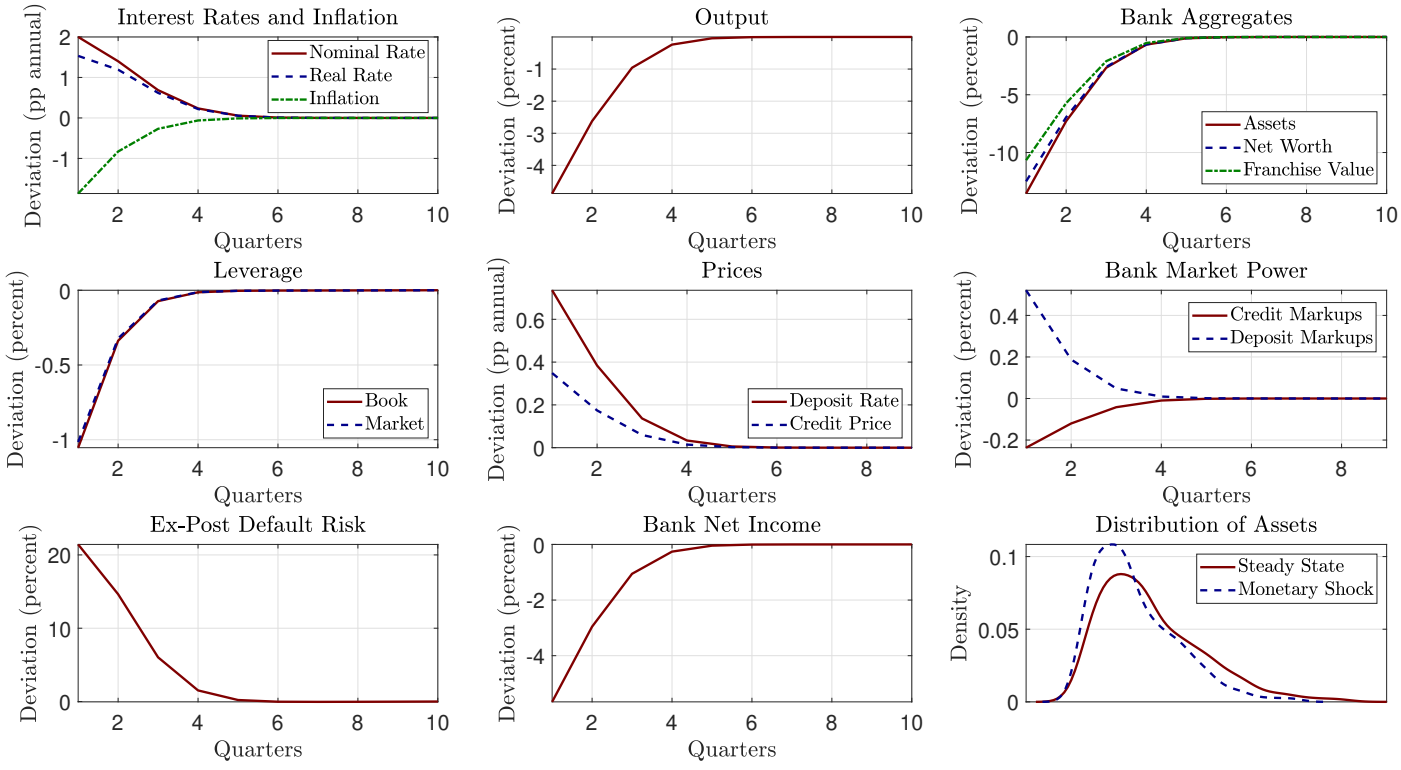
(B) Deposit mark-ups



- Both credit and deposit mark-ups:
  - Increasing in size
  - Increasing in permanent and idiosyncratic returns
- $\Rightarrow$ trilateral correlation:
  - I Market power (credit and deposit)
  - II Size
  - III Profits

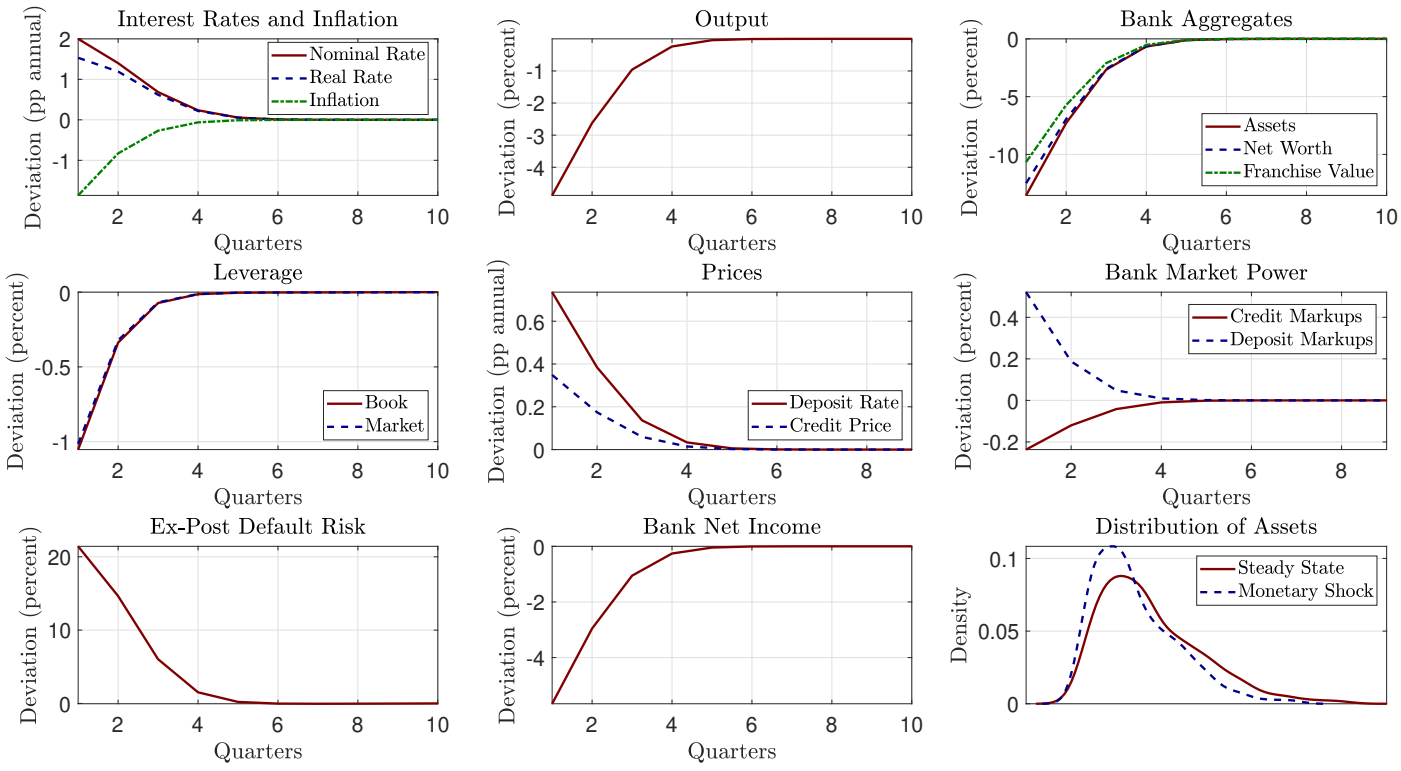
Monetary Policy in HBANK

Monetary Policy Transmission: Aggregate Effects



- 50 bp. increase in R $\Rightarrow$ exogenous increase in banks' marginal cost
- Substantial contraction in **output**
- Assets, net worth, net income & franchise value $\Downarrow$
- Leftward shift in the distribution of assets
- Default risk $\Uparrow$

Monetary Policy Transmission: Aggregate Effects



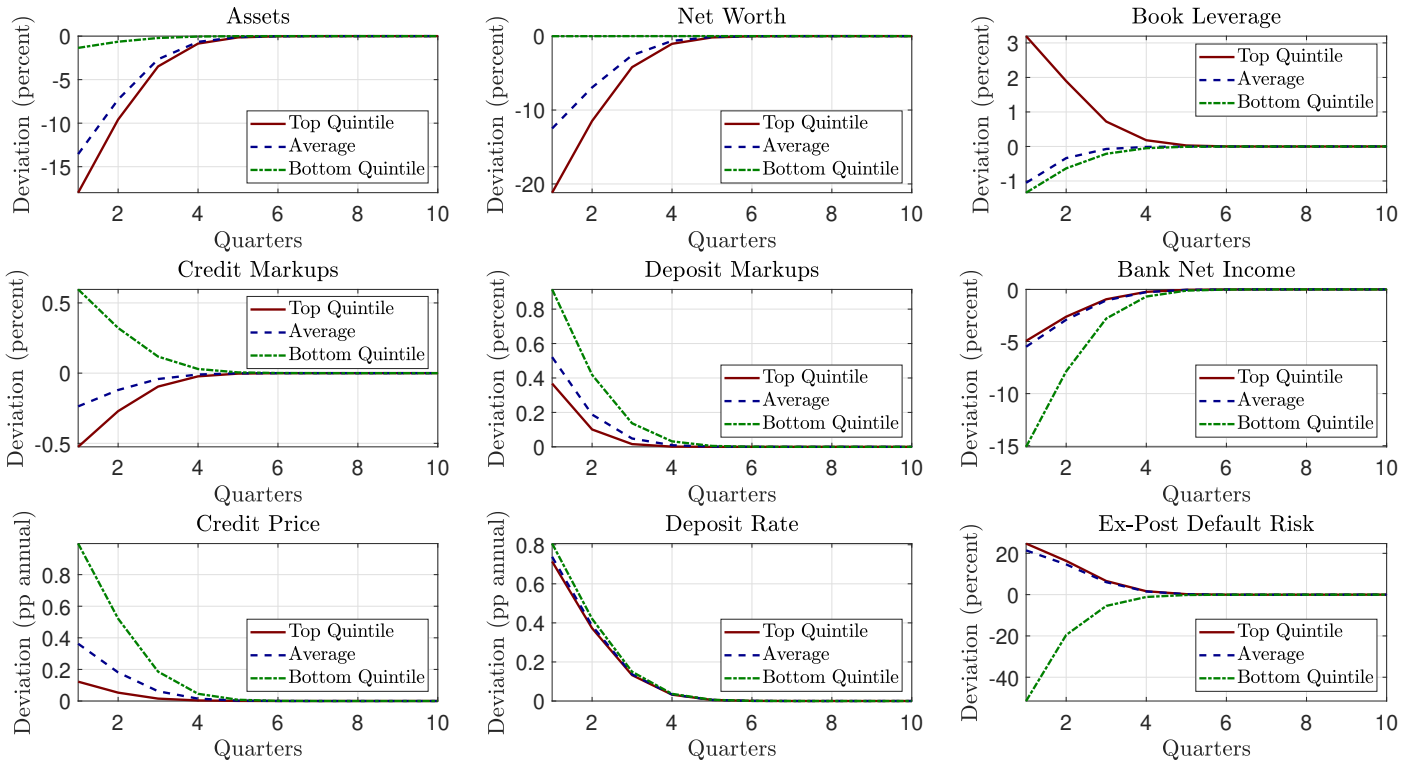
- Market power channel:

1. Credit mark-up $\Downarrow$
2. Deposit mark-up $\Uparrow$

} Real rigidites $\Rightarrow$ imperfect pass-through

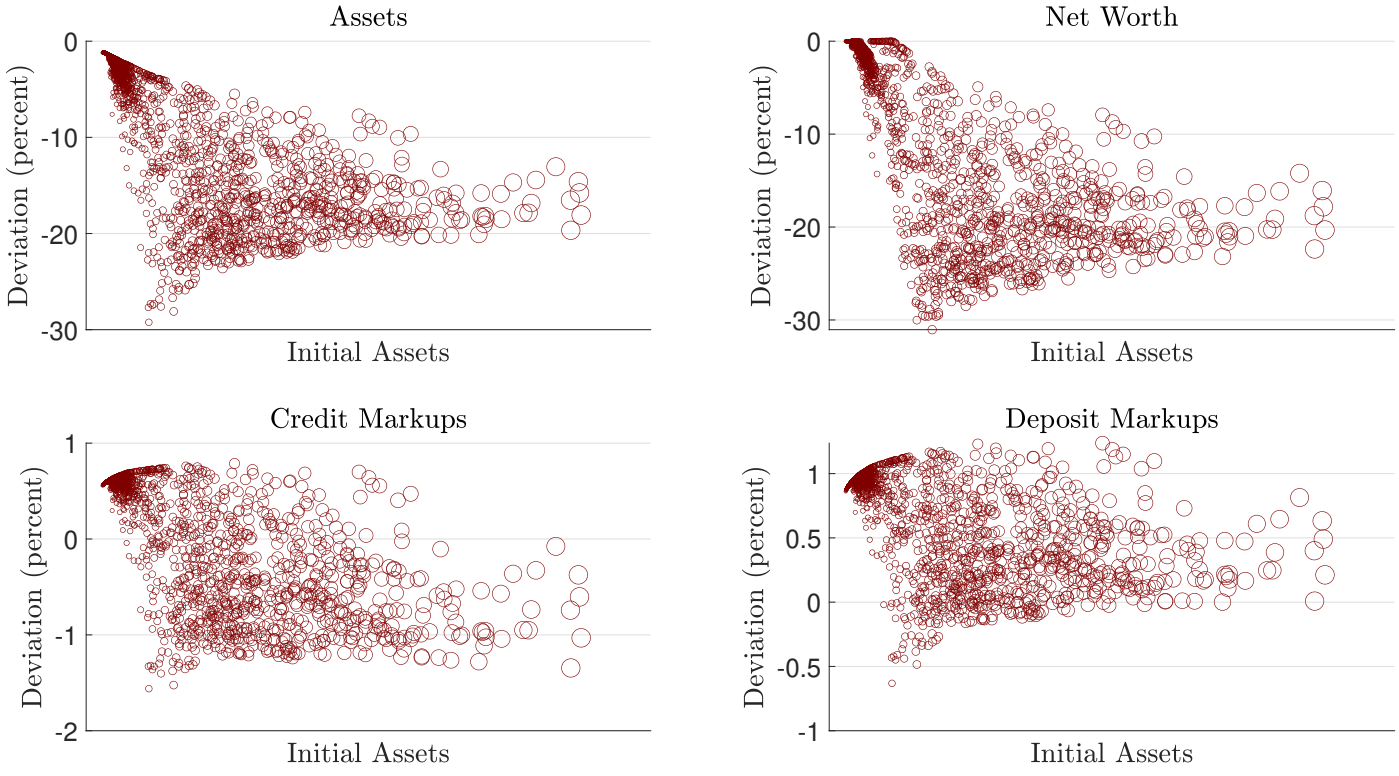
Monetary Policy Transmission: Cross-Section

▶ Densities & Mom.



- Large banks shrink by more ⇒ MPL increasing in size
- Leverage and default risk increase more for large banks ⇒ risk concentration
- Credit and deposit price pass-through decreasing in size

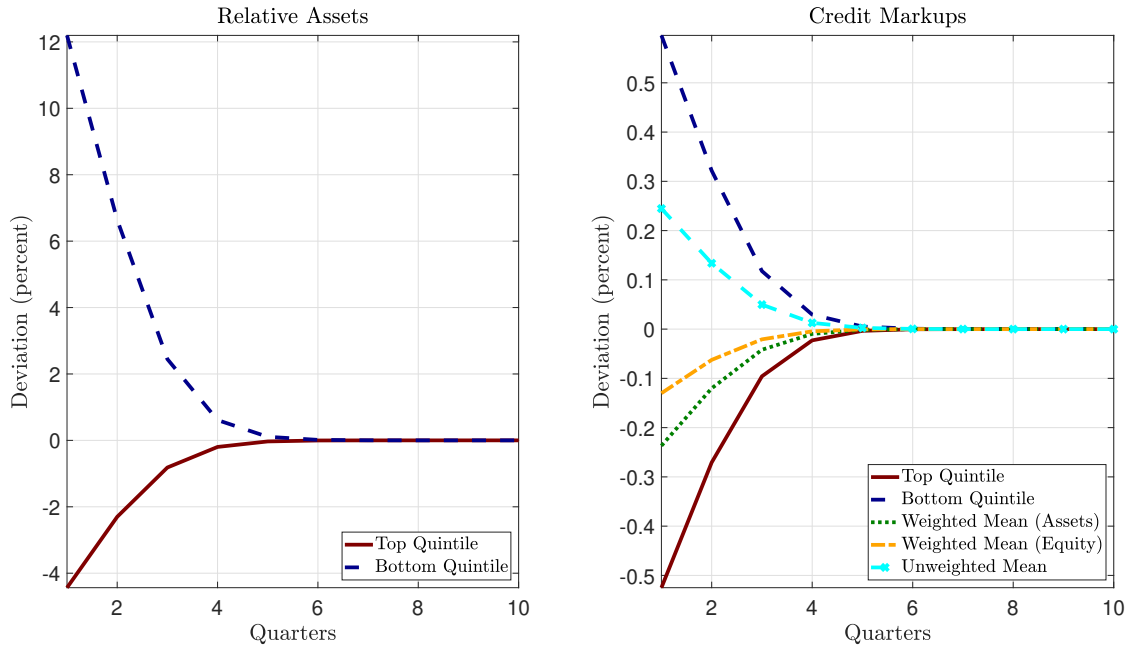
Monetary Policy Transmission: Cross-Section (cont'd)



- Contraction in **size** for all banks, large banks by more $\Rightarrow$ MPL increasing in size
- Compression of credit mark-ups $\Rightarrow$ increase for small banks, decrease for big
  - Dispersion $\Downarrow$
- Uniform (almost) increase in **deposit** mark-ups $\Rightarrow$ larger increase for small banks
  - Dispersion $\Uparrow$
  - Absolute increase in mark-up larger for big banks

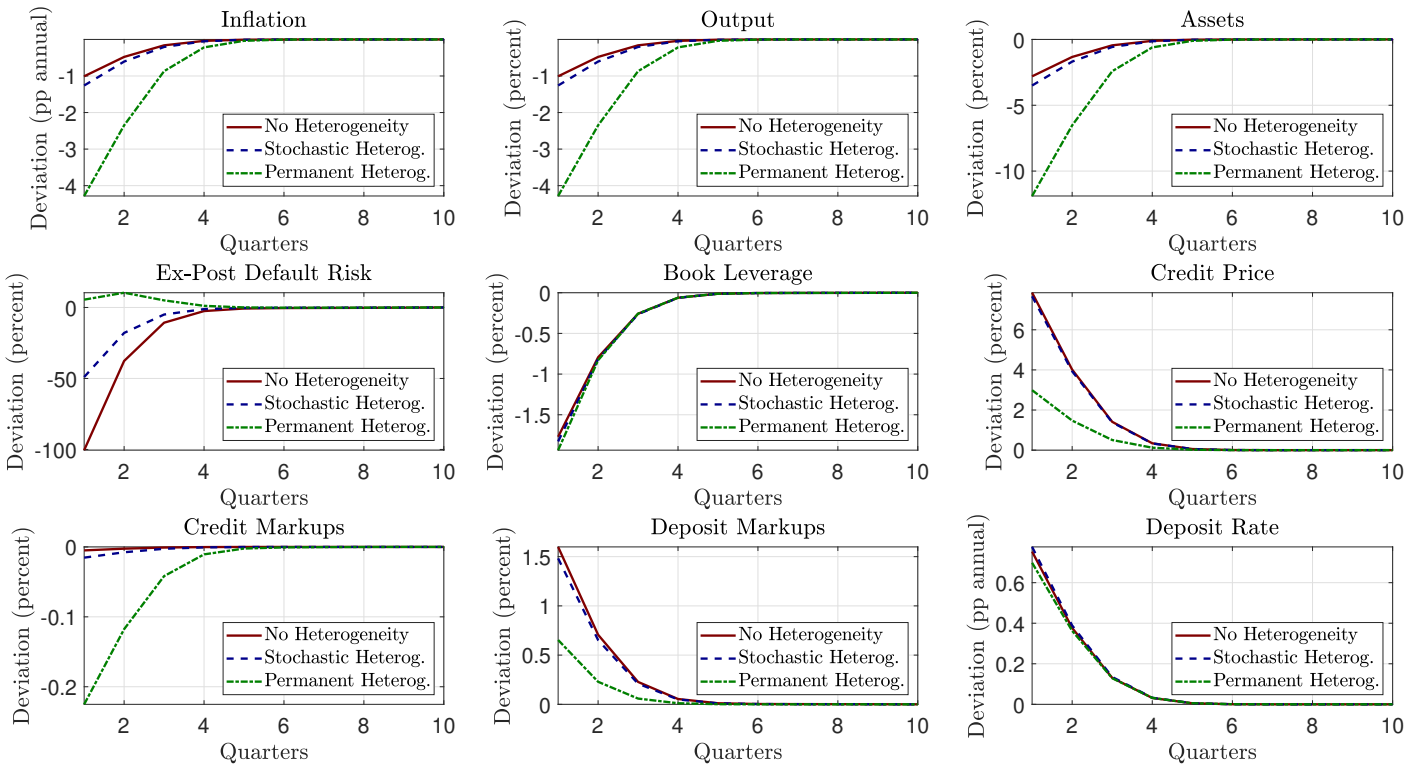
Inspecting the Mechanism

Inspecting the Mechanism: Credit Mark-ups



- Opposite response of credit mark-ups
  - Small banks ⇑
  - Big banks ⇓
- Relative size: sufficient statistic for the response of mark-ups
- MPL increasing with size ⇒ small banks become relatively larger
  - Dispersion & concentration ⇓ (as in the data)
- Aggregation & weighting matter
  1. Unweighted average ⇑
  2. Weighted average ⇓

