

# State-dependent pass-through from monetary policy to lending rates

Federico Puglisi

Northwestern University

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- Understanding the **source of pass-through heterogeneity** is crucial to assess the real effects of MP on the macroeconomy.

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⇒ **Positive Skewness**.

2 Length and Fatness vary by location and time.  
⇒ **Skewness varies over time and space**.

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- **HOW:** Local Projections & detailed micro-data on lending
  - **High-Frequency Proxy** identification of exogenous variation in MP rate changes.
  - Panel Local projections with interaction terms
  - **Branch/product-level** lending rates on **new** loans.

## This Paper: Theoretical Contribution

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**A:** Theoretical model of lender imperfect competition

- Bertrand **competition**
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- 5 Larger mass searching borrowers  $\Rightarrow$  stronger price complementarity among lenders.
- 6 Stronger complementarity  $\Rightarrow$  larger MP pass-through to lending rates.

# Literature Review

## State-Dependence of Monetary Policy

- Mortgage Refinancing/Prepayment channel. Berger et al. (2021), Eichenbaum et al. (2022).
- ⇒ **Explore state-dependence arising from bank's strategic pricing and customer search & switching frictions.**

## Monetary Policy Transmission through Banks

- Long stream: banks' regulatory and asymmetric information constraints. Bernanke and Blinder (1988), Kashyap and Stein (2000).
  - Recent stream: banks' market power in liquidity provision. Nagel (2016), Drechsler et al. (2017), Wang et al. (2020).
- ⇒ **Expand to role of bank imperfect competition and consumer frictions.**

## IO literature on Customer Search and Switching costs.

- Yankov (2018), Luco (2019), Andersen et al. (2020)
- ⇒ **Expand on the role of search & switching costs on interest-setting.**

# Outline

## 1 Introduction

## 2 Data

- Core Micro-Data: Branch-Level Lending Rates
- Macro: US National/State/County-Level.
- Lender Financials.
- Other.

## 3 Skewness Zoom-In

## 4 Empirical Analysis

## 5 Theoretical Framework

## 6 Conclusions

## Core Micro-Data

### **Branch-Level Lending Rates (S&P GMI Ratewatch):**

- Time Span: 2001-2019.
- 100,000+ branches (brick-and-mortar offices, cyber offices).
- 7500 financial institutions (banks, credit unions, savings and loan companies, brokers...).
- 30+ Loan Products (House, Consumer Durables, Small Business Loans, Commercial RE).

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- 30+ Loan Products (House, Consumer Durables, Small Business Loans, Commercial RE).
- Monthly **new** loan advertised rates (New to the literature).
- Loan product characteristics.
- Branch location, ownership & rate-setting rights.

Data: Macro at all levels.

**1 National - Level :**

- GDP, CPI Index, Commodity Price Index, Excess Bond Premium, Home Price Index, Home Ownership Indexes.

**2 State - Level :**

- GDP (total and by Industry), Personal Income,
- Inflation (Hazell et al. (2020))
- State Home Price Index.

**3 County/MSA - Level :**

- Unemployment (BLS-LAUS)
- Wages (BLS-QCEW & CES)
- House Prices (Zillow)

## Data: Lending at all levels

### 4 **Lender - level** (Call Reports):

- Assets and liabilities.
- Interest revenue and expense by Asset & Liability category
- Number of branches and deposits by branch county-level.

### 5 **Other: Branch - level** (FDIC Summary of Deposits):

- Anagraphic and total deposits by branch/year.

### 6 **Other: Loan - level** (Freddie-Mac Data):

- Loan characteristics (Location, LTV)
- New/Renegotiation/Cash-out status
- Borrower characteristics (FICO)

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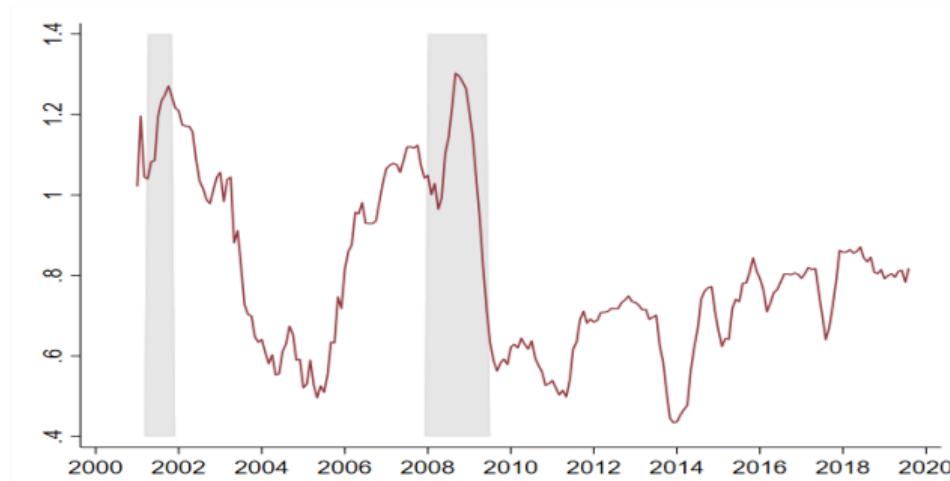
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## Branch-Level Data: variation over time and space

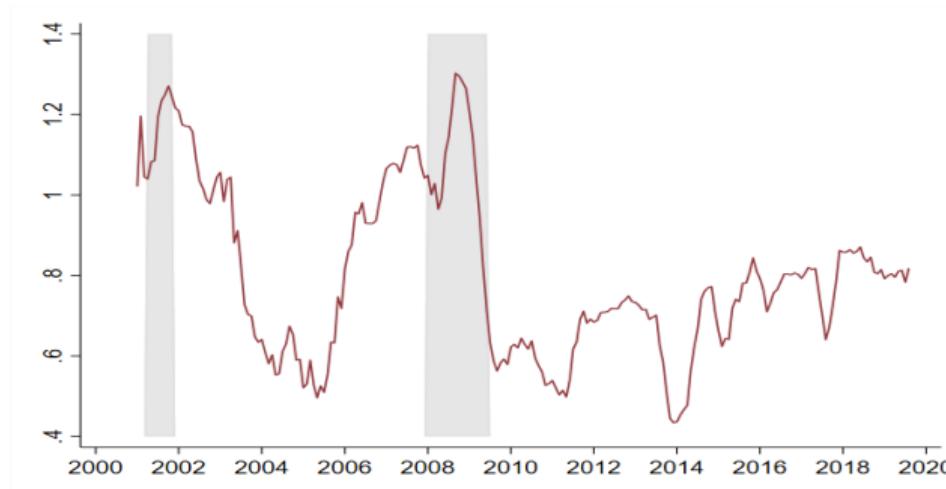
**Example: New advertised Loan Rates for Personal Recreational Vehicle purchase.**



Lending rates skewness, US overall distribution.

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## 4 Empirical Analysis

- Advertised Lending Rates
- Unemployment

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## Local projection specification

**Methodology:** Local projections. County (c) /month (m) level.

$$\begin{aligned}\text{Outcome Variable}_{t+h,c} &= \alpha + \beta_0 \text{MP}_t + \beta_1 \left[ \widehat{\text{MP}}_t \times \widehat{\text{Skewness}}_{t-1,c} \right] + \\ &+ \sum_{k=1}^2 \rho_{1,k} \text{MP}_{t-k} + \sum_{k=1}^2 \rho_{2,k} \left[ \widehat{\text{MP}}_{t-k} \times \widehat{\text{Skewness}}_{t-k-1,c} \right] + \\ &+ \sum_{k=1}^2 \gamma_k X_{t-k,c} + \sum_{k=1}^2 \delta_k X_{t-k,US} + \sum_{k=1}^2 \chi_k X_{t-k,Bank} + \varepsilon_{t,c}\end{aligned}$$

**Outcome Variables:** County Average Lending Rate, County Unemployment Rate.

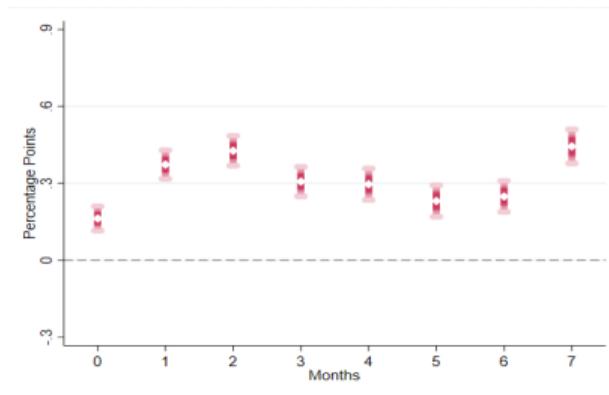
**Controls:** National GDP, Defl, Stock Market, Excess Bond Premium, county: wage growth, unemployment, home prices, Herfindal Index, ROA, Cost of Funds, Loan Loss Provisions, Category/County FE.

**Identification:** High Frequency Proxy from Bauer and Swanson (2022).

**Note:**  $\widehat{\text{Skewness}}$  defines the county-level skewness subtracted of its long-run mean.

## Coefficient Plots: Lending Rates

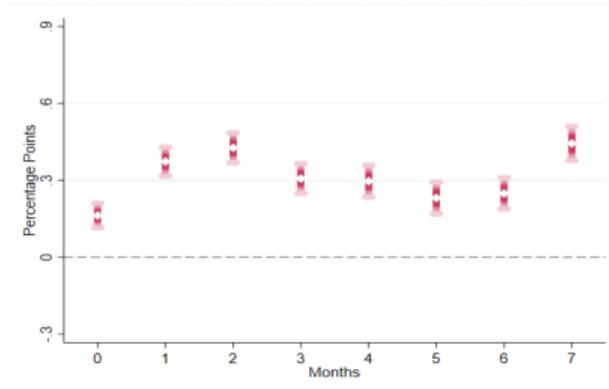
Average response of county lending rates to 100 b.p. MP shock



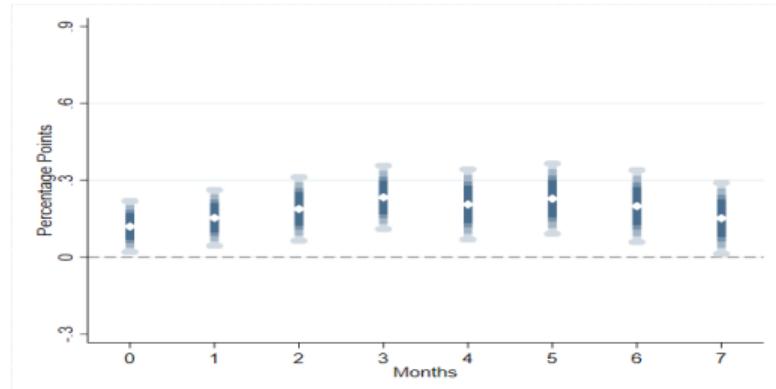
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- Pass-Through significantly higher when skewness is high.

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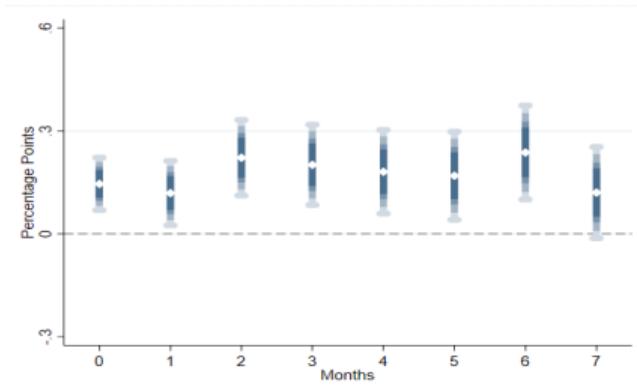


(b) Additional impact with skewness 1 s.d. above mean ( $\beta_1$ )

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## Robust Specification: Lending Rates

Average response of county average lending rates to 100 b.p. MP shock, robust specification

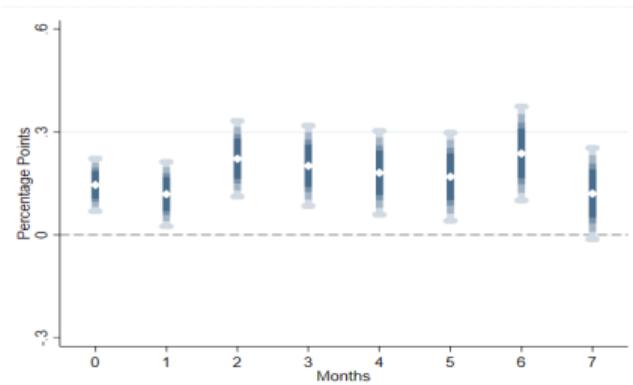


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- Skewness remains highly significant.
- Variance is not significant.

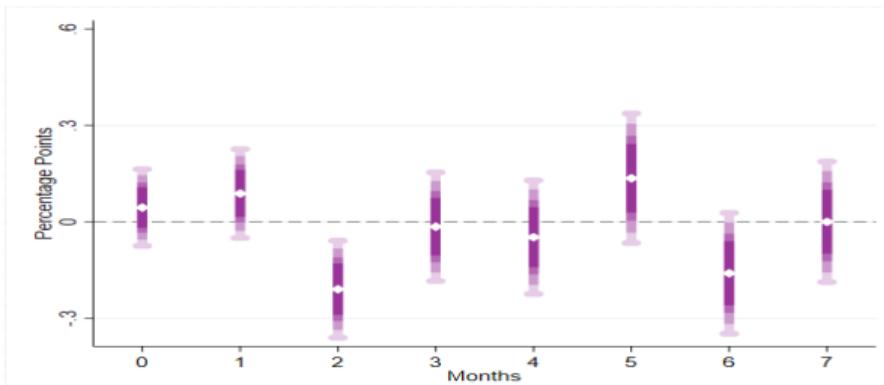
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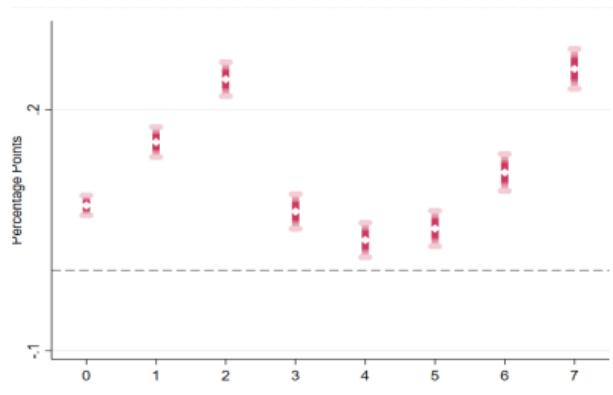


(c) Additional impact: variance 1 s.d. above mean ( $\beta_3$ )

▶ Table Results

## Coefficient Plots: Unemployment Rate

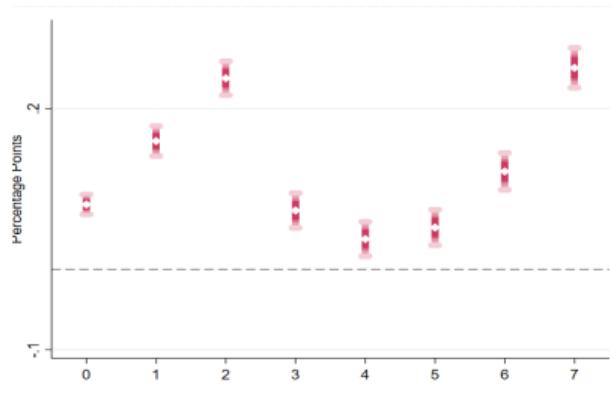
Average response of county unemployment rate to 100 b.p. MP shock



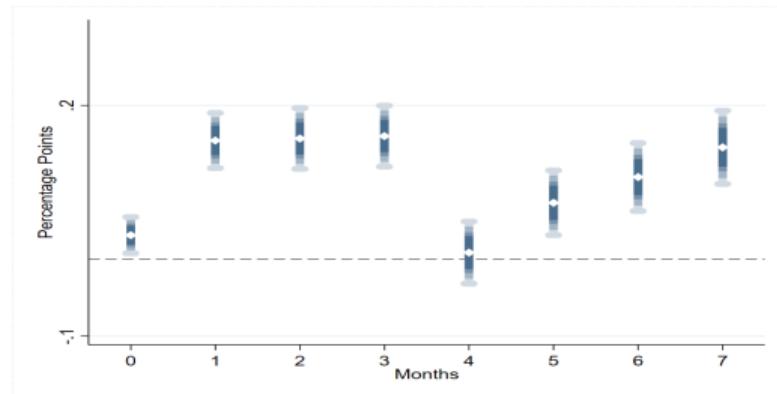
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## Robustness

- Variance vs Skewness.
- Increased Set of Interaction Terms.
- Different High-Frequency Proxy.
- Average Interest Rate Expense.
- Robustness with Respect to US pooled Skewness.
- Real Personal Income (State/Lender Level Data).
- Loan-Level Data on Realized Rates.

► More Robustness

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2 Data

3 Cross-sectional Moments Zoom-in

4 Empirical Analysis

5 Theoretical Framework

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# Main Model Ingredients

## Skewness to Theory:

- The key mechanism underlying the relevance of the skewness as a state variable involves:
  - 1 Lenders imperfect price competition.
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► Very Simple Illustrative Framework

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## Model Structure:

- Repeated Bertrand Competition: two banks (Bank H & L) and many identical clients.

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## Game Timeline

Each period is made of 4 stages:

- **Stage 0:** A measure one continuum of clients becomes in need for a new loan of which:

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- **Solution** mass of searching customers will be:

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$$\lambda_1 * (1 - S(r_{t-1}^H - r_{t-1}^L))$$
  
$$S(r_{t-1}^H - r_{t-1}^L) = \text{measure of clients with search cost} > \text{expected gain from switching to lender L.}$$

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- **Stage 2:** Monetary Policy shock hits  $\Rightarrow$  Banks' marginal cost of lending.

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- Clients choice:
  - Client of L takes loan from L if  $v - z_L - r_t^L > 0$ .
  - Client of H who did not search borrows if:  $v - z_H - r_t^H > 0$

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  - Client of H who did search borrows if:  $v - z_H - r_t^H \geq v - z_L - r_t^L$

## Where the fun happens: demand functions

**Demand Functions:**

**Bank H:**

$$X_H(r_H, r_L) = \bar{Q}_H - \beta_H r_H + \kappa r_L$$

**Bank L:**

$$X_L(r_H, r_L) = \bar{Q}_L - \beta_L r_L + \kappa r_H$$

## Where the fun happens: demand functions

**Demand Functions expanded:**

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$$X_H(r_H, r_L) = \left[ \bar{Q}_H - \underbrace{\left[ \lambda_1 S + \frac{1}{2} \lambda_1 (1 - S) \right] r_H}_{\beta_H} + \underbrace{\left[ \frac{1}{2} \lambda_1 (1 - S) \right] r_L}_{\kappa} \right]$$

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**State Dependency:**  $S = S(r_{t-1}^H, r_{t-1}^L)$

## Profit Functions

**Bank H:**

$$\pi_H = [r_H - c] \left[ \bar{Q}_H - \underbrace{\left[ \lambda_1 S + \frac{1}{2} \lambda_1 (1 - S) \right]}_{\beta_H} r_H + \underbrace{\left[ \frac{1}{2} \lambda_1 (1 - S) \right]}_{\kappa} r_L \right]$$

**Bank L:**

$$\pi_L = [r_L - c] \left[ \bar{Q}_L - \underbrace{\left[ \lambda_2 + \frac{1}{2} \lambda_1 (1 - S) \right]}_{\beta_L} r_L + \underbrace{\left[ \frac{1}{2} \lambda_1 (1 - S) \right]}_{\kappa} r_H \right]$$

**Solution Strategy:**

- Best Responses. ([▶ details](#))
- Equilibrium Rates. ([▶ details](#))
- Pass-Through.

## Results about the Pass-Through.

Consider the Pass-Through, respectively  $\frac{\partial r_L^*}{\partial c}$ ,  $\frac{\partial r_H^*}{\partial c}$

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$$\frac{1}{2} < \frac{\partial r_i^*}{\partial c} < 1 \quad \text{for } i = H, L^1.$$

- **Intuition 1.1:** Pass-Through  $> \frac{1}{2}$  (Monopolist).
- **Intuition 1.2:** Pass-Through  $< 1$  (Bertrand Paradox).

<sup>1</sup> Technical Condition:  $\kappa < \beta_i$

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- **Take-Away** Mass of borrowers searching pins down how close the pass-through is to either of the two extremes.

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## Results about the Pass-Through.

### Proposition 2

$\frac{\partial r_i^*}{\partial c}$  is increasing in  $(r_{t-1}^H - r_{t-1}^L)$  and  $\lambda_1$ .

**Intuition:** Larger difference among past rates  $\Rightarrow$  More clients search.

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► Variance vs Skewness

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### Implications:

- 1 Empirical Test of Proposition 3. (next slide)
- 2 **Path Dependence** of Monetary Policy.

<sup>1</sup> Technical Condition  $\lambda_2 > \lambda_1 S$

► Variance vs Skewness

## Empirical Test of Proposition 3

Table: Responsiveness of High vs Low Rate lender to a 100 b.p. monetary policy shock when skewness is high

Month	0	1	2	3	4	5	6	7	8	9	10
Low Rate	-0.01 (-0.69)	-0.01 (-0.39)	0.03 (1.25)	0.04* (1.89)	0.06** (2.35)	0.08*** (3.40)	0.42*** (16.37)	0.45*** (17.43)	0.38*** (14.81)	0.09*** (3.41)	0.20*** (7.91)
High Rate	-0.06* (-2.56)	-0.04 (-1.24)	0.01 (0.40)	0.13*** (3.46)	0.15*** (3.91)	0.13*** (3.31)	0.10*** (2.61)	0.07* (1.69)	0.09** (2.21)	0.20*** (4.90)	0.14*** (3.52)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N	2317536	2200605	2139583	2080359	2028567	1983506	1943036	1898621	1860857	1823443	1784944
R <sup>2</sup>	0.977	0.968	0.961	0.955	0.950	0.946	0.943	0.940	0.938	0.936	0.934

t statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## Conclusions

- **Lending rate skewness** is a **quantitatively** important **state-variable** for MP effects.

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**THANKS!**

## Conclusions

- Lending rate skewness is a **quantitatively** important state-variable for MP effects.
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- Can account for heterogeneity across space and time of MP effects.

**THANKS!**

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- **Search Frictions** create skewness-based state-dependent responses of lending rates to MP.

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## Conclusions

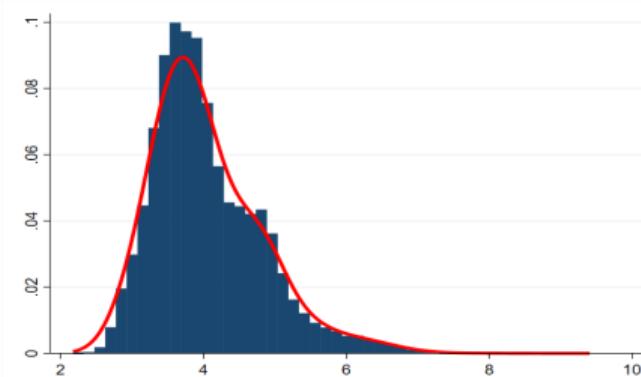
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- **Future work:**
  - 1 Include data on loan applications to measure search efforts empirically.
  - 2 Extend analysis to deposit rates.
  - 3 Explore GE outcomes in general dynamic macro model.

**THANKS!**

# APPENDIX

## APPENDIX

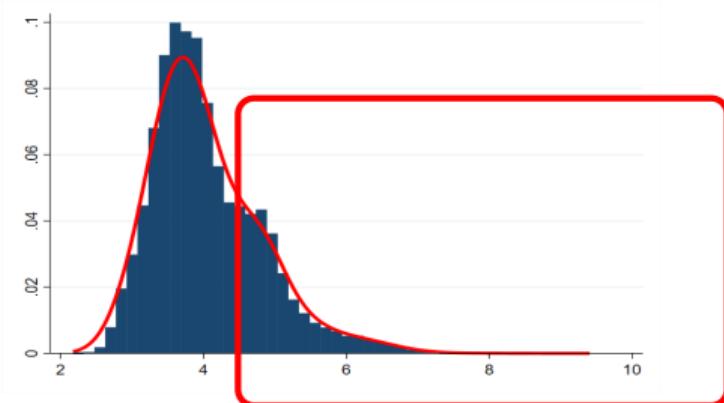
## Facts: The curious shapes of the lending rate distributions.



(a) 30Y Mortgage Rates. Minneapolis-MSA. 2019-M1.

- Pronounced Asymmetric shape, market concentration but...

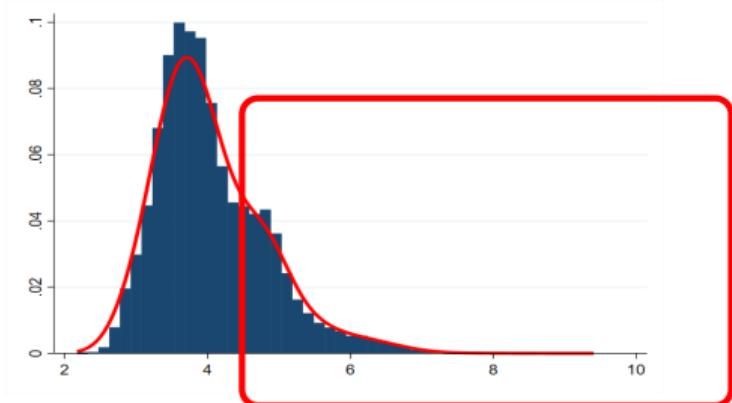
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(b) Skewness Time-Series. Minneapolis-MSA

- Pronounced Asymmetric shape, market concentration but...
- Asymmetry is time-varying (next slides)

► MSA-Cross Distribution

► Branch-Level Distribution

► Online Marketplace dispersion

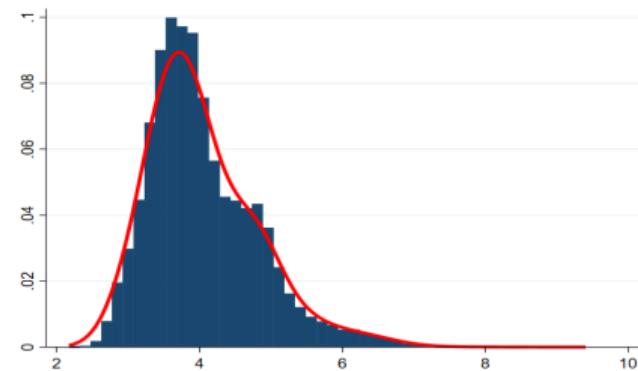
► Row Rates

► MP Pass-Through Heterogeneity

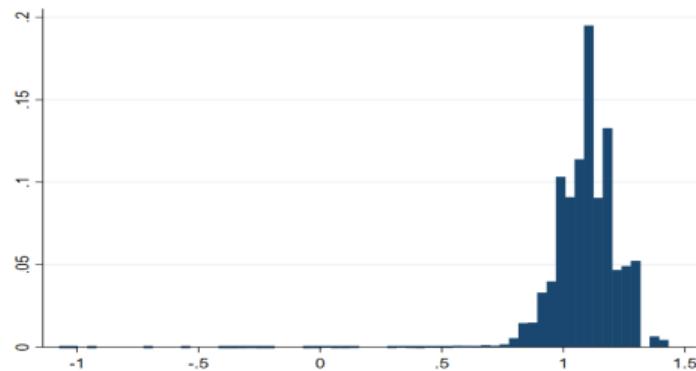
► Back

## Facts: The curious shapes of the lending rate distributions.

### Mortgage Rates cross-section. Minneapolis MSA vs All MSAs. Purged Borrower/Loan type.



(a) Distribution in 2019-M1.



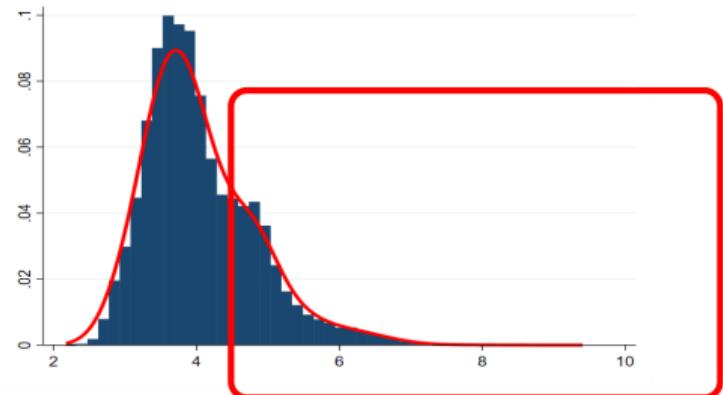
(b) Skewness Distribution Over MSAs. (Recessions in grey)

- Pronounced Asymmetric shape, market concentration but...
- Skewness cross-section MSA distribution centered around 1 and positive.

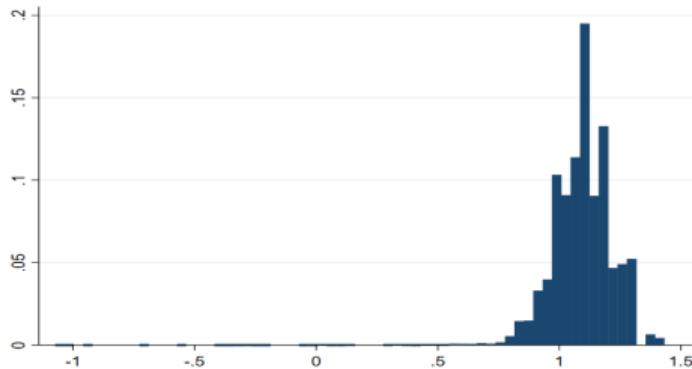
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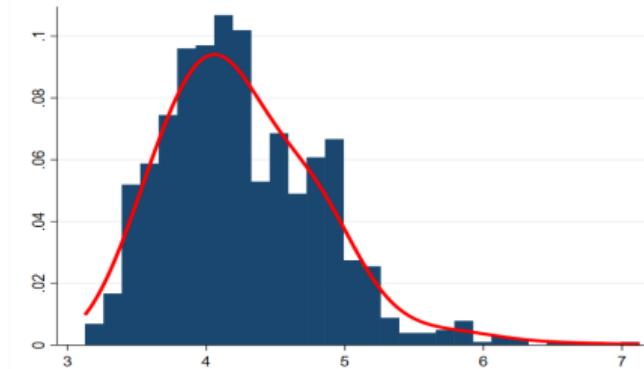
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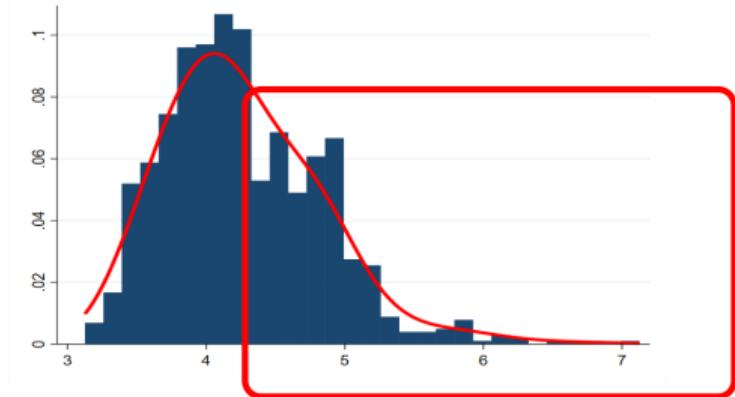


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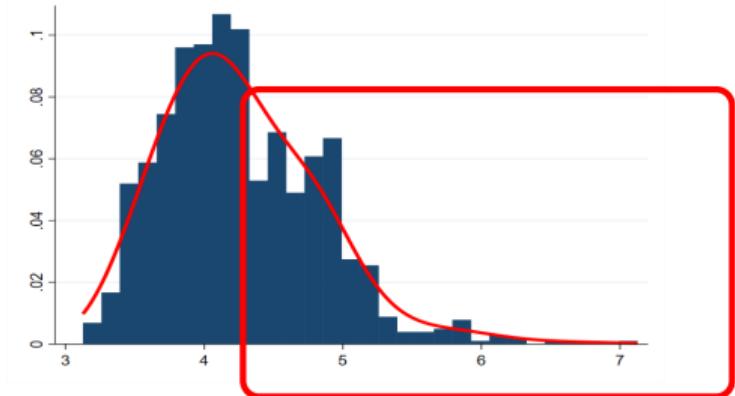