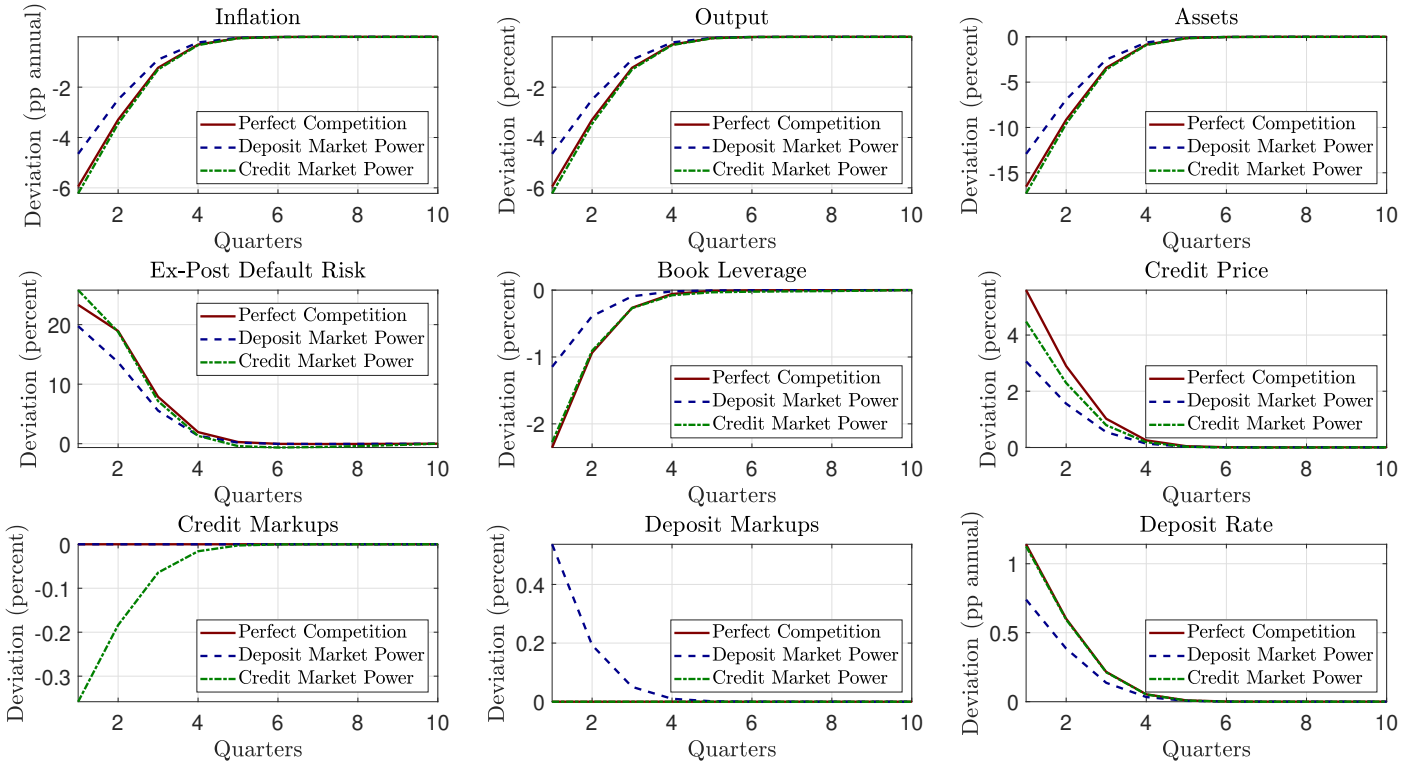
Inspecting the Mechanism: Heterogeneity



- Permanent heterogeneity: substantial amplification of MP shock
- Large banks $\Rightarrow$ higher MPL $\Rightarrow$ amplification

Inspecting the Mechanism: Market Power

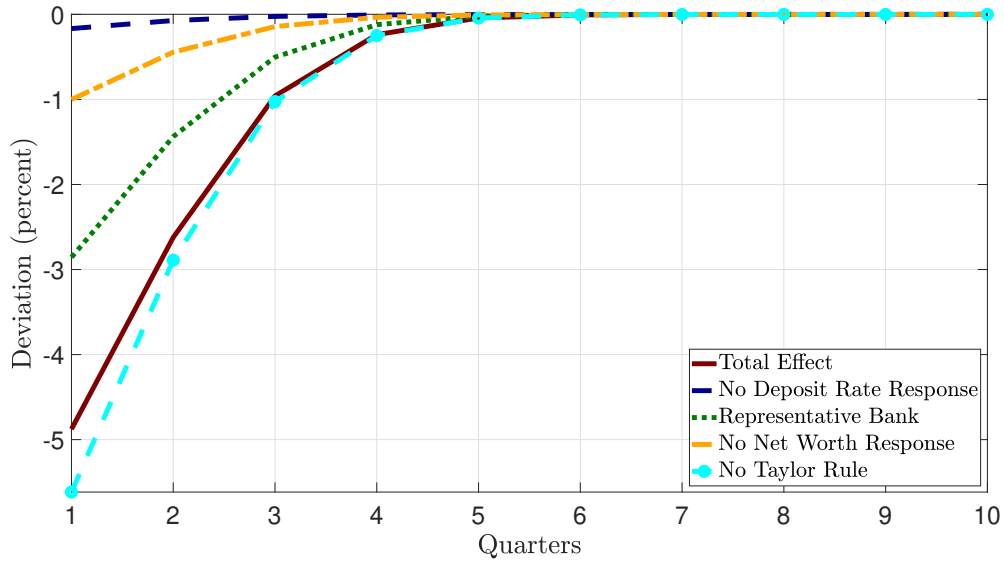
▸ CES



- Credit mkt. power: pro-cyclical mark-ups, rigid P, elastic Q $\Rightarrow$ (mild) amplification
- Deposit mkt. power: low pass-through on deposit rates and MC $\Rightarrow$ dampening
  - I Deposit mark-up elasticity increasing in the risk-free rate
  - II $\frac{C_t^{\psi}}{B_t^{\nu}}$ counter-cyclical $\Rightarrow$ deposit spread increases after MP contraction
- Financial stability vs deposit market power trade-off

Inspecting the Mechanism: PE vs GE

▸ Asymmetry



I Cost of funds response crucial for bank lending channel
  - Shutting down deposit rate response ⇒ 95% dampening

II Financial accelerator mechanism important
  - Shutting down net worth response ⇒ 80% dampening

III Bank heterogeneity matters
  - Representative bank approximation ⇒ 40% dampening

Conclusion

- Monetary policy activates a banking market power channel
- Bank heterogeneity matters
- HBANK: heterogeneity + incomplete insurance + two-sided market power + nominal rigidities
  - Credit & deposit market power
  - Bank heterogeneity

  $\Rightarrow$ Crucial for MP transmission
- Future ongoing work:
  I. ZLB
  II. Heterogenous effects of unconventional monetary policy: FG, LSAP, negative rates
  III. Global banks
  IV. Granularity and bank network centrality

Thank You!

Estimation of Credit Mark-ups

▸ Decomposition ▸ Back

- Credit mark-up: $\mu^k_{i,t} = \frac{p_{i,t}}{c_{i,t}}$
- p: measure of loan price

$$p = \frac{\text{Interest income on loans and leases}}{\text{Total loans and leases}}$$

- c: marginal cost of loans$\Rightarrow$ cost of funds + marg. net non-int. expenses
  - Cost of funds:

$$\frac{\text{Int. exp. on domestic deposits \& fed funds}}{\text{Domestic deposits \& fed funds}}$$

  - Marginal net non-interest expense: marginal non-interest expense minus marginal non-int. income
    I. Panel regression (translog function) of non-interest expenses on loans, salaries and securities (Corbae and D'Erasmo, 2021) ▸ Regression
    II. Marginal non-interest expense is the derivative of non-interest expense wrt loans
    III. Same for marginal non-interest income (excluding salaries)

Estimation of Deposit Mark-ups

▸ Decomposition ▸ Back

- Deposit mark-up: $\mu^b_{i,t} = \frac{p_{i,t}}{c_{i,t}}$
- p: measure of safe revenue from funds

$$p = \frac{\text{Int. inc. from fed funds \& US treasuries \& agency debt}}{\text{Total fed funds \& US treasuries \& agency debt}}$$

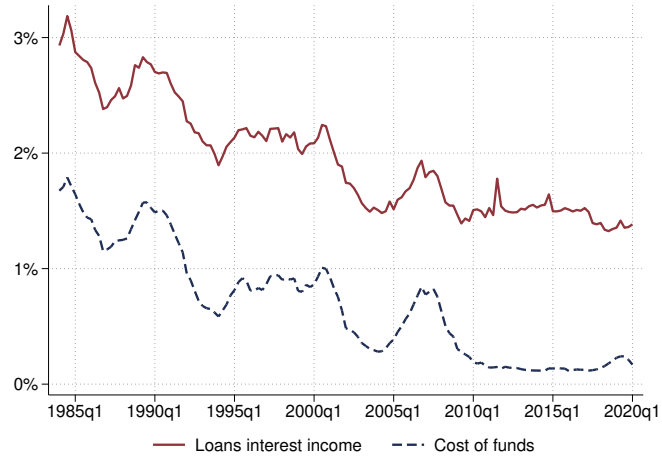
- c: marginal cost of deposits$\Rightarrow$ interest expenses + marg. net non-int. exp.
  - Interest expenses on deposits:

$$\frac{\text{Int. exp. on domestic deposits}}{\text{Domestic deposits}}$$

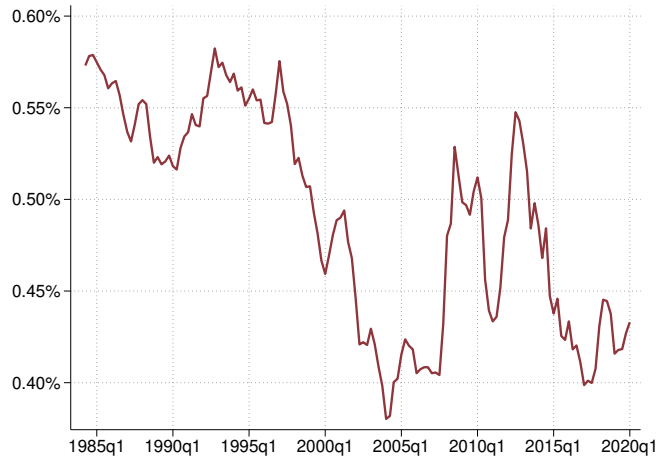
  - Marginal net non-interest expense: marginal non-interest expense minus marginal non-int. income
    I. Panel regression (translog function) of non-interest expenses on loans, salaries, securities and deposits (Corbae and D'Erasmo, 2021) ▸ Regression
    II. Marginal non-interest expense is the derivative of non-interest expense wrt deposits
    III. Same for marginal non-interest income (excluding salaries)