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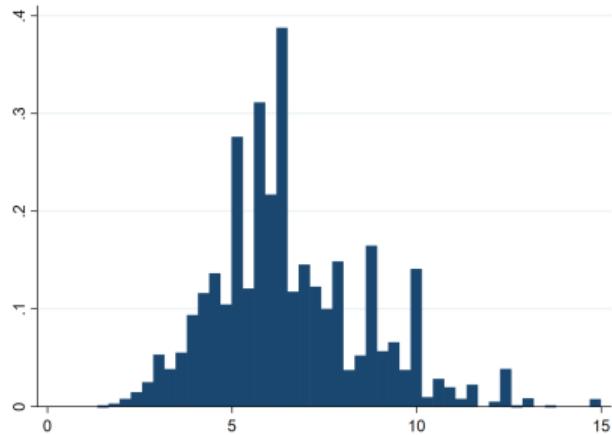


(b) Skewness over time. (Recessions in grey)

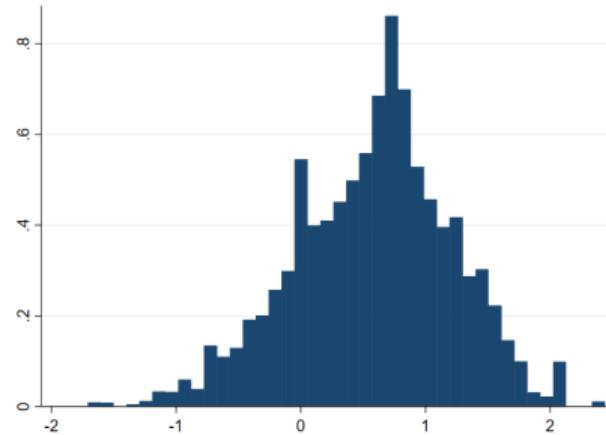
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## Facts: The Distribution of offered rates by lender branch

Offered Rates on Pers Rec Veichle Loans



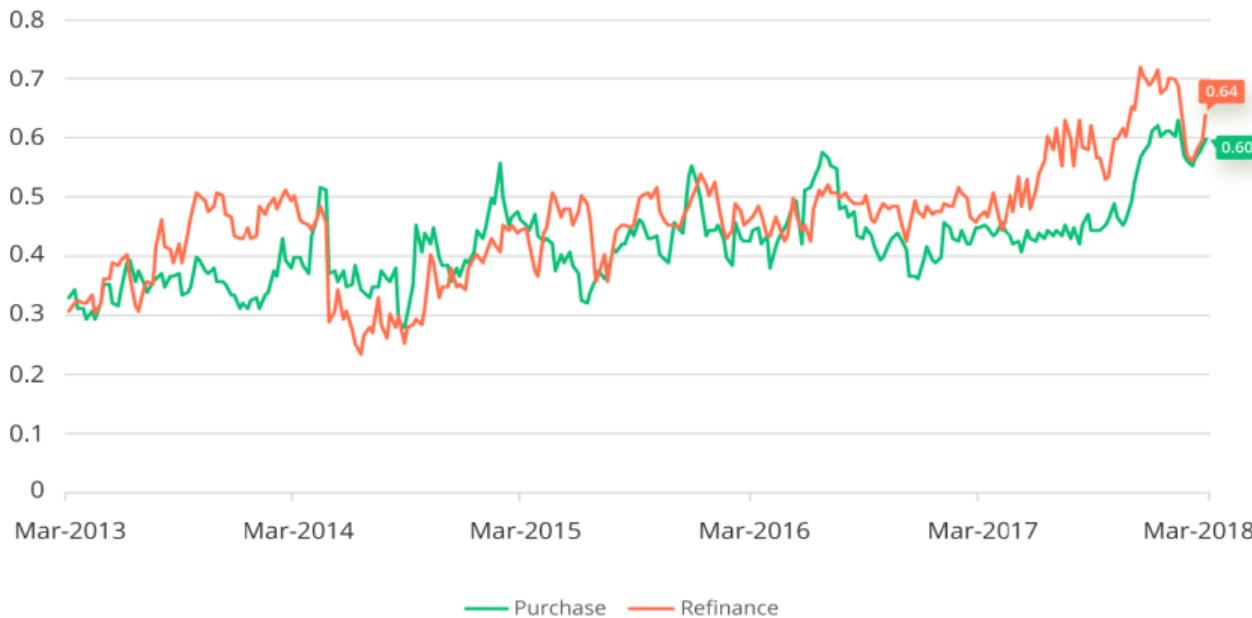
(a) L.A. Cross-sectional Distribution Lending Rates. 2016m1.



(b) National distribution of cross-sectional skewness.

▶ Back

## Facts: The lending rate dispersion on Online Marketplaces



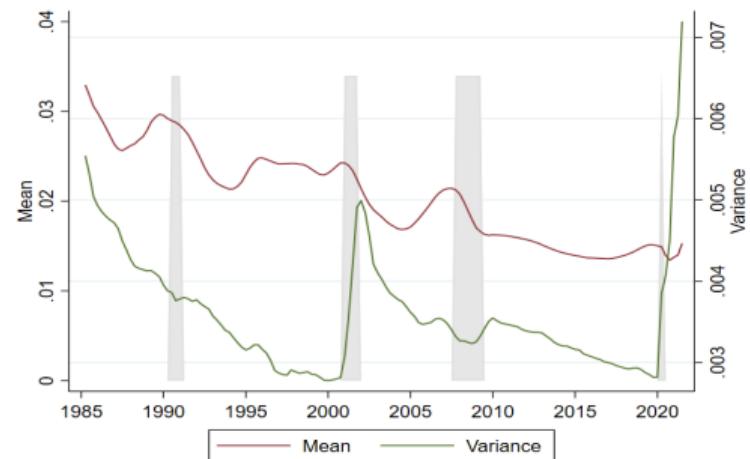
Interest Rate Dispersion on LendingTree.com

▶ Back

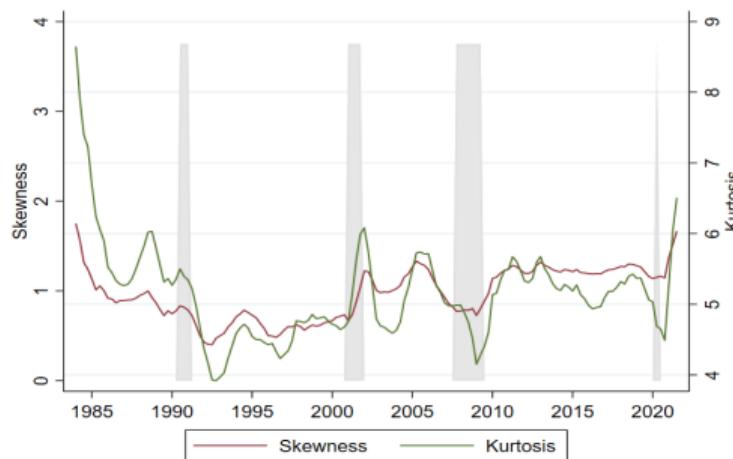
## Lender-Level Distribution: higher order moments non-trivial dynamics

### C&I Loan average interest rates

Mean and Variance



Skewness and Kurtosis

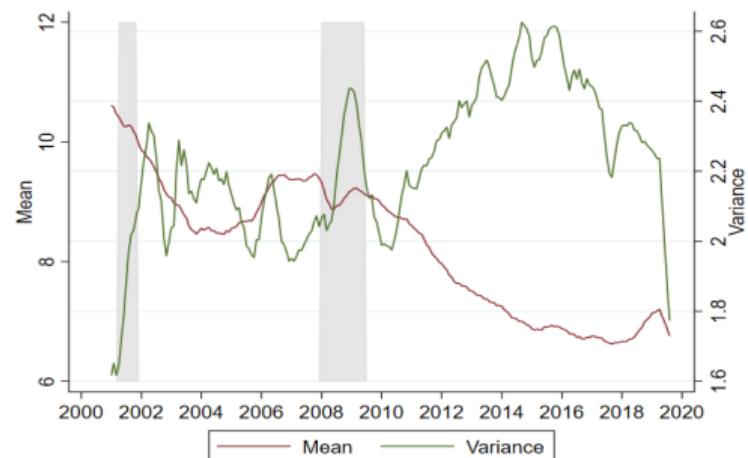


- Significant Time-Variation.
- Correlation between Skewness and Kurtosis.
- Different behaviour across different Recessions.

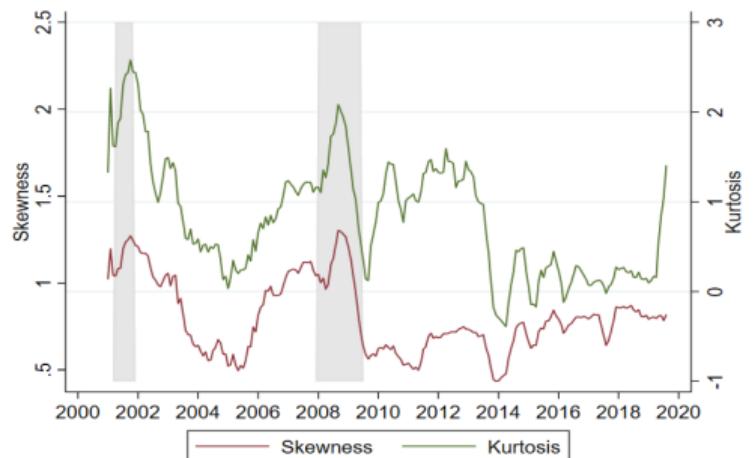
## Branch-Level Distribution: higher order moments non-trivial dynamics

### Personal Recreational Vehicle Advertised Loan Rates.

Mean and Variance

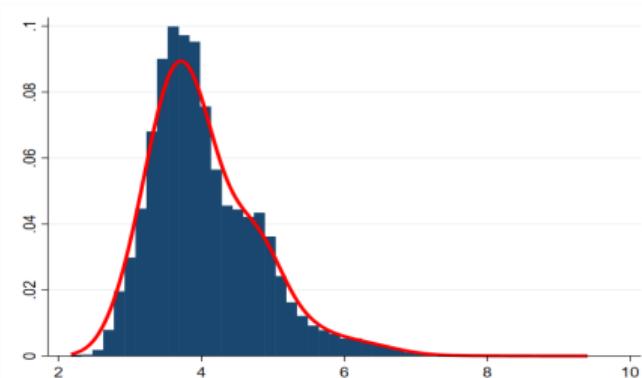


Skewness and Kurtosis



▶ Back to Outline

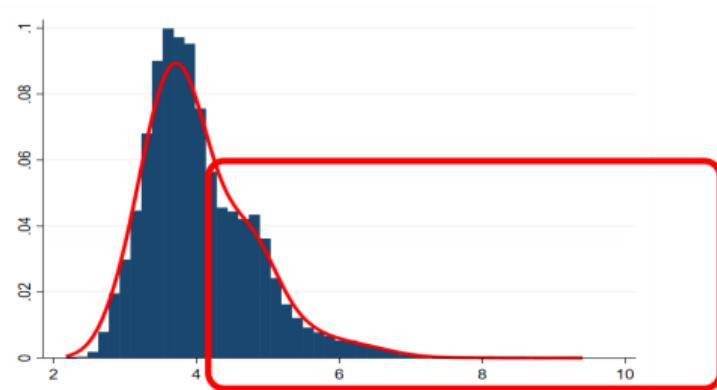
## Freddie Mac Data on Realized House Mortgage Rates



(a) 30Y Mortgage Rates. Minneapolis-MSA. 2019-M1.

- Displayed distribution is residualized wrt Borrowers and Loan Observables as in Hurst et al. (2016).
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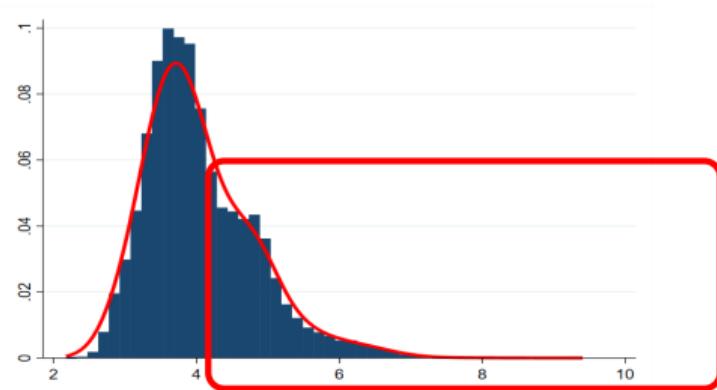
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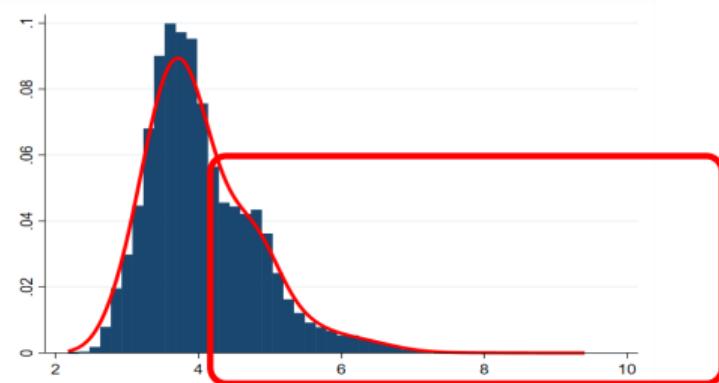
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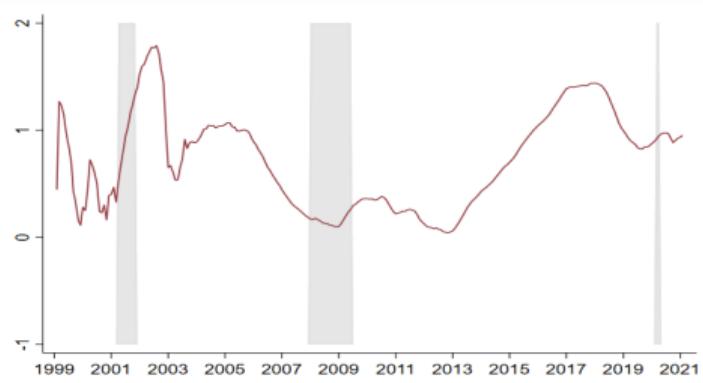
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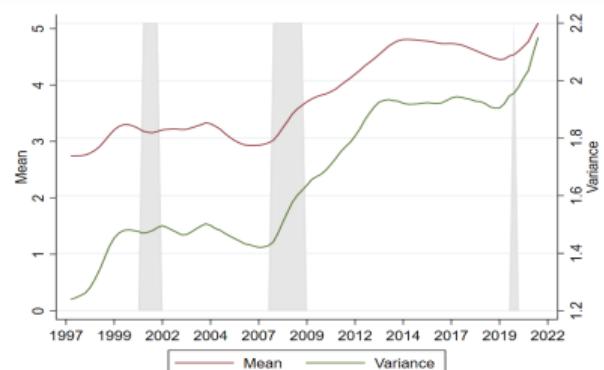
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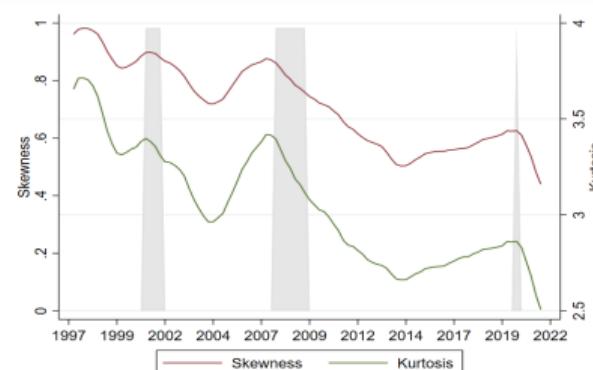
# Evolution of Asset Average Maturity Distribution 1st to 4th Moment

## Asset average maturity over time.

Mean and Variance



Skewness and Kurtosis



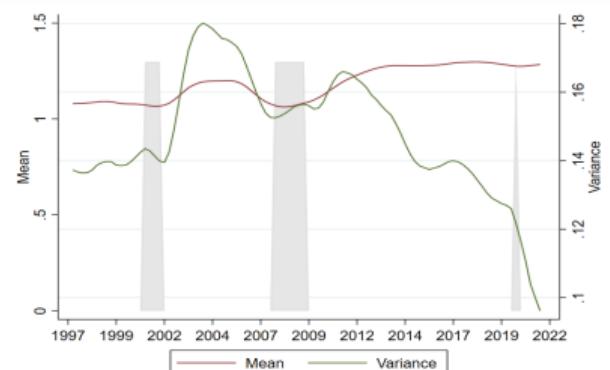
Asset average maturity computed as weighted average maturity assigning mid maturity to each asset category.