Decomposition of Credit Mark-ups

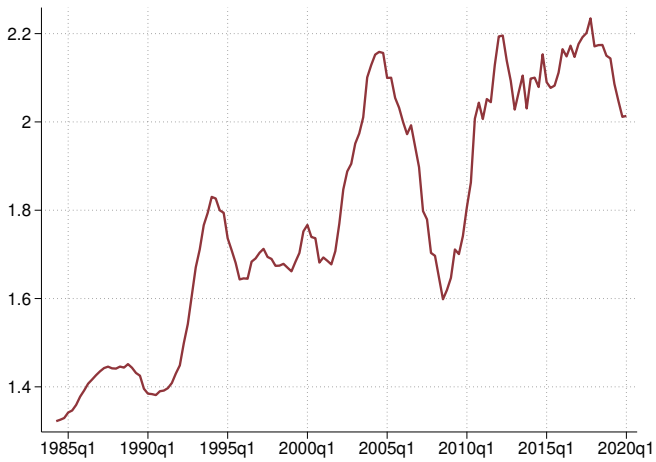
Back



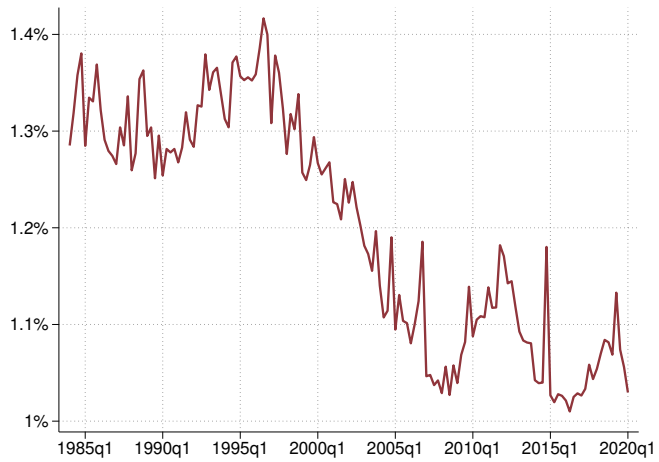
(A) Loan income and cost of funds



(B) Marginal net non-interest expenses



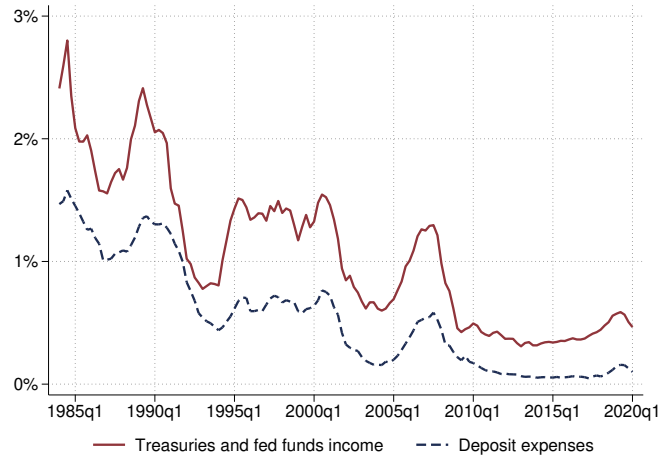
(C) Credit mark-up



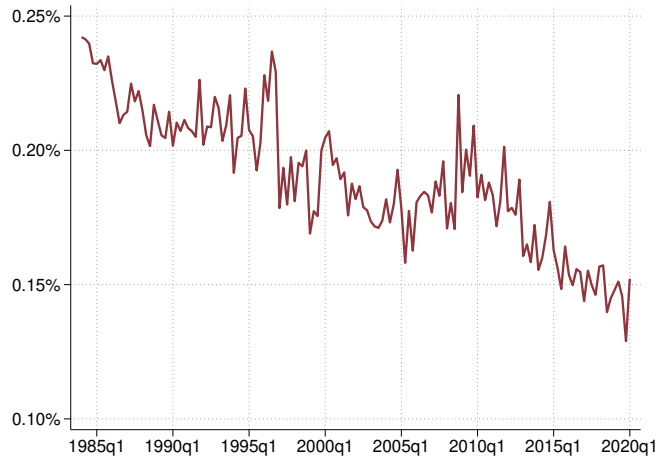
(D) Credit spread

Decomposition of Deposit Mark-ups

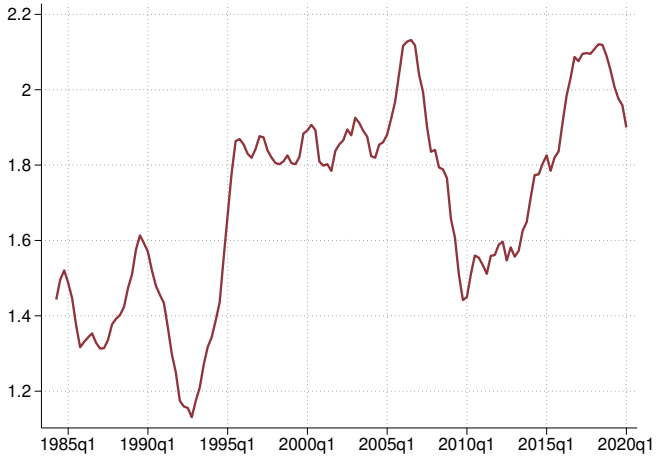
Back



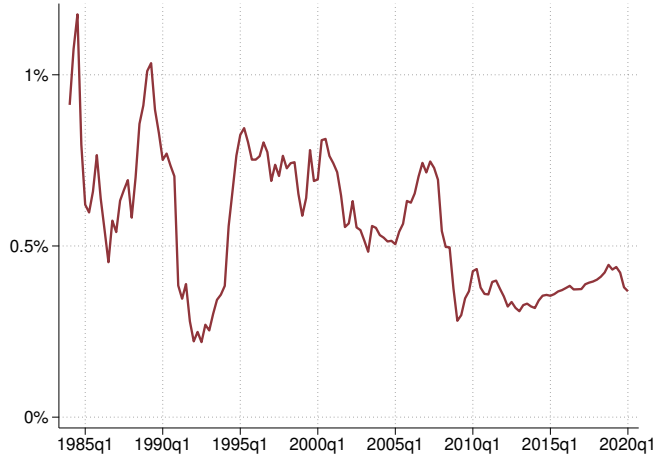
(A) Safe income and deposit expenses



(B) Marginal net non-interest expenses



(C) Deposit mark-up



(D) Deposit spread

Regressions for marginal non-interest expenses: Credit Mark-up

Back

- Trans-log for non-interest expenses:

$$\begin{aligned}\log(NIE_{i,t}) = {} & \alpha_i + \delta_t + \beta_{l,1}\log(l_{i,t}) + \beta_{w,1}\log(w_{i,t}) + \beta_{q,1}\log(q_{i,t}) \\ & + \beta_{l,2}\log(l_{i,t})^2 + \beta_{w,2}\log(w_{i,t})^2 + \beta_{q,2}\log(q_{i,t})^2 + \beta_{l,w}\log(l_{i,t})\log(w_{i,t}) \\ & + \beta_{l,q}\log(l_{i,t})\log(q_{i,t}) + \beta_{w,q}\log(w_{i,t})\log(q_{i,t}) + \varepsilon_{i,t}\end{aligned}$$

- Marginal non-interest expenses:

$$MNIE_{i,t} = \frac{\partial NIE_{i,t}}{\partial l_{i,t}} = \frac{NIE_{i,t}}{l_{i,t}}\left[\beta_{l,1} + 2\beta_{l,2}\log(l_{i,t}) + \beta_{l,w}\log(w_{i,t}) + \beta_{l,q}\log(q_{i,t})\right]$$

- Marginal non-interest income: exclude salaries

$$MNII_{i,t} = \frac{\partial NII_{i,t}}{\partial l_{i,t}} = \frac{NII_{i,t}}{l_{i,t}}\left[\beta_{l,1} + 2\beta_{l,2}\log(l_{i,t}) + \beta_{l,q}\log(q_{i,t})\right]$$

- Marginal net non-interest expenses:

$$MNNIE_{i,t} = MNIE_{i,t} - MNII_{i,t}$$

Regressions for marginal non-interest expenses: Deposit Mark-up

Back

- Trans-log for non-interest expenses:

$$\begin{aligned}\log(NIE_{i,t}) = {} & \alpha_i + \delta_t + \beta_{l,1}\log(l_{i,t}) + \beta_{w,1}\log(w_{i,t}) + \beta_{q,1}\log(q_{i,t}) + \beta_{d,1}\log(d_{i,t}) \\ & + \beta_{l,2}\log(l_{i,t})^2 + \beta_{w,2}\log(w_{i,t})^2 + \beta_{q,2}\log(q_{i,t})^2 + \beta_{d,2}\log(d_{i,t})^2 \\ & + \beta_{l,w}\log(l_{i,t})\log(w_{i,t}) + \beta_{l,q}\log(l_{i,t})\log(q_{i,t}) + \beta_{w,q}\log(w_{i,t})\log(q_{i,t}) \\ & + \beta_{l,d}\log(l_{i,t})\log(d_{i,t}) + \beta_{w,d}\log(w_{i,t})\log(d_{i,t}) + \beta_{q,d}\log(q_{i,t})\log(d_{i,t}) + \varepsilon_{i,t}\end{aligned}$$

- Marginal non-interest expenses:

$$MNIE_{i,t} = \frac{\partial NIE_{i,t}}{\partial d_{i,t}} = \frac{NIE_{i,t}}{d_{i,t}}\left[\beta_{d,1} + 2\beta_{d,2}\log(d_{i,t}) + \beta_{l,d}\log(l_{i,t}) + \beta_{w,d}\log(w_{i,t}) + \beta_{q,d}\log(q_{i,t})\right]$$