▶ Back

# Evolution of Liabilities Average Maturity 1st to 4th Moment.

## Liability average maturity over time.

Mean and Variance



Skewness and Kurtosis



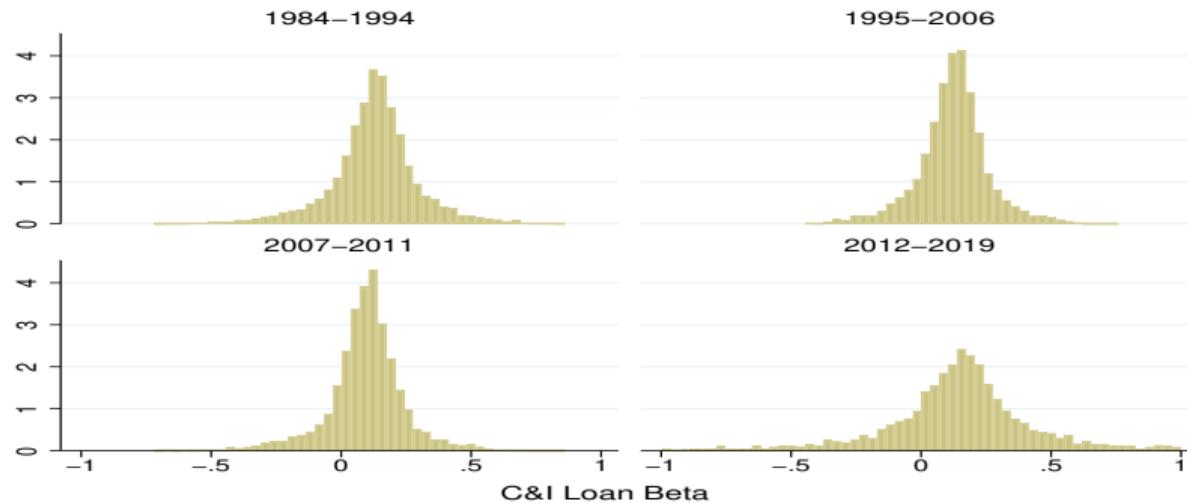
Liability average maturity computed as weighted average maturity assigning mid maturity to each liability category.

▶ Back

## Evolution of C&I Loans Dynamic Beta full distribution

Beta: Measure of sensitivity of Loan Rate to movements in the policy rate (Drechsler et al. (2017))

$$\Delta \text{Rate}_{bank,t} = \alpha_{bank} + \alpha_t + \sum_{k=1}^4 \beta_{bank,k} \Delta FFR_t + \varepsilon_{bank,t} \quad \text{BETA} = \sum_{k=1}^4 \beta_k$$

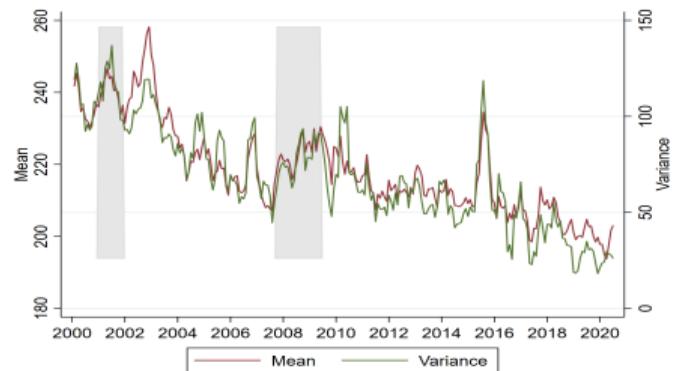


▶ Back

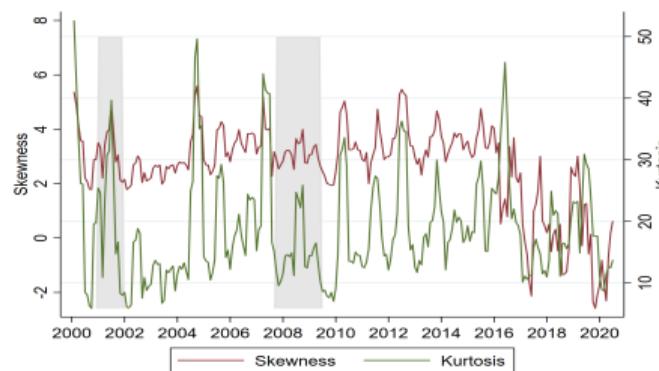
# Evolution of Interest Rate Distribution 1st to 4th Moment. Dealscan

**Dealscan interest rate spreads moments over time (average moment value over all Loan Types)**

Mean and Variance



Skewness and Kurtosis



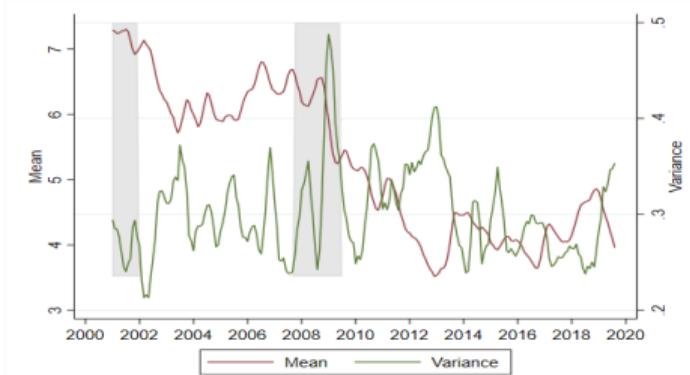
Interest rates spread on base rate from Dealscan Data at monthly frequency.

▶ Back

# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

**Ratewatch interest rate spreads moments over time (30 Yr Fxd Mtreplace @ 175K)**

Mean and Variance



Skewness and Kurtosis



Interest rates at monthly frequency.

▶ Back

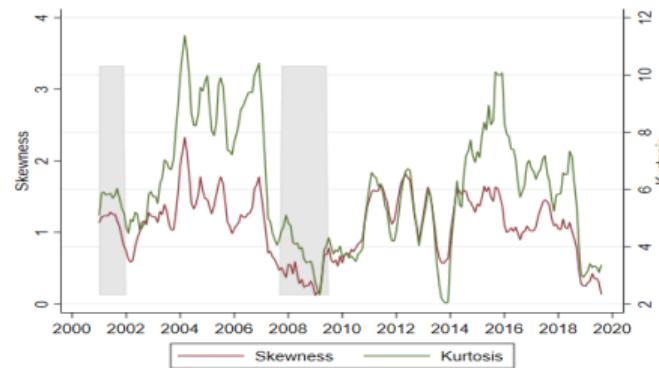
# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

**Ratewatch interest rate spreads moments over time (3 Year ARM @ 175K)**

Mean and Variance



Skewness and Kurtosis

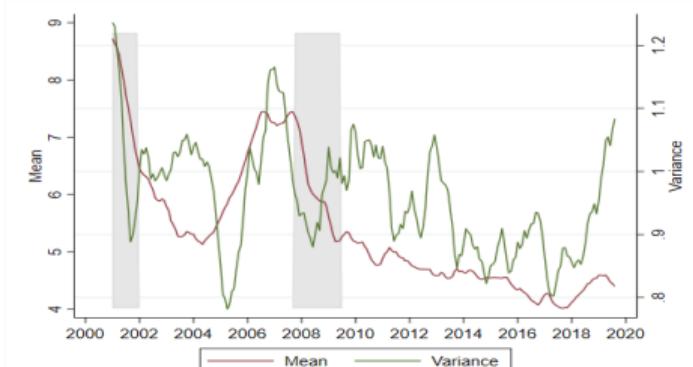


Interest rates at monthly frequency.

# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

**Ratewatch interest rate spreads moments over time (Construction Loan @ 175K)**

Mean and Variance



Skewness and Kurtosis



Interest rates at monthly frequency.

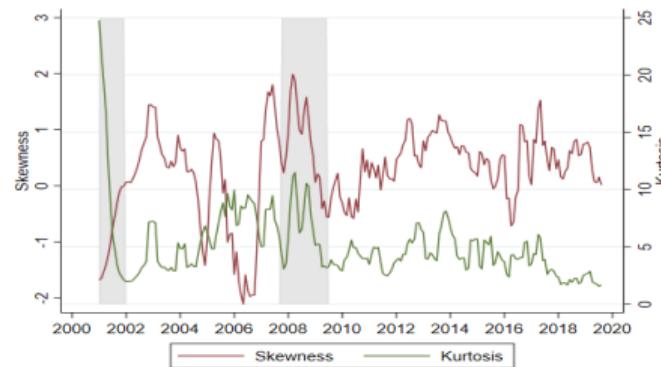
# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

**Ratewatch interest rate spreads moments over time (Bus Loan Secured @ 50K)**

Mean and Variance



Skewness and Kurtosis

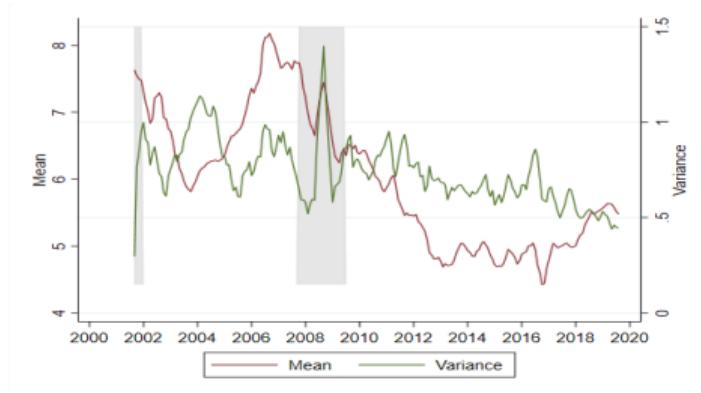


Interest rates at monthly frequency.

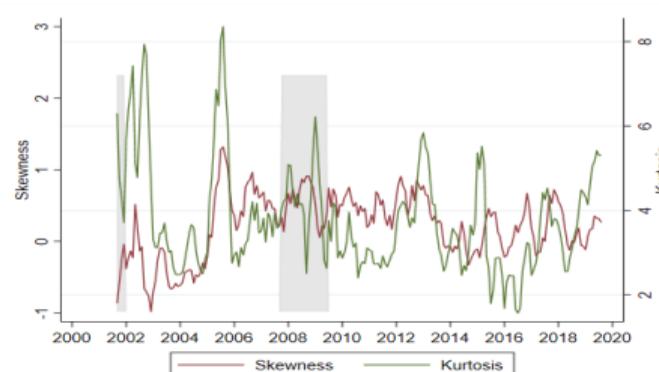
# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

**Ratewatch interest rate spreads moments over time (Comm Real Estate @ 1M)**

Mean and Variance



Skewness and Kurtosis

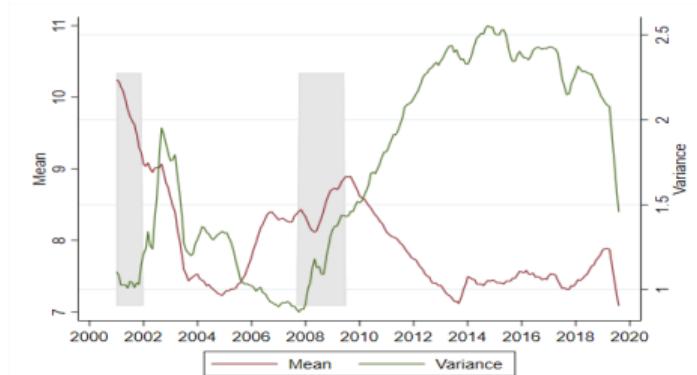


Interest rates at monthly frequency.

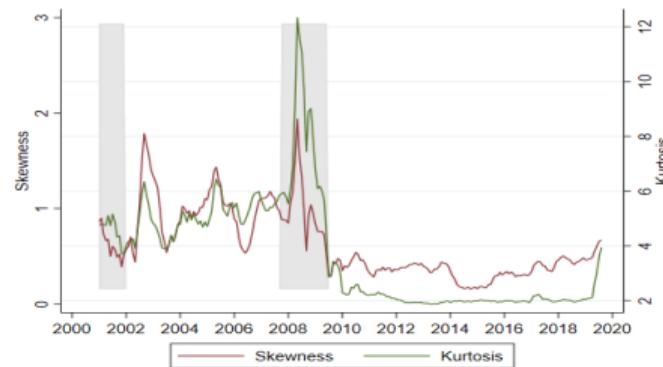
# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

## Ratewatch interest rate spreads moments over time (Boat New)

Mean and Variance



Skewness and Kurtosis



Interest rates at monthly frequency.

# Evolution of Interest Rate Distribution 1st to 4th Moment. Ratewatch

## Ratewatch interest rate spreads moments over time (Personal Vehicle New)

Mean and Variance



Skewness and Kurtosis

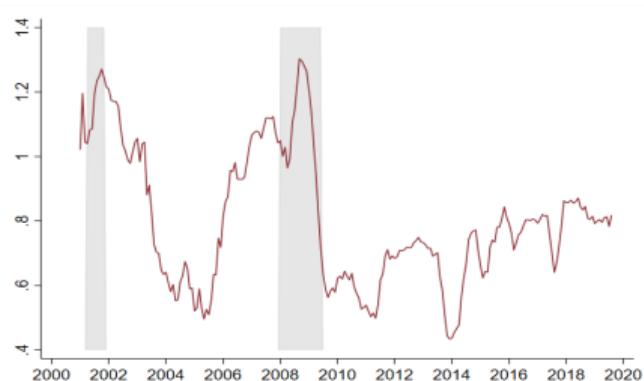


Interest rates at monthly frequency.

▶ Back

## Branch-Level Data: cross-sectional skewness over time

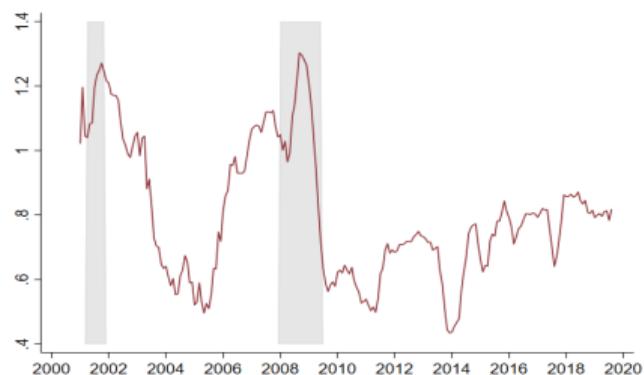
**Example: New advertised Loan Rates for Personal Recreational Vehicle purchase.**



(a) Lending rates skewness, US overall distribution.

## Branch-Level Data: cross-sectional skewness over time

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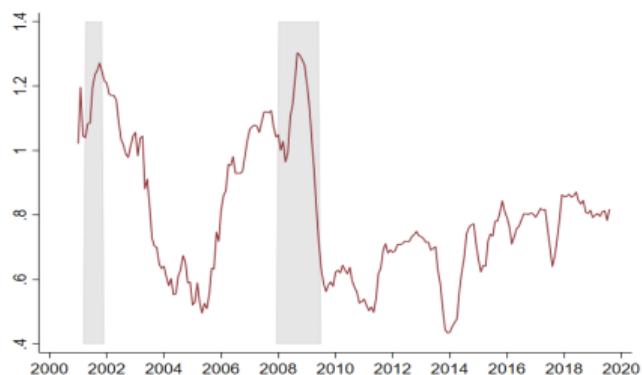
(a) Lending rates skewness, US overall distribution.



(b) Mean of within-county skewness measures.

## Branch-Level Data: cross-sectional skewness over time

**Example: New advertised Loan Rates for Personal Recreational Vehicle purchase.**



(a) Lending rates skewness, US overall distribution.

- ⇒ High variation.
- ⇒ Distribution of skewness across counties shifts over time.



(b) Mean of within-county skewness measures.

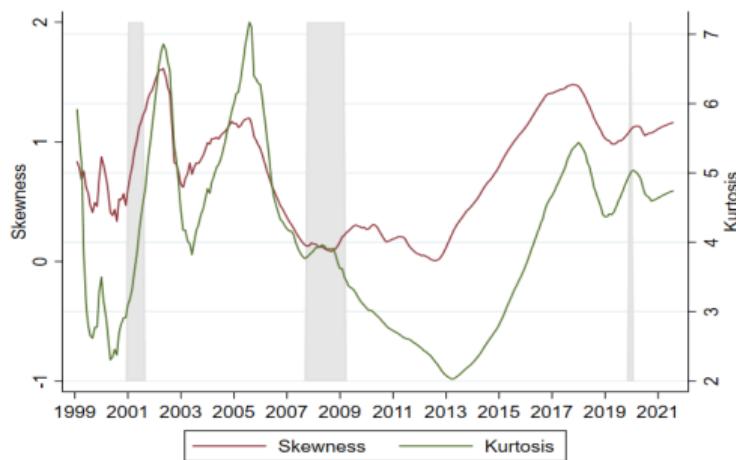
# Loan-Level Distribution: higher order moments non-trivial dynamics

## Freddie Mac Mortgage Rates. Purged. Moments over time.

Skewness and Kurtosis, County-Level Mean



Skewness and Kurtosis, pooled-US Mean



▶ Back

## MP Pass-Through heterogeneity Across-States

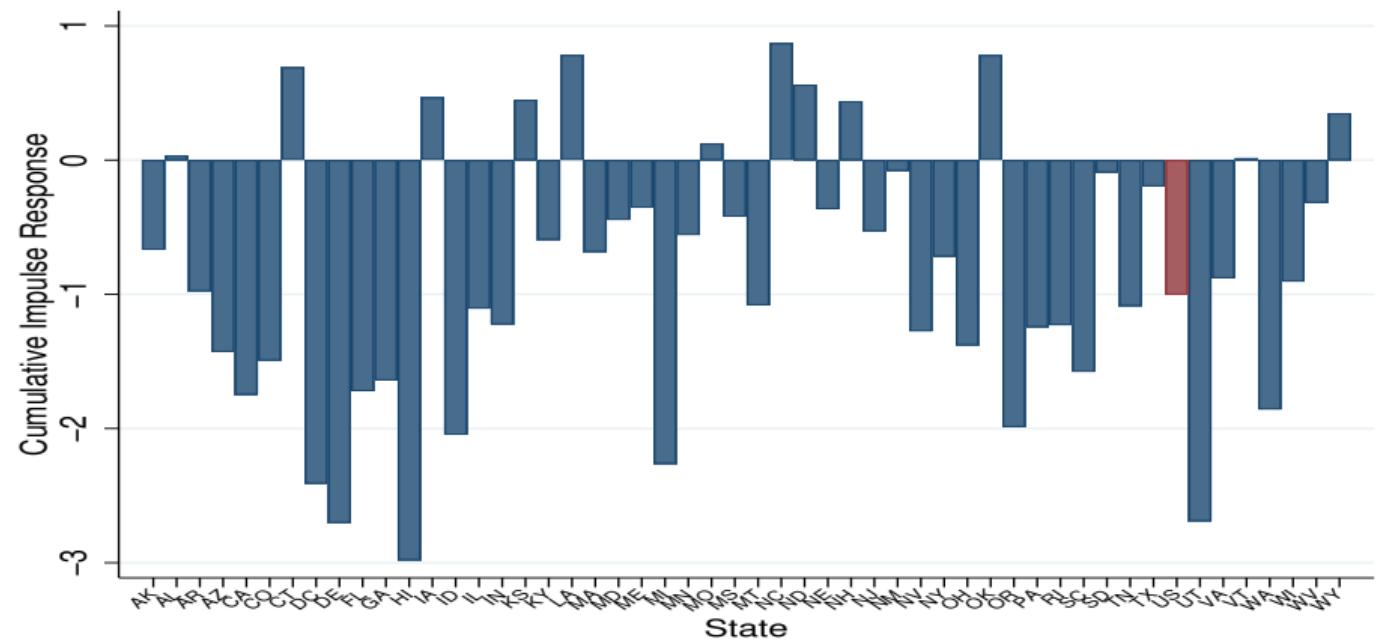


Figure: IRF to 1% MP Shock. IV Local Projections.

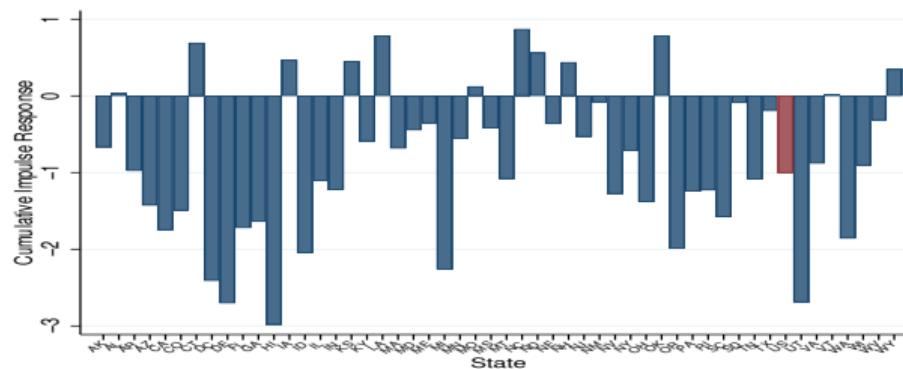
▶ Back

## MP Heterogeneity Across States

**Methodology:** IV Local Projections with High-Frequency Proxy by State.<sup>1</sup>

$$\text{Pers.Inc}_{t+h,s} = \alpha_s + \beta_s \underline{\text{FFR}}_t + \sum_{k=1}^2 \rho_k \text{FFR}_{t-k} + \sum_{k=1}^2 \gamma_k X_{s,t-k} + \sum_{k=1}^2 \delta_k X_{US,t-k} + \varepsilon_{s,t}$$

2 Years Cumulative Impulse Response of Real Personal Income to MP shock



<sup>2</sup> Proxy Identification as in Jarociński and Karadi (2020)

## Estimation Results

Average Income response to  $MP_s = \alpha + \beta \text{ bank moments}_s + \gamma \text{ controls}_s + \varepsilon_s$

VARIABLES	(1) Baseline	(2) SM Banks	(3) NII
Asset Mat M1	0.57** (0.22)	0.68*** (0.22)	0.64*** (0.21)
Liab Mat M1	-5.38 (3.29)	-5.28 (3.13)	-3.67 (3.22)
Asset Mat M3	-0.05*** (0.02)	-0.06*** (0.02)	-0.05*** (0.02)
Liab Mat M3	16.09* (8.57)	19.45** (8.30)	18.37** (8.20)
Constant	9.07*** (2.94)	5.95* (3.13)	5.75* (3.15)
Controls	YES	YES	YES
Observations	51	51	51
R-squared	0.57	0.62	0.62

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

▶ Back

▶ More on Controls

▶ Full-Table

Average income response to  $MP_s = \alpha + \beta \text{ bank moments}_s + \gamma \text{ controls}_s + \varepsilon_s$

### Bank Moments:

- Asset Average Maturity.
- Liability Average Maturity.
- Average Interest Rate Earned.
  - Mean (M1)
  - Skewness (M3)

### Controls:

- House Price Growth
- Percent of total GDP:
  - Durables
  - Non-Durables
  - Construction
  - Services
- Bank Related Variables:
  - Capital Ratio
  - Net Interest Income
  - Percent of Small Medium Banks.

▶ back

## Estimation Results

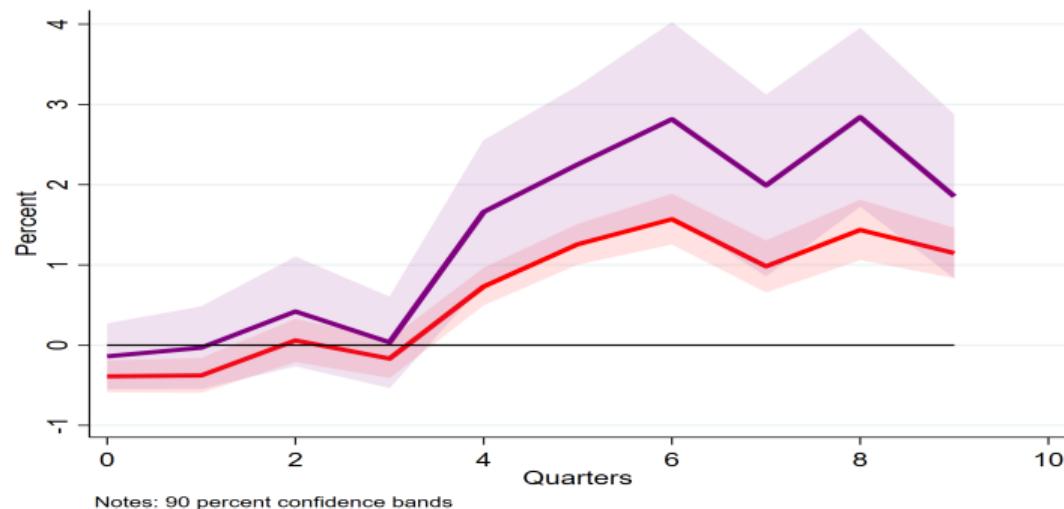
VARIABLES	(1) Baseline	(2) SM Banks	(3) NII
House Prices	-51.50** (22.55)	-43.04* (21.82)	-43.00* (21.76)
Asset Mat M1	0.57** (0.22)	0.68*** (0.22)	0.64*** (0.21)
Liab Mat M1	-5.38 (3.29)	-5.28 (3.13)	-3.67 (3.22)
Asset Mat M3	-0.05*** (0.02)	-0.06*** (0.02)	-0.05*** (0.02)
Liab Mat M3	16.09* (8.57)	19.45** (8.30)	18.37** (8.20)
Int Rate M1	46.32 (45.60)	-3.04 (48.77)	-22.11 (52.76)
Equity Ratio	-38.37* (21.54)	-5.84 (25.18)	-11.18 (23.71)
Non-Durables	-0.02 (0.03)	0.00 (0.03)	0.02 (0.04)
Durables	-0.05* (0.03)	-0.04 (0.03)	-0.04 (0.03)
Constr	-0.22* (0.13)	-0.12 (0.13)	-0.12 (0.13)
Services	-0.04** (0.02)	-0.03 (0.02)	-0.03 (0.02)
SM Banks		2.59** (1.16)	
Net Interest			24608778.81** (10821772.96)
Constant	9.07*** (2.94)	5.95* (3.13)	5.75* (3.15)
Observations	51	51	51
R-squared	0.57	0.62	0.62

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## Dynamic US States

Impulse responses to 50bp exogenous decrease in MP Rate. Deposit Rates

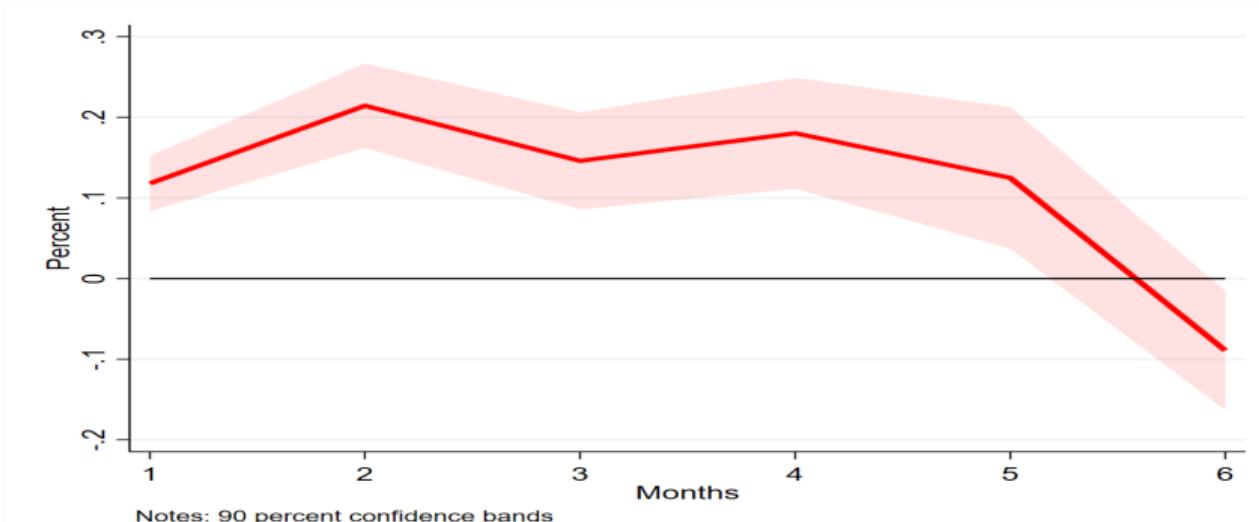


Red line: bank moment channel is shut down. Purple Line: bank moment channel is active.

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## Dynamic Granular Level Data: Ratewatch Data - Consumer Durable Goods