- Marginal non-interest income: exclude salaries

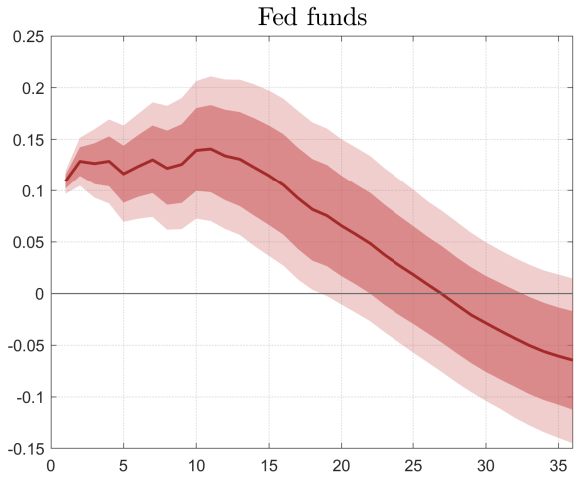
$$MNII_{i,t} = \frac{\partial NII_{i,t}}{\partial d_{i,t}} = \frac{NII_{i,t}}{d_{i,t}}\left[\beta_{d,1} + 2\beta_{d,2}\log(d_{i,t}) + \beta_{l,d}\log(l_{i,t}) + \beta_{q,d}\log(q_{i,t})\right]$$

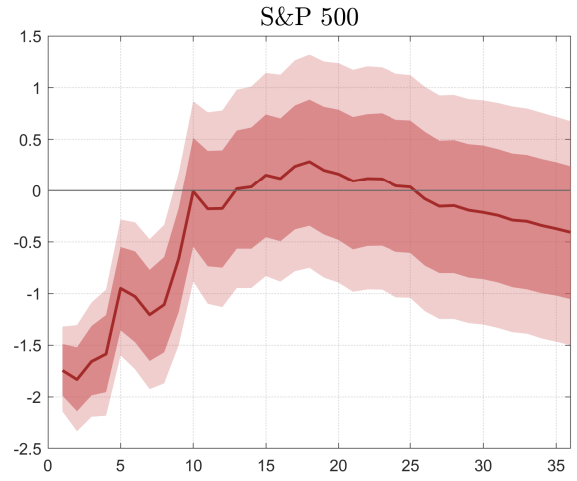
- Marginal net non-interest expenses:

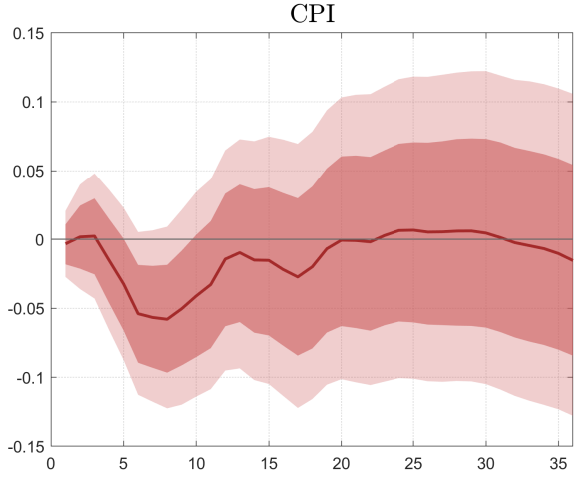
$$MNNIE_{i,t} = MNIE_{i,t} - MNII_{i,t}$$