Impulse Response of offered loan rates to MP: Coefficients

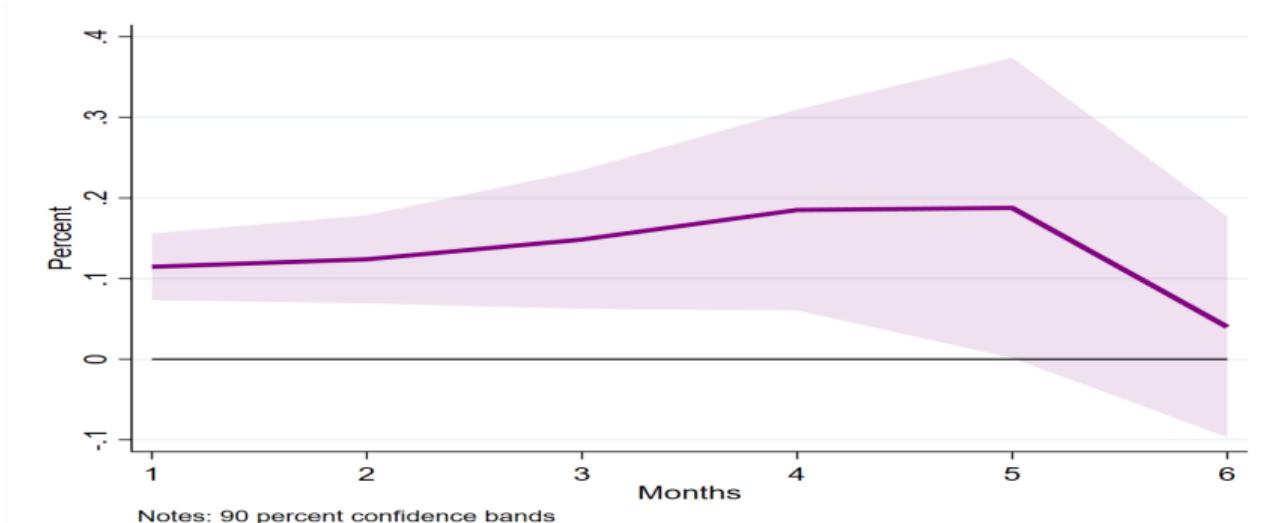


Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

▶ back

## Dynamic Granular Level Data: Ratewatch Data - Consumer Durable Goods

Impulse Response of offered loan rates to MP: Coefficients

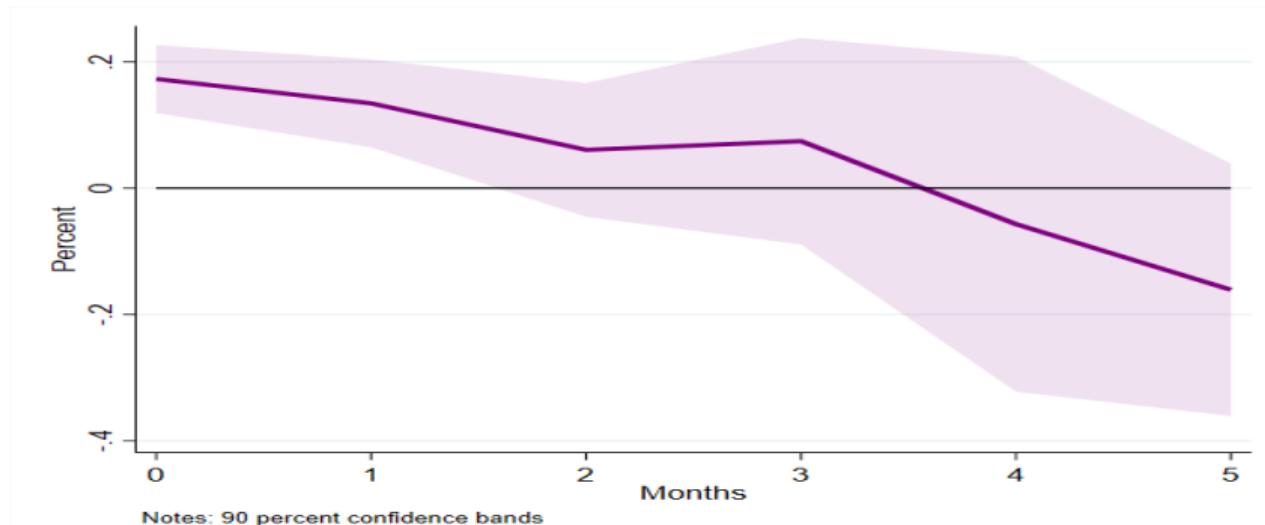


Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

▶ back

# Dynamic Granular Level Data: Ratewatch Data - Consumer Durable and House Mortgages

Impulse Response of offered loan rates to MP: Skewness Coeff

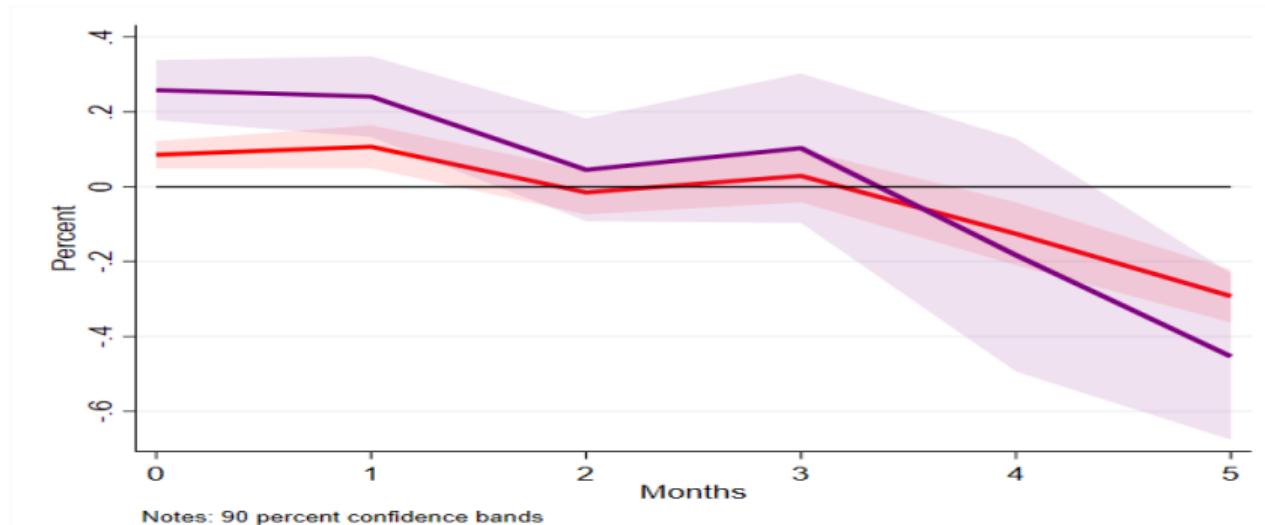


Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

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# Dynamic Granular Level Data: Ratewatch Data - Consumer Durable and House Mortgages

Impulse Response of offered loan rates to MP: 1sd Skewness

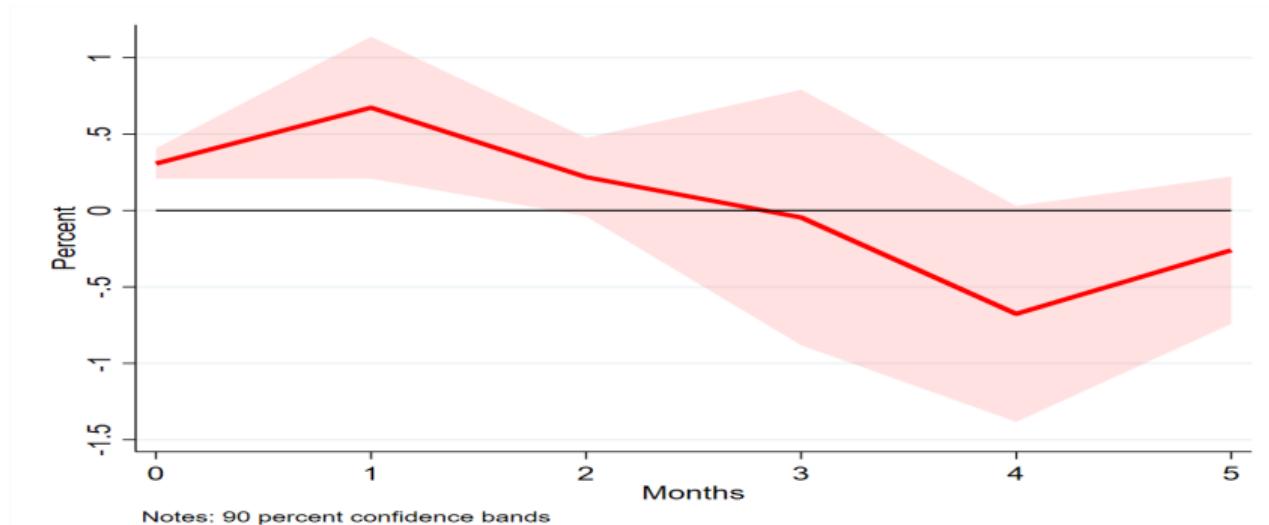


Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

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## Dynamic Granular Level Data: Ratewatch Data - Business Investment

Impulse Response of offered loan rates to MP: Coefficients

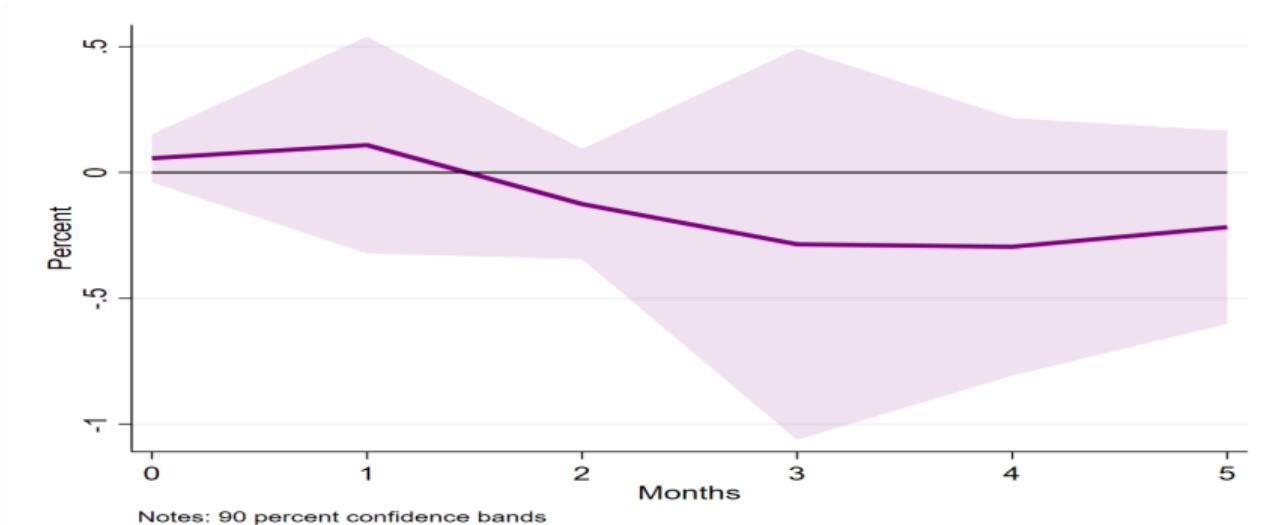


Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

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## Dynamic Granular Level Data: Ratewatch Data - Business Investment

Impulse Response of offered loan rates to MP: Coefficients

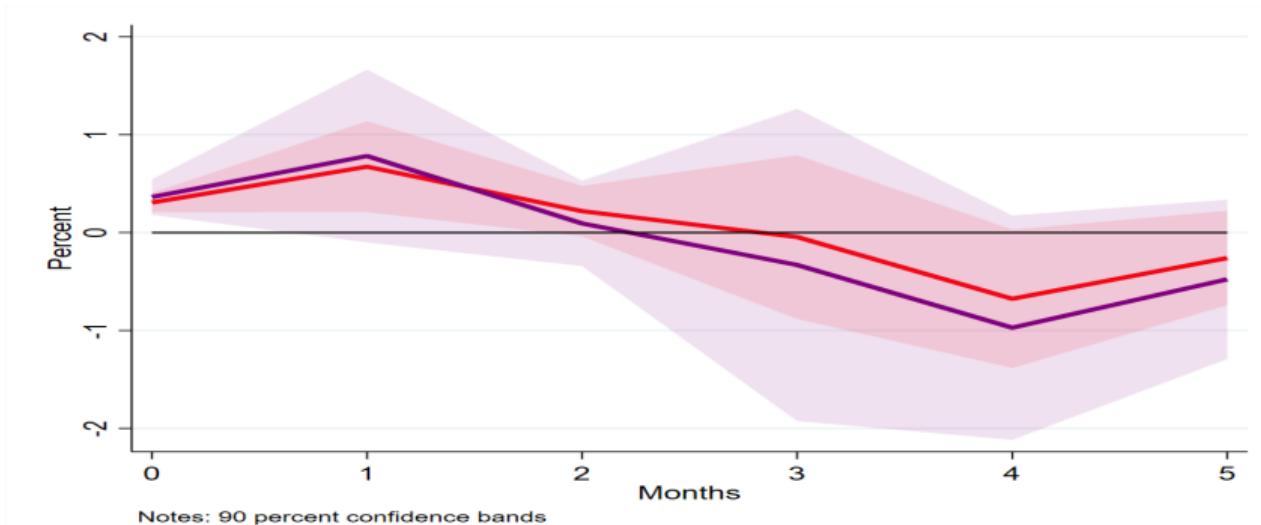


Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

▶ back

## Dynamic Granular Level Data: Ratewatch Data - Business Investment

Impulse Response of offered loan rates to MP: Coefficients



Impulse responses to exogenous increase in the 10Y Treasury. Red line: pure shock. SE clustered at the county/Category category level.

▶ back

## Branch/County-Level Data: Unemployment

Month	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MP shock	0.46**	0.97***	1.02**	1.20**	2.86***	1.06**	1.57***
H.Skew. MP Shock	0.41**	0.85***	0.73**	0.27	1.27***	0.23	0.40
H.Mean. MP Shock	0.18	1.15***	0.33*	0.02	-0.80***	0.08	0.82***
High Concentr	-0.06	0.30	0.42*	0.36*	0.01	0.03	0.26
Avg Loss Prov.	0.51***	0.63***	0.84***	0.90***	0.70***	1.19***	1.34***
Avg Cost Funds	0.21***	0.19**	0.07	-0.05	-0.15	-0.25**	0.03
Controls	✓	✓	✓	✓	✓	✓	✓
N	74668	72251	70360	67228	65164	63834	62358
R <sup>2</sup>	0.175	0.109	0.111	0.162	0.020	0.168	0.209

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . S.E. clustered at County/Category level. F-Test: 55.571

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⇒ High Skewness increases Unemployment response to MP.

## Loan/MSA-Level Data: Freddie Mac House Mortgage Loans

**Methodology:** IV Local Projections with High Frequency Proxy.

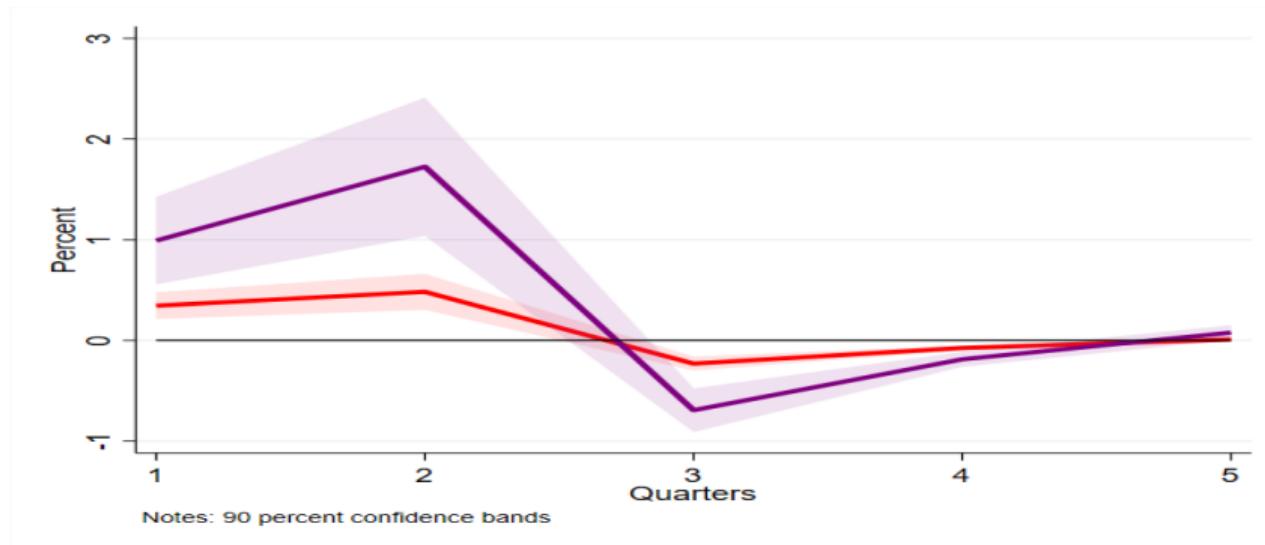
$$\begin{aligned}\text{Refinancing Rates}_{t+h,s} &= \alpha + \underline{\beta_0 \text{Treasury Rate}}_t + \underline{\beta_H} [\text{Treasury Rate}_t \times \text{Skewness}_{t,s}] + \\ &+ \sum_{k=1}^2 \rho_{1,k} \text{Treasury Rate}_{t-k} + \sum_{k=1}^2 \rho_{2,k} [\text{TreasuryRate}_{t-k} \times \text{Skewness}_{t-k,s}] + \\ &+ \sum_{k=1}^2 \gamma_k X_{s,t-k} + \sum_{k=1}^2 \delta_k X_{US,t-k} + \varepsilon_{s,t}\end{aligned}$$

**Controls:** CPI, GDP, Unemployment, Home Equity, Bank Herfindal Index, LTV, Age/Maturity, FE.

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## Loan/MSA-Level Data: Freddie Mac House Mortgage Loans

Impulse Response of Refinancing Rate to 50 b.p. exogenous decrease in MP rate.