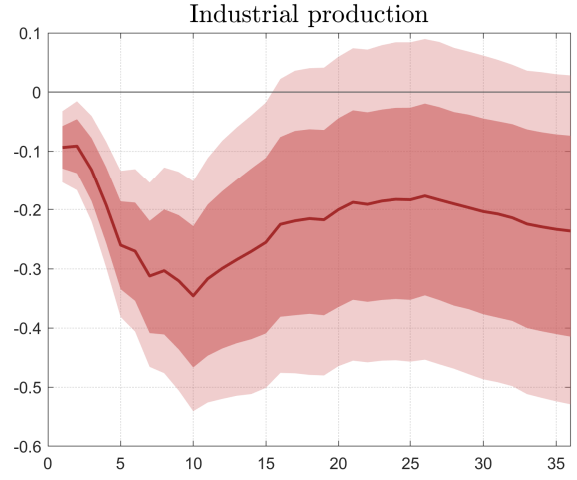
IRFs for Macro Variables

Back



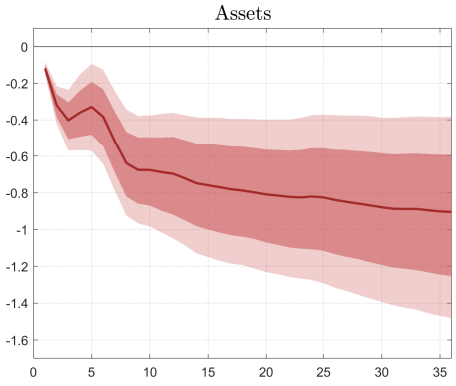


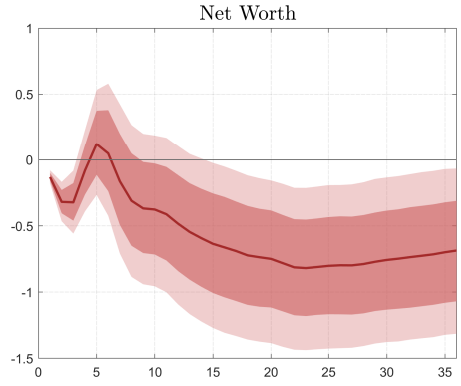


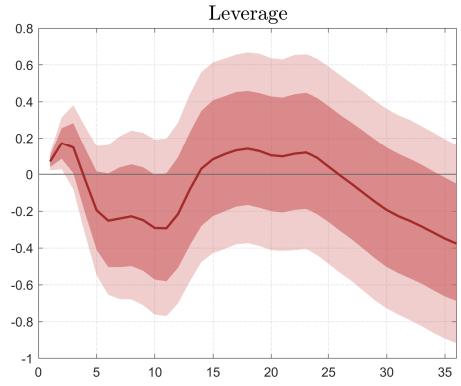


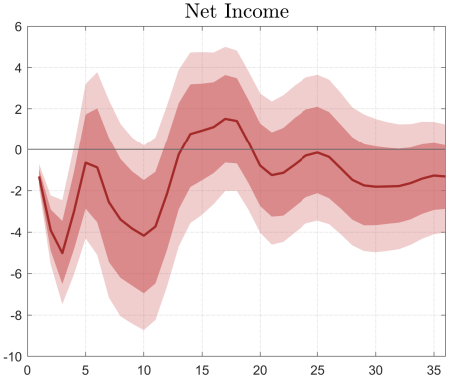
IRFs for Second Moment

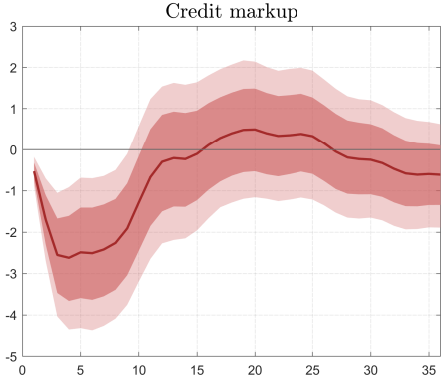
Back

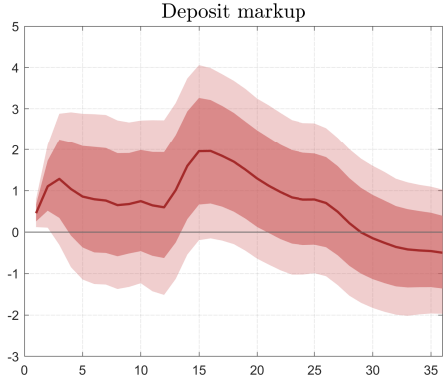






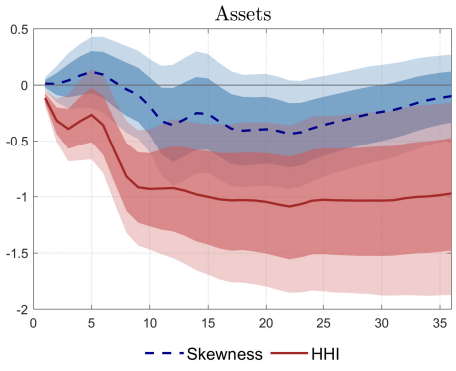


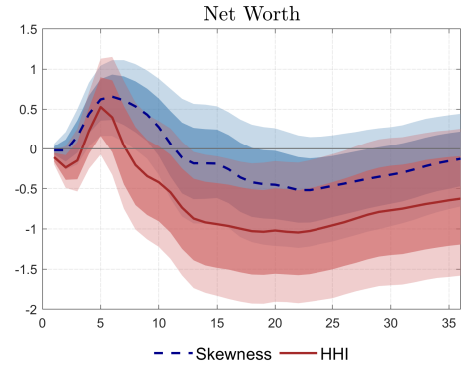


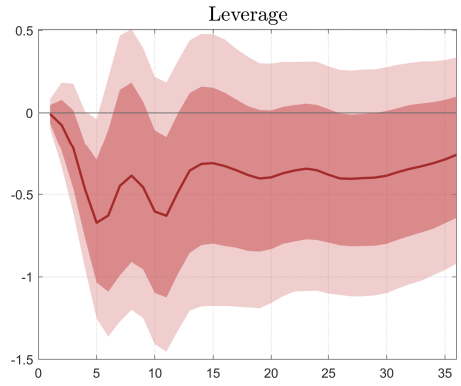


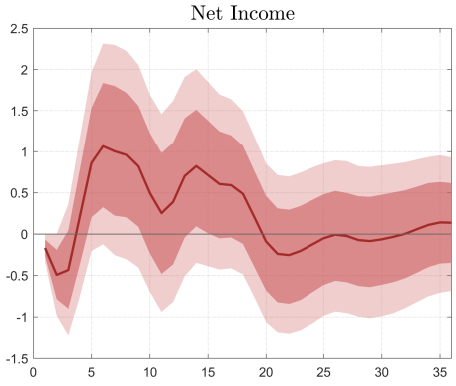
IRFs for Third Moment

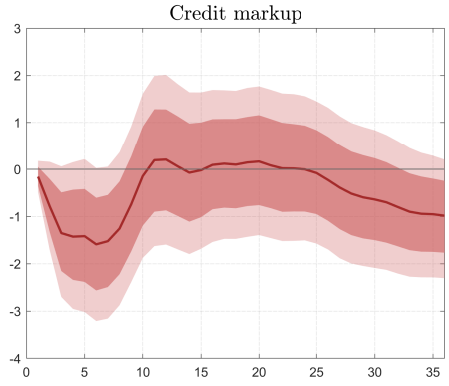
Back

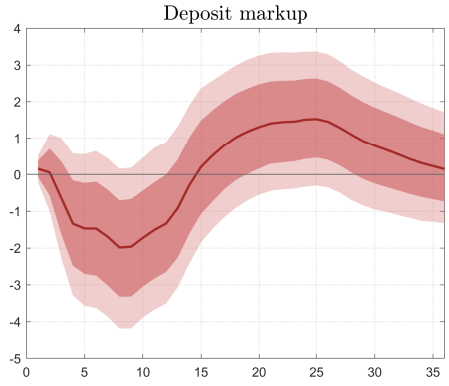










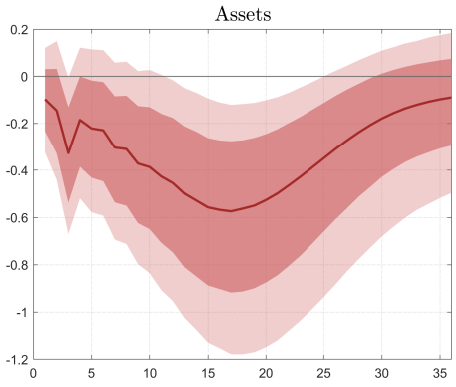


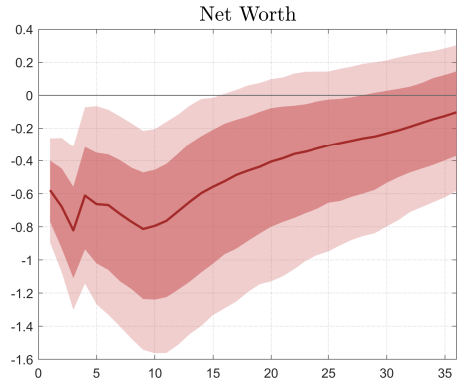
First Stage F-Statistics

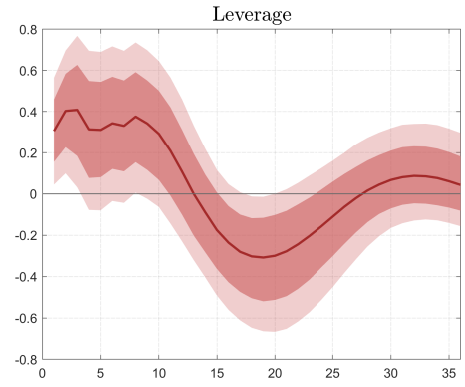
Back

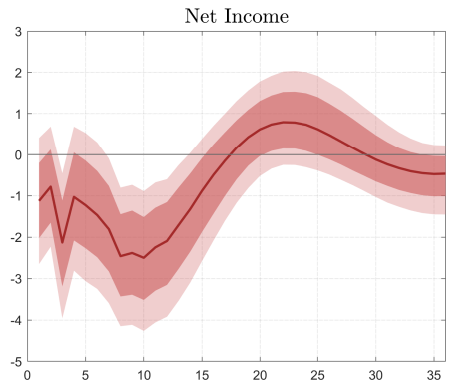
	Baseline	Karadi-Jarociński	Start 1990	End 2012	Quarterly
Aggregate responses					
Assets	36.38	18.18	34.79	30.16	35.78
Net Worth	33.10	16.08	32.10	26.84	33.62
Leverage	31.70	13.96	30.28	26.15	32.55
Net Income	38.02	19.13	31.87	30.89	40.36
Credit Mark-up	35.44	17.00	32.61	27.82	39.33
Deposit Mark-up	32.89	18.21	32.49	26.95	36.04
Heterogeneous responses					
Assets Q1	33.60	17.34	30.46	27.47	35.61
Assets Q5	35.65	17.30	34.24	29.03	35.97
Net Worth Q1	33.52	17.65	31.67	26.60	35.47
Net Worth Q5	33.54	17.34	32.96	28.06	33.80
Leverage Q1	33.41	18.61	29.50	27.51	35.90
Leverage Q5	33.43	15.79	31.05	27.61	34.00
Net Income Q1	32.21	19.51	30.34	26.17	36.45
Net Income Q5	31.25	12.73	33.32	25.61	36.41
Credit Mark-up Q1	36.10	20.77	33.13	29.66	38.63
Credit Mark-up Q5	35.27	16.81	32.58	27.67	39.15
Deposit Mark-up Q1	28.42	18.32	27.17	22.26	37.00
Deposit Mark-up Q5	33.00	17.10	32.54	27.12	35.63

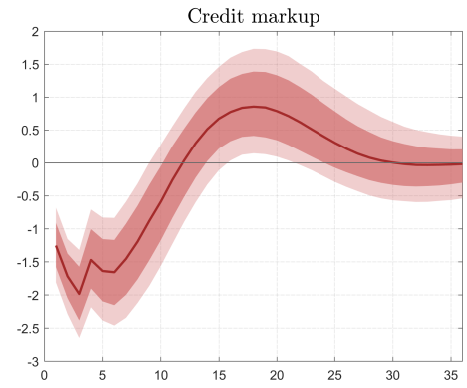
Robustness: Quarterly Data

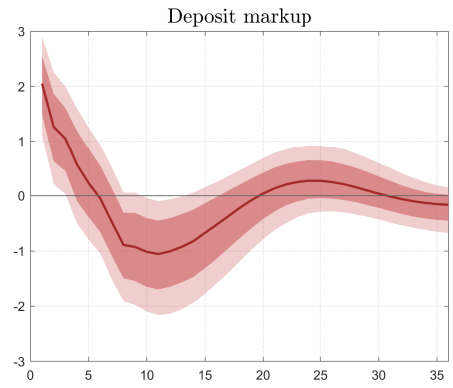




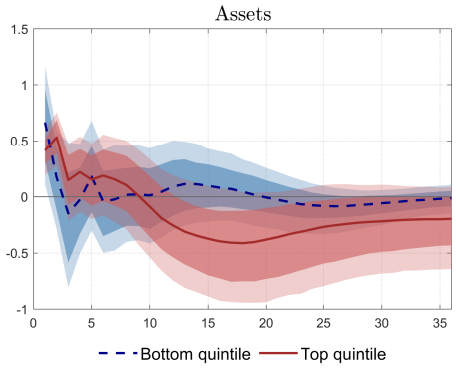


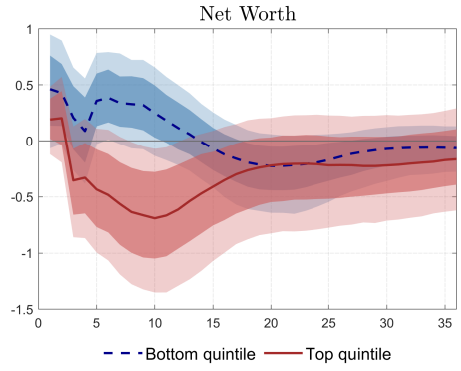


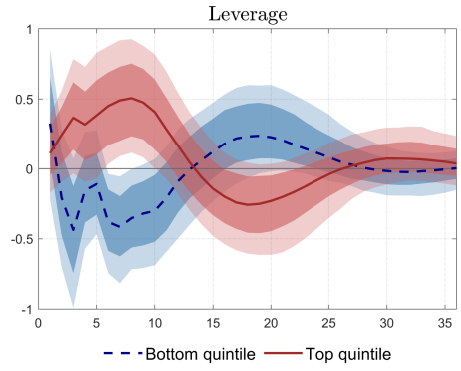


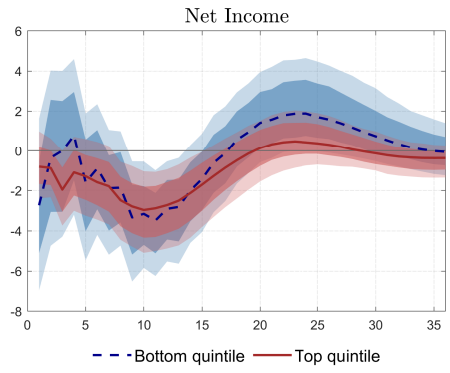


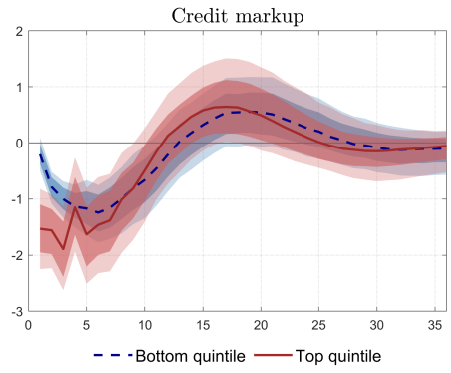
Robustness: Quarterly Data (cont'd)

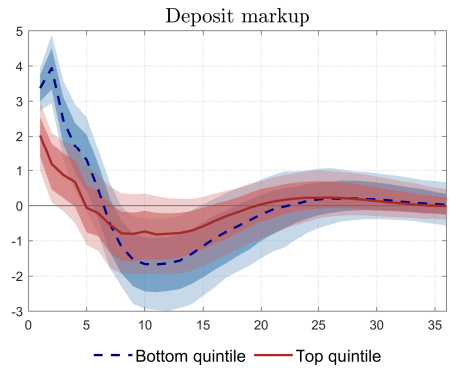












KIMBALL SPECIFICATION: DEPOSIT MARKET

BACK

- Klenow and Willis (2016) parametric specification for the deposit market aggregator:

$$\Upsilon\left(\frac{b}{B}\right) = 1 + (\theta_b - 1)exp\left(\frac{1}{\epsilon_b}\right)\epsilon_b^{\frac{\theta_b}{\epsilon_b}-1}\left[\Gamma\left(\frac{\theta_b}{\epsilon_b}, \frac{1}{\epsilon_b}\right) + \Gamma\left(\frac{\theta_b}{\epsilon_b}, \frac{-\left(\frac{b}{B}\right)^{\epsilon_b/\theta_b}}{\epsilon_b}\right)\right]$$

- $\Gamma(.,.)$ is the incomplete Gamma function
- θ_b governs the average deposit mark-up
- ϵ_b governs the slope of the deposit mark-up function