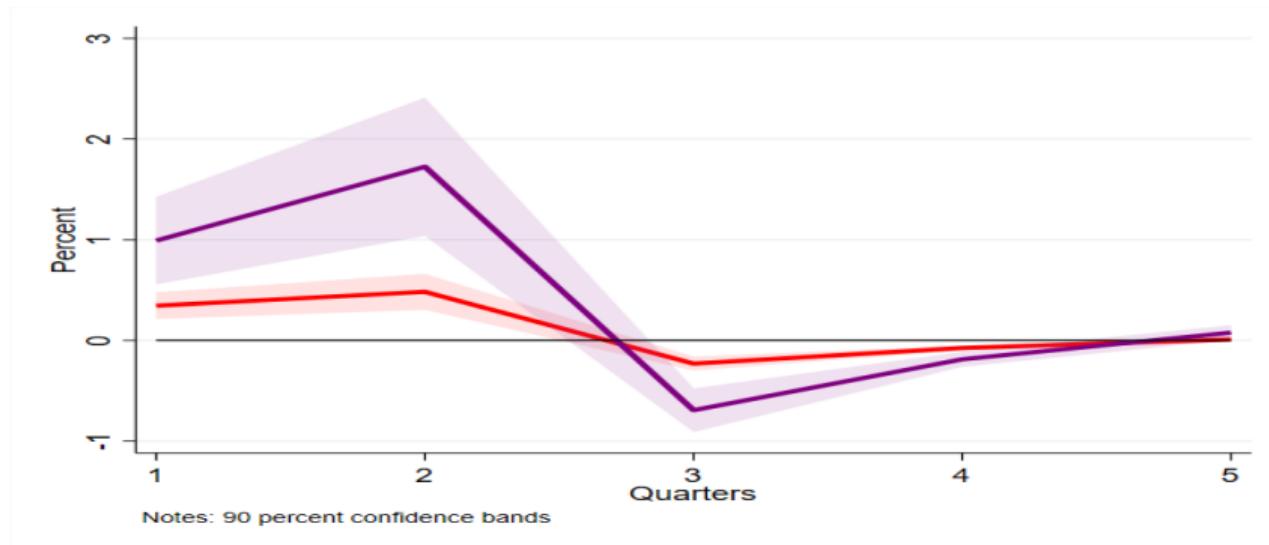
Red line: Standard Pass-Through. Purple Line: High Skewness Pass-Through. SE clustered at the county level.

⇒ MSA with High Mortage Rate Skewness stronger response in Refinancing rates.

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## Loan/MSA-Level Data: Freddie Mac House Mortgage Loans

Impulse Response of Refinancing Rate to 50 b.p. exogenous decrease in MP rate.



Red line: Standard Pass-Through. Purple Line: High Skewness Pass-Through. SE clustered at the county level.

⇒ MSA with High Mortage Rate Skewness stronger response in Refinancing rates.

## US States/Bank Panel: Real Personal Income

**Methodology:** Local projections. State (s) /month (m) level.

$$\begin{aligned}\text{Outcome Variable}_{t|t+h,s} &= \alpha + \beta_0 \mathbf{MP}_t + \beta_1 \left[ \widehat{\mathbf{MP}_t \times \text{Skewness}_{t-1,s}} \right] + \\ &+ \sum_{k=1}^2 \rho_{1,k} \mathbf{MP}_{t-k} + \sum_{k=1}^2 \rho_{2,k} \left[ \widehat{\mathbf{MP}_{t-k} \times \text{Skewness}_{t-k-1,s}} \right] + \\ &+ \sum_{k=1}^2 \gamma_k \mathbf{X}_{t-k,s} + \sum_{k=1}^2 \delta_k \mathbf{X}_{t-k,s} + \sum_{k=1}^2 \chi_k \mathbf{X}_{t-k,BANK} + \varepsilon_{t,s}\end{aligned}$$

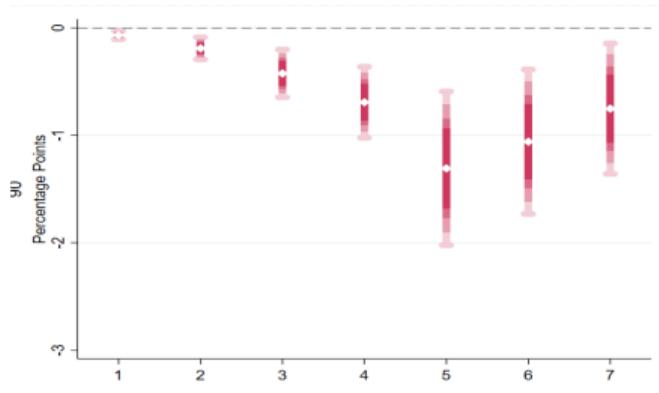
**Outcome Variables:** State Real Personal Income.

**Controls:** National GDP, Defl, Stock Market, Excess Bond Premium, state personal income, home prices, Bank Herfindal Index, Bank ROA, Cost of Funds, Loan Loss Provisions, Category/State FE.

**Identification:** High Frequency Proxy from Bauer and Swanson (2022).

**Note:**  $\widehat{\text{Skewness}}$  defines the state-level skewness subtracted of its long-run mean.

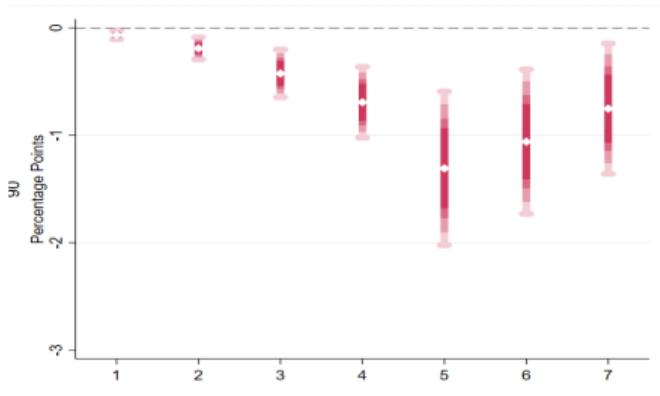
## Coefficient Plots



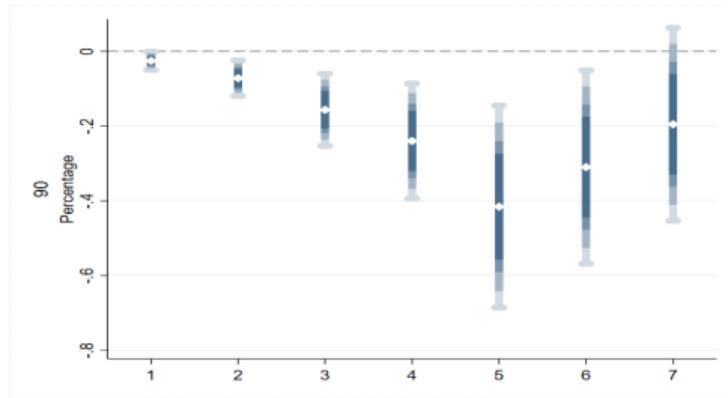
(a) Standard MP response ( $\beta_0$ ).

- Response to 100 b.p. MP shock.

## Coefficient Plots



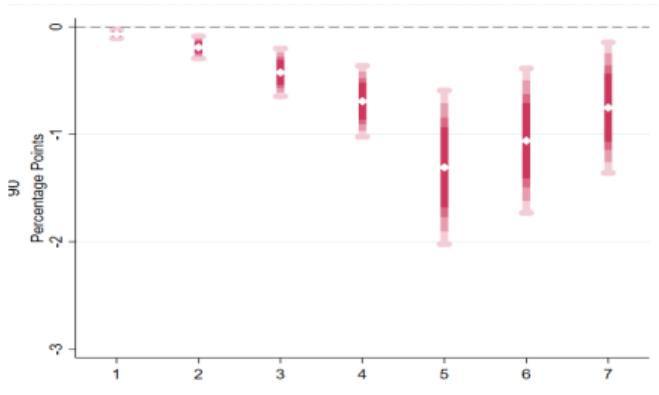
(a) Standard MP response ( $\beta_0$ ).



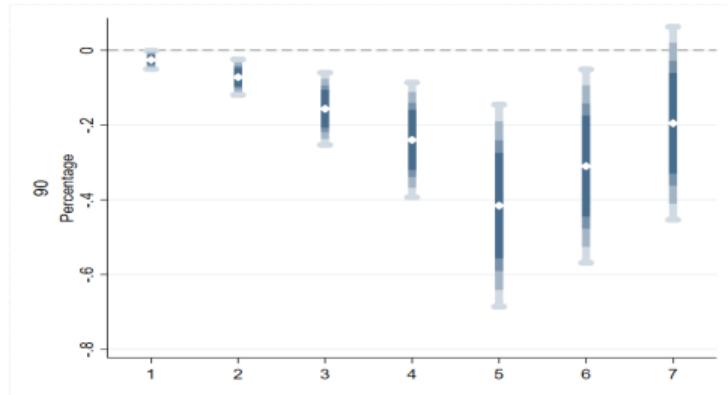
(b) Difference in MP response with high skewness ( $\beta_1$ )

- Response to 100 b.p. MP shock.
- 1/4 higher when skewness is high.

## Coefficient Plots



(a) Standard MP response ( $\beta_0$ ).



(b) Difference in MP response with high skewness ( $\beta_1$ )

- Response to 100 b.p. MP shock.
- 1/4 higher when skewness is high.



## Robust Specification: Lending Rates

**Table:** Average response of average county lending rates to a 100 b.p. MP shock, robust specification

Month	0	1	2	3	4	5	6	7	8	9	10
$MP_t$	0.22*** (8.44)	0.34*** (10.84)	0.48*** (13.62)	0.44*** (11.87)	0.37*** (8.95)	0.23*** (5.55)	0.29*** (6.67)	0.55*** (12.54)	0.38*** (8.62)	0.44*** (8.87)	0.52*** (10.12)
Skew.	0.15*** (3.73)	0.12** (2.48)	0.22*** (3.95)	0.20*** (3.37)	0.18*** (2.91)	0.17*** (2.59)	0.24*** (3.40)	0.12* (1.77)	0.16** (2.34)	0.00 (0.06)	-0.00 (-0.03)
Mean	-0.13*** (-6.14)	-0.04** (-2.03)	-0.17*** (-6.72)	-0.28*** (-9.33)	-0.31*** (-9.16)	-0.15*** (-4.01)	-0.27*** (-7.27)	-0.22*** (-5.38)	-0.18*** (-4.67)	-0.30*** (-7.56)	-0.32*** (-7.90)
Var.	0.04 (0.73)	0.09 (1.25)	-0.21*** (-2.73)	-0.02 (-0.18)	-0.05 (-0.53)	0.14 (1.32)	-0.16* (-1.67)	-0.00 (-0.00)	-0.23** (-2.45)	-0.34*** (-3.29)	-0.13 (-1.16)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N	123775	111611	108658	105835	101058	98156	96266	92717	91096	88863	85569
$R^2$	0.974	0.967	0.963	0.956	0.950	0.947	0.942	0.937	0.935	0.931	0.927

t statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

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## Robust Specification: Unemployment Rate

**Table:** Average response of county unemployment rate to 100 b.p. MP shock, robust specification

Month	0	1	2	3	4	5	6	7	8	9	10
$MP_t$	0.04*** (4.96)	0.28*** (20.15)	0.36*** (24.02)	0.26*** (17.23)	0.21*** (13.41)	0.23*** (14.27)	0.37*** (21.92)	0.49*** (26.25)	0.56*** (29.86)	0.57*** (31.73)	0.19*** (11.42)
Skew.	0.04*** (3.12)	0.12*** (6.67)	0.11*** (5.50)	0.09*** (4.58)	-0.05** (-2.38)	0.02 (0.91)	0.04* (1.91)	0.09*** (3.54)	0.05** (2.00)	0.02 (0.67)	0.02 (1.01)
Mean	0.09*** (14.53)	-0.04*** (-4.12)	-0.11*** (-10.29)	-0.02* (-1.71)	-0.03** (-2.44)	-0.00 (-0.26)	-0.18*** (-14.68)	-0.18*** (-13.21)	-0.17*** (-12.38)	-0.28*** (-21.11)	-0.05*** (-3.81)
Var.	-0.00 (-0.12)	0.04* (1.70)	-0.02 (-0.65)	-0.11*** (-3.80)	-0.03 (-1.06)	-0.11*** (-3.77)	0.07** (2.39)	-0.05 (-1.38)	0.02 (0.53)	0.08** (2.45)	-0.04 (-1.48)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N	121832	110059	107270	104565	99944	97147	95369	91929	90388	88241	85016
$R^2$	0.969	0.939	0.928	0.929	0.931	0.928	0.920	0.909	0.907	0.920	0.933

t statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

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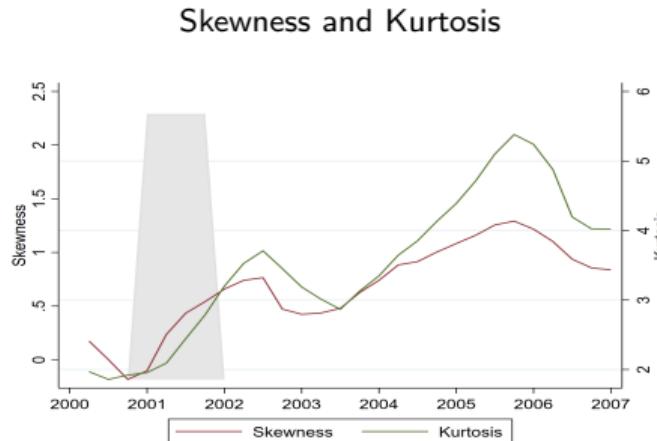
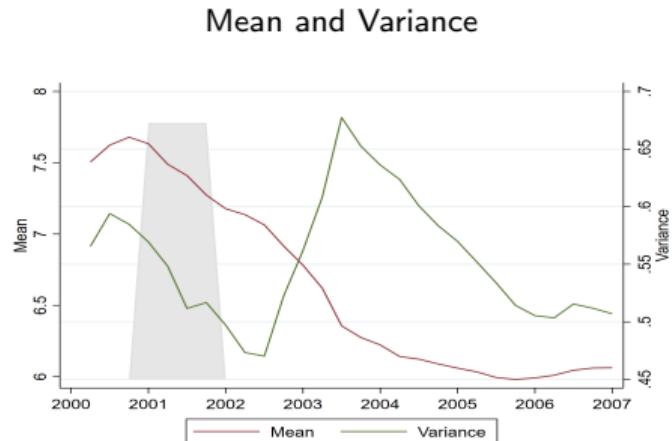
## More Robustness

- Internal Instrument vs Two Stage Least Square.
- Different Lags of the State Variables.
- Refinancing Channel. Berger et al. (2021), Eichenbaum et al. (2022).

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# Evolution of Interest Rate Distribution 1st to 4th Moment

Eich. et al. AER 2022 Mortgage Rate interest rate moments over time (average moment value over all counties, FICO scores maturity group)



Interest rates on Mortgage Loans from the House Mortgage Disclosure Data at quarterly frequency.