KIMBALL SPECIFICATION: ASSET MARKET

BACK

- Klenow and Willis (2016) parametric specification for the asset market aggregator:

$$\Phi\left(\frac{k}{K}\right) = 1 + (\theta_k - 1)exp\left(\frac{1}{\epsilon_k}\right)\epsilon_k^{\frac{\theta_k}{\epsilon_k}-1}\left[\Gamma\left(\frac{\theta_k}{\epsilon_k}, \frac{1}{\epsilon_k}\right) + \Gamma\left(\frac{\theta_k}{\epsilon_k}, \frac{\left(\frac{k}{K}\right)^{\epsilon_k/\theta_k}}{\epsilon_k}\right)\right]$$

- $\Gamma(.,.)$ is the incomplete Gamma function
- θ_k governs the average credit mark-up
- ϵ_k governs the slope of the credit mark-up function

Numerical Algorithm: Stationary Equilibrium

Back

I. Guess aggregate $K \Rightarrow$ find Y and C

II. Solve household problem conditional on w and $R \Rightarrow$ store SDF Λ
   - Endogenous gridpoint (Carroll (2006))

III. Solve banking problem conditional on Λ, C and guess K using projection methods. Banks internalize the impact of their quantity choices on prices via credit and deposit Kimball
   - Idiosyncratic state vector $\Rightarrow$ 10 grid points for net worth
   - 3 permanent profitability types η_j
   - Discretize ξ_j with 7 nodes
   - Assume leverage constr. binds $\Rightarrow$ get Lagrange multipl. $\Rightarrow$ check if constr. binds (re-solve)

IV. Run long stochastic simulation for each permanent profitability type using the new policy functions $\Rightarrow$ compute K'

V. Conditional on K' solve NK block and find Π
   - In SS, $\Pi = 1$

VI. Iterate II-V to convergence

Numerical Algorithm: Transitional Equilibrium

Back

Shooting algorithm (Boppart et al. (2018), Kaplan et al. (2018))

I Choose T at which it is conjectured the economy is back at SS

II Project mean-reverting path of MIT shock to MP $\{\epsilon_{mt}\}_{t=1}^{T}$ that hits at $t = 1$

III Guess path for $\{K_t\}_{t=1}^{T} \Rightarrow$ get $\{Y_t, C_t, w_t\}_{t=1}^{T}$

IV Guess path for $\{V_t, n'_t\}_{t=1}^{T}$

V Solve NK block backwards by setting $\Pi_T = \Pi^{SS}$

VI Solve household problem backwards by setting policy function for deposits to its SS $b'_T = b^{SS} \Rightarrow$ store $\{\Lambda_t\}_{t=1}^{T}$

VII Solve banking problem backwards conditional on the paths of endogenous state variables

VIII Simulate banking distribution forwards using the policy functions in VII

IX Compute the new path $\{K'_t\}_{t=1}^{T}$

X Iterate III-IX to convergence

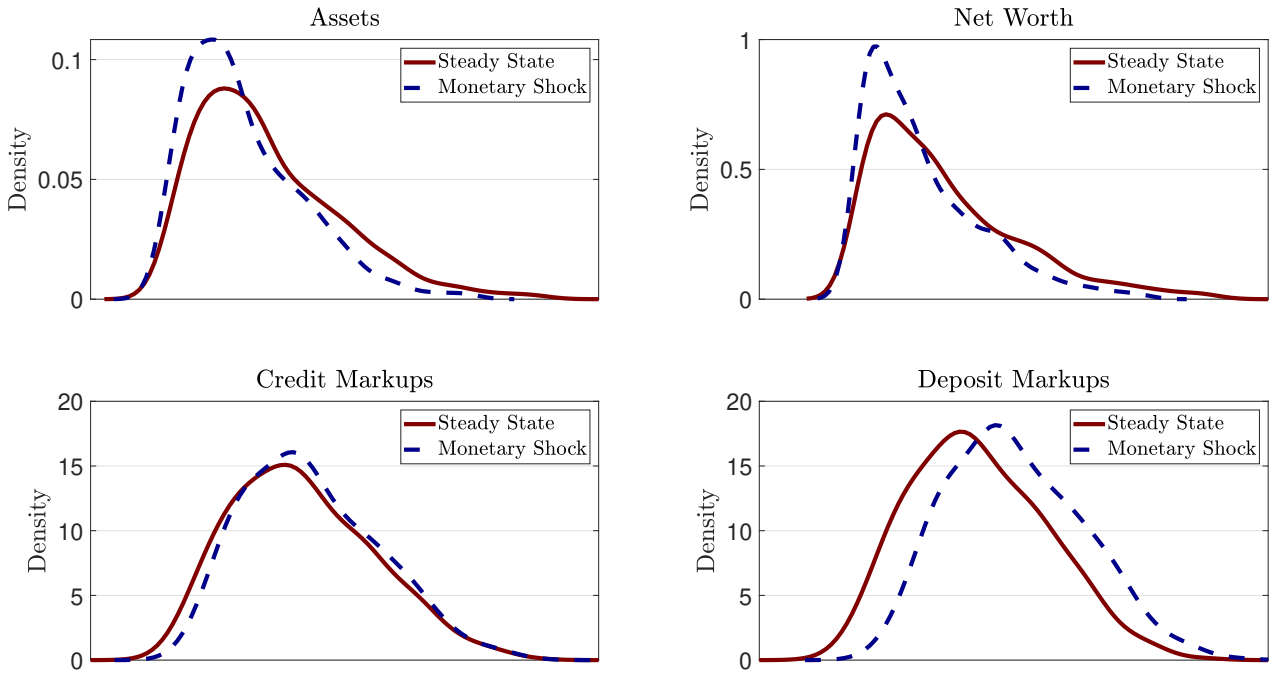
Calibration

Back

Parameter	Value	Description
	Macro	
β	0.996	Discounting
α	0.36	Capital Share
ψ	1	Risk Aversion
	Banking	
σ	0.9	Dividend Payout Rule
ν	1	Deposit Liquidity
λ	0.1	Leverage Constraint
ζ_1	0.01	Credit Adjustment Linear
ζ_2	1.25	Credit Adjustment Quadratic
	Bank Returns	
ρ_ξ	0.415	Idiosync. Return, Persistence
σ_ξ	0.019	Idiosync. Return, st. dev.
σ_η	0.011	Persistent Return, st. dev.
	Bank Market Power	
θ_k	5	Demand Elasticity, Credit
θ_b	10	Supply Elasticity, Deposits
ϵ_k	1.5	Super elasticity, Credit
ϵ_b	1.5	Super elasticity, Deposits
	New Keynesian Block	
γ	10	Elasticity of Substitution, Retail
φ	100	Price Adjustment Cost, Retail
ϕ_π	1.25	Taylor Rule Inflation Coefficient
$\bar{R}$	1.61	Taylor Rule Target Rate (p.a.)

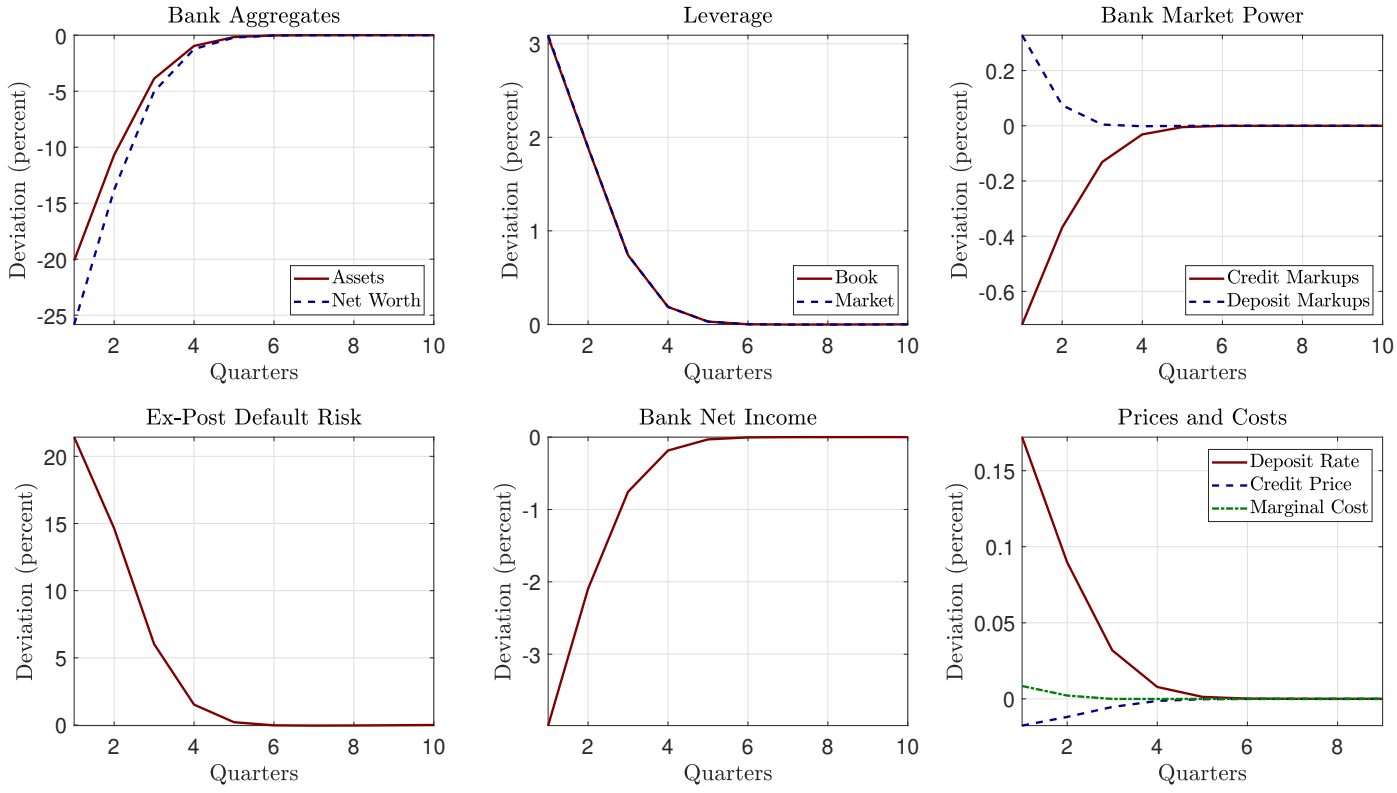
Monetary Policy Transmission: Density Shifts

▸ Back



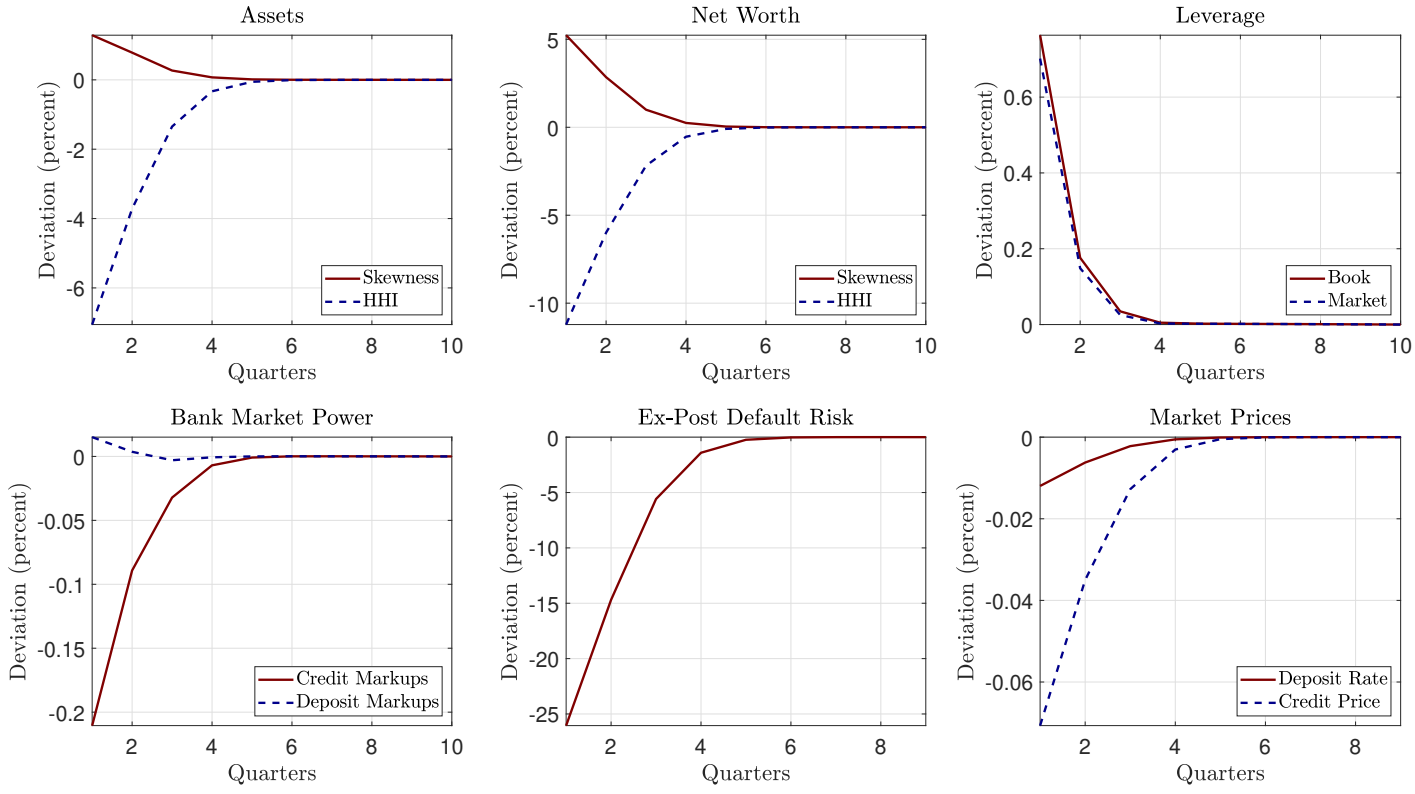
Monetary Policy Transmission: Second Moment

▸ Back



Monetary Policy Transmission: Third Moment

Back



Monetary Policy Transmission: Market Structure

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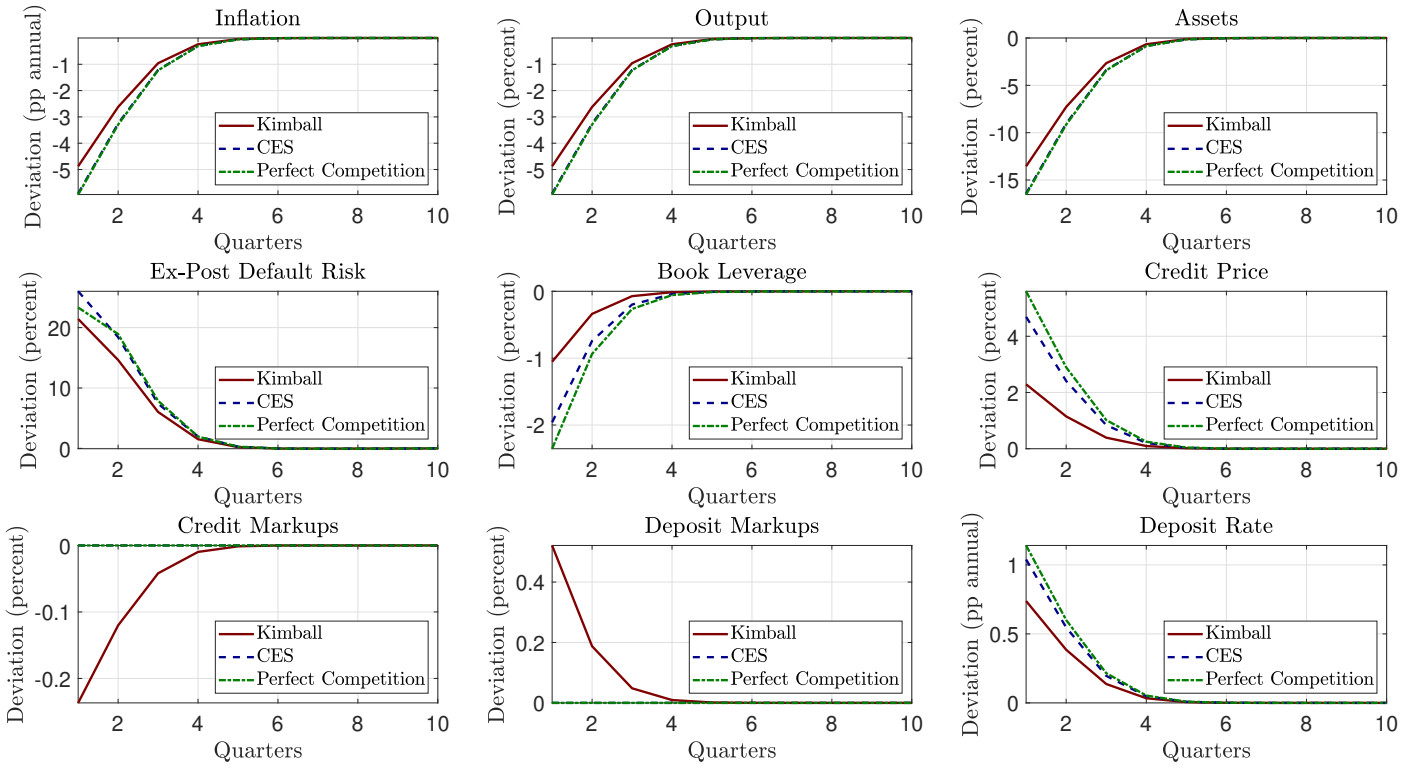

Inspecting the Mechanism: Asymmetric Responses

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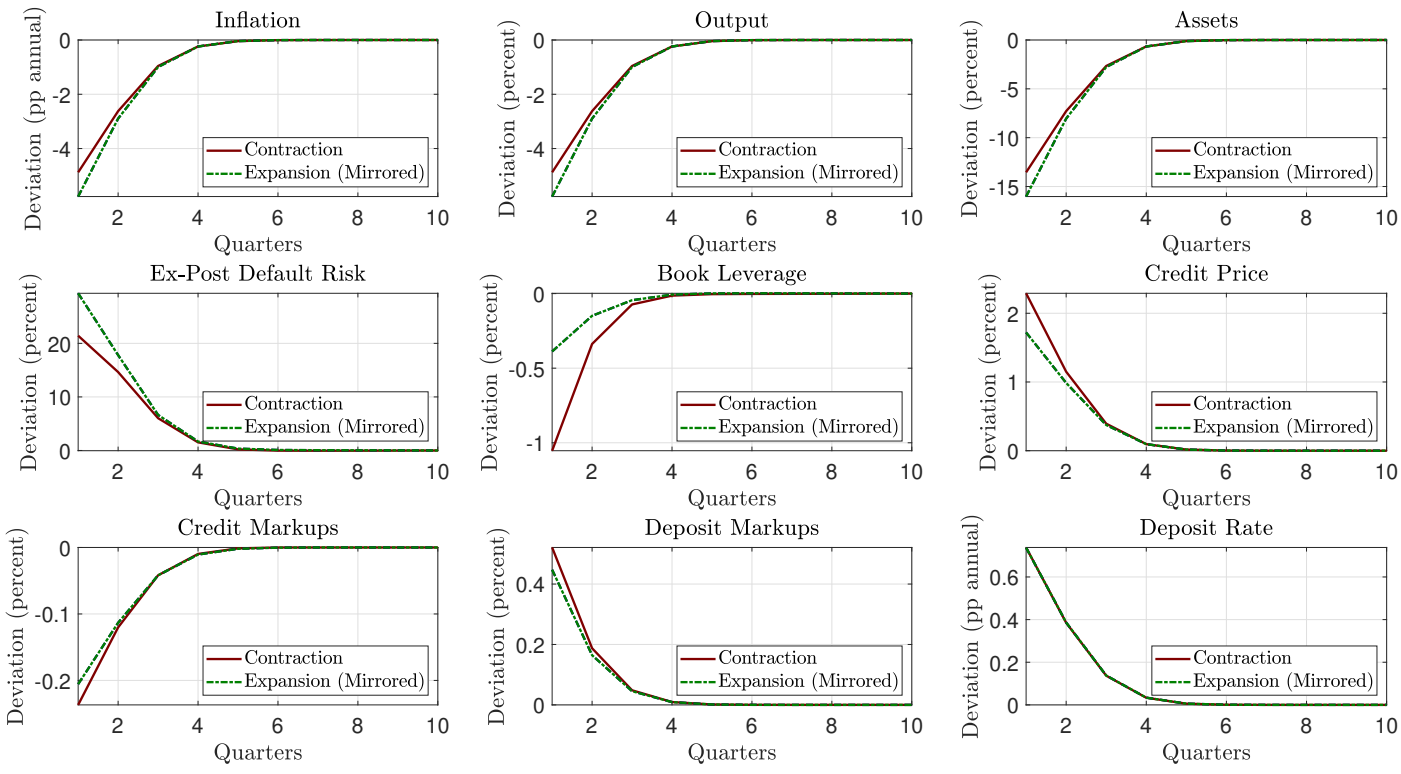

Asymmetric Responses: Cross-Section

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