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## Loan/MSA-Level Data: Freddie Mac House Mortgage Loans

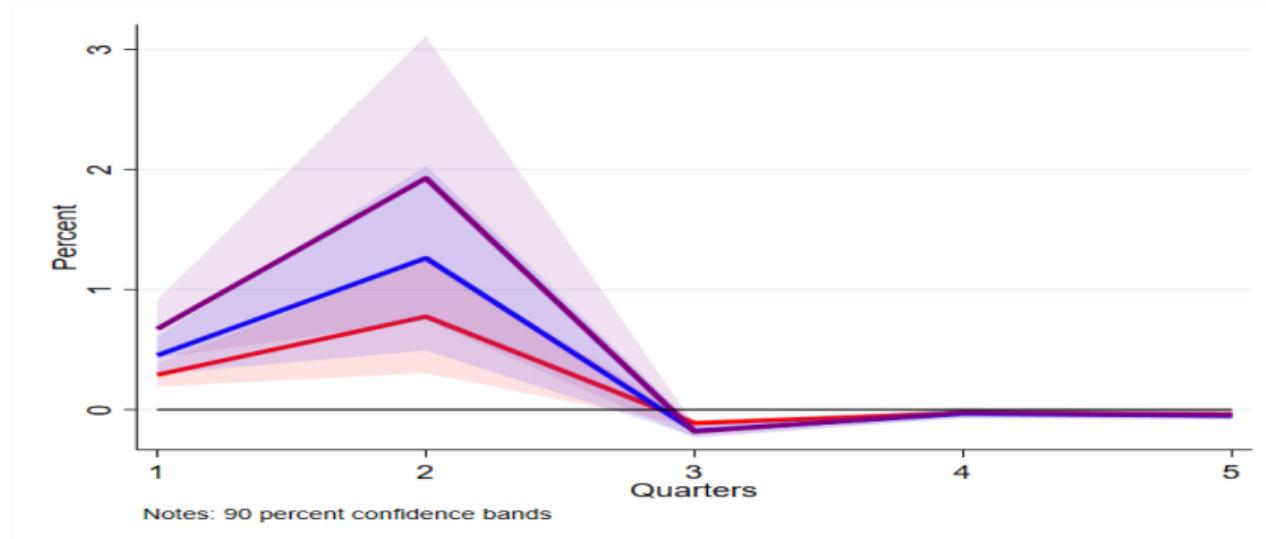
**Methodology:** IV Local Projections with High Frequency Proxy.

$$\begin{aligned}\text{Refinancing Rates}_{t+h,s} &= \alpha + \beta_0 \underline{\text{Treasury Rate}}_t + \beta_1 [\underline{\text{Treasury Rate}}_t \times \underline{\text{Skewness}}_{t,s}] + \\ &+ \beta_2 [\underline{\text{Treasury Rate}}_t \times \underline{\text{Rate Gap}}_{t,s}] + \\ &+ \sum_{k=1}^2 \rho_{1,k} \underline{\text{Treasury Rate}}_{t-k} + \sum_{k=1}^2 \rho_{2,k} [\underline{\text{Treasury Rate}}_{t-k} \times \underline{\text{Skewness}}_{t-k,s}] + \\ &+ \sum_{k=1}^2 \gamma_k X_{s,t-k} + \sum_{k=1}^2 \delta_k X_{US,t-k} + \varepsilon_{s,t}\end{aligned}$$

**Controls:** CPI, GDP, Unemployment, Home Equity, Bank Herfindal Index, LTV, Age/Maturity, FE.

## Loan/MSA-Level Data: Freddie Mac House Mortgage Loans

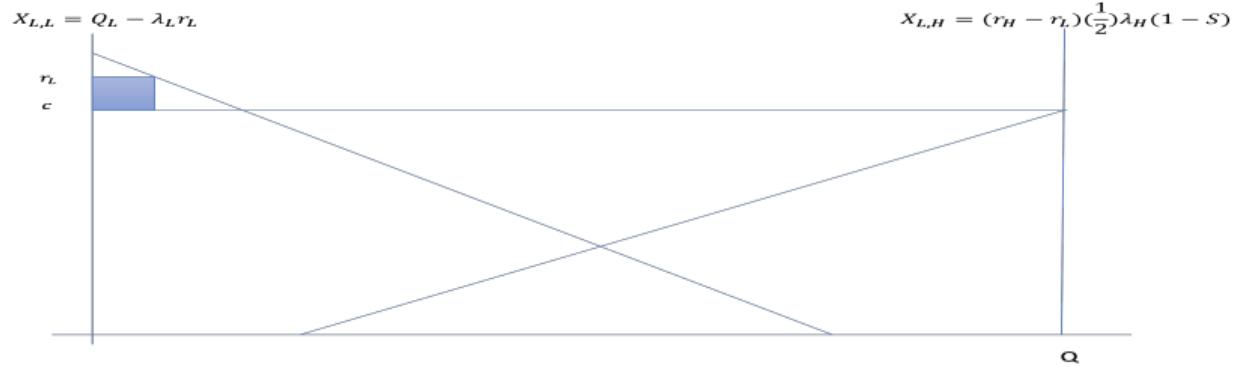
Impulse Response of **refinancing rates** to MP with Refinancing and Bank Moment Channels



Impulse responses to 50bp exogenous decrease in 30Y Mortgage Rate. Red line: pure shock. Blue Line: Refinancing Channel is active. Purple Line: bank moment channel is active. SE clustered at the county level.

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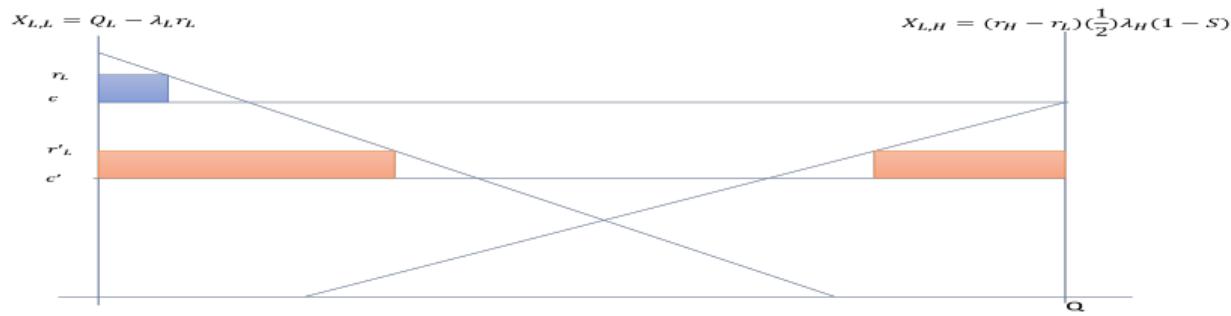
## Graphic Intuition, Strategic L fixed H



Low skewness.

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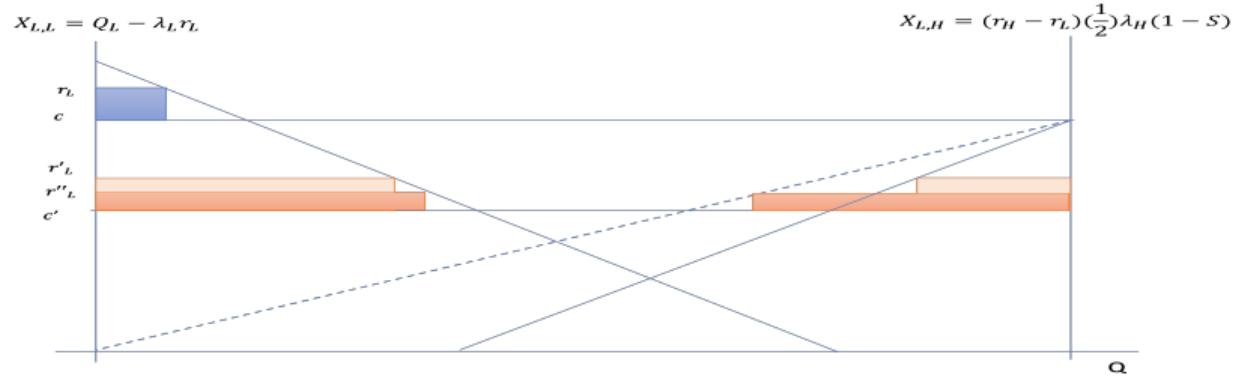
# Graphic Intuition



Lower skewness. MP easing.

▶ back

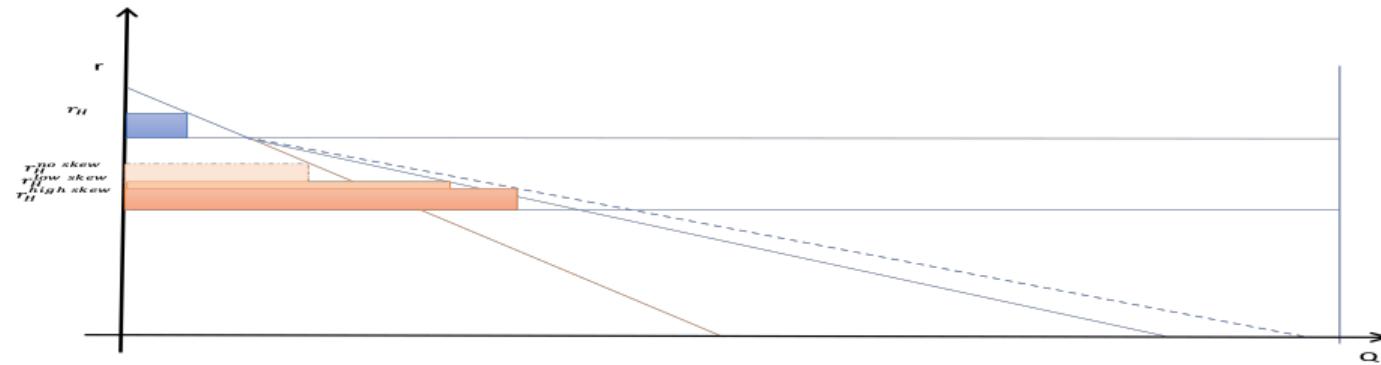
# Graphic Intuition



Higher skewness. Same MP easing.

▶ back

# Graphic Intuition



No/Low/High Skewness. MP Easing.

▶ back

## Model Appendix

**Model Appendix:** (Very Simple framework and old Model versions)

## (Very) Simple Conceptual Framework

	Bank	Borrower
Type A	high market power	high switching cost $\phi$
Type B	low market power	low switching cost $\phi$

### Borrower's Choice

$$\min e(r) = \begin{cases} r_{t-1,A}, & \text{if old loan product} \\ r_{t,A} + \psi, & \text{if new loan product} \\ r_{t,B} + \phi_A & \text{if switch bank B} \end{cases}$$

### Bank's problem:

$$\max_{r_{t,A}, S} \pi = [r_{t,A} - c] \mathbf{1}_{S=\text{Lend}}$$

$$(IC1) \quad r_{t,A} \leq r_{t,B} + \phi_A \quad \text{if } r_{t,A} = r_{t-1,A}$$

$$(IC2) \quad r_{t,A} + \psi \leq r_{t,B} + \phi_A \quad \text{if } r_{t,A} \neq r_{t-1,A}$$

## (Very) Simple Conceptual Framework

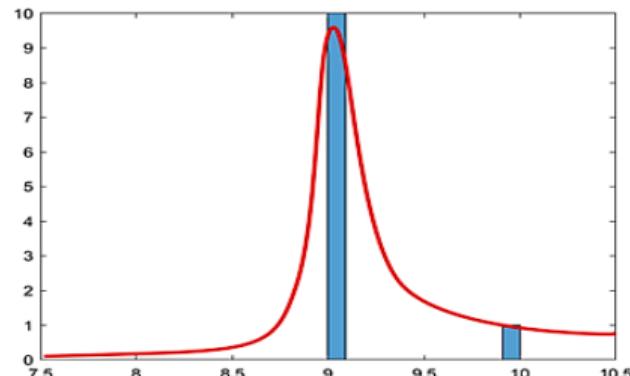
**Assume:**

- $r_{t,b} = c$
- $c = r_{FED}$
- $n - x$  banks type B,  $x$  type A

**Starting Point :**

$$r_{t,B} = r_{t,FED} = c = 9\%$$

$$r_{t,A} = 10\%$$



Quarter 1: Bank Rates Distribution

▶ Back

## (Very) Simple Conceptual Framework

One quarter later FED easens by 0.5%:

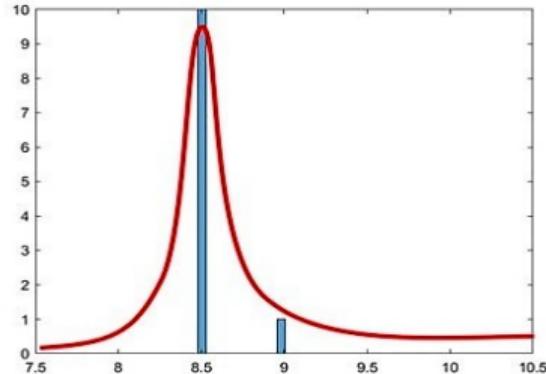
$$r_{t,B} = c = 8.5\%$$

Assume:

- 1  $\phi_A = 1\%$
- 2  $\psi_A = 0.5\%$

$$r_{t,A} = 9\%$$

Pass-Through:  $\frac{(n-x)*(9\%-8.5\%)+x*(10\%-9\%)}{0.5\%} > 1$



Quarter 2: Bank Rates Distribution

▶ Back

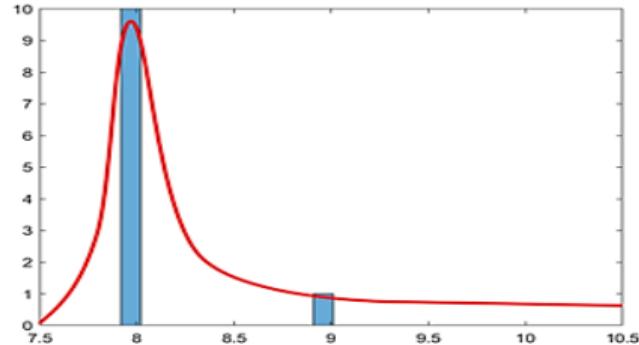
## (Very) Simple Conceptual Framework

One quarter later FED easens again by 0.5%:

$$r_{t,B} = c = 8\%$$

$$r_{t,A} = r_{t-1,A} = 9\%$$

Pass-Through:  $\frac{(n-x)*(8.5\%-8\%)+x*(9\%-9\%)}{0.5\%} < 1$



Quarter 3: Bank Rates Distribution

- Competition among banks with local market power gives rise cross-sectional differences among banks
- Higher order moments can act as a state for MP efficacy.

▶ Back

## Best Responses:

**Best Responses for Duopoly with Bank H:**

**Bank H:**

$$r_H = \frac{[\bar{Q}_H + \kappa r_L + \beta_H c]}{2\beta_H}$$

**Bank L:**

$$r_L = \frac{[\bar{Q}_L + \kappa r_H + \beta_L c]}{2\beta_L}$$

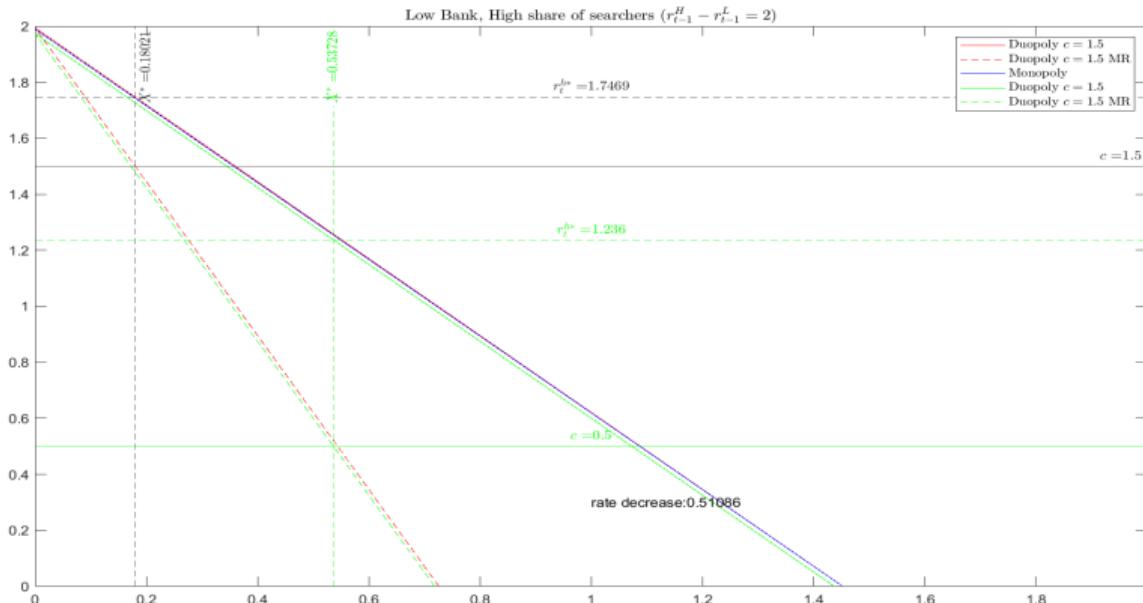
**Substituting  $r_H$  into  $r_L$ : Bank L:**

$$r_L = \left[ \frac{\bar{Q}_L}{2\beta_L} + \frac{\bar{Q}_H}{4\beta_H\beta_L} \right] + \left[ \frac{\kappa^2}{4\beta_H\beta_L} \right] r_L + \left[ \frac{\kappa\beta_H}{4\beta_H\beta_L} + \frac{1}{2} \right] c$$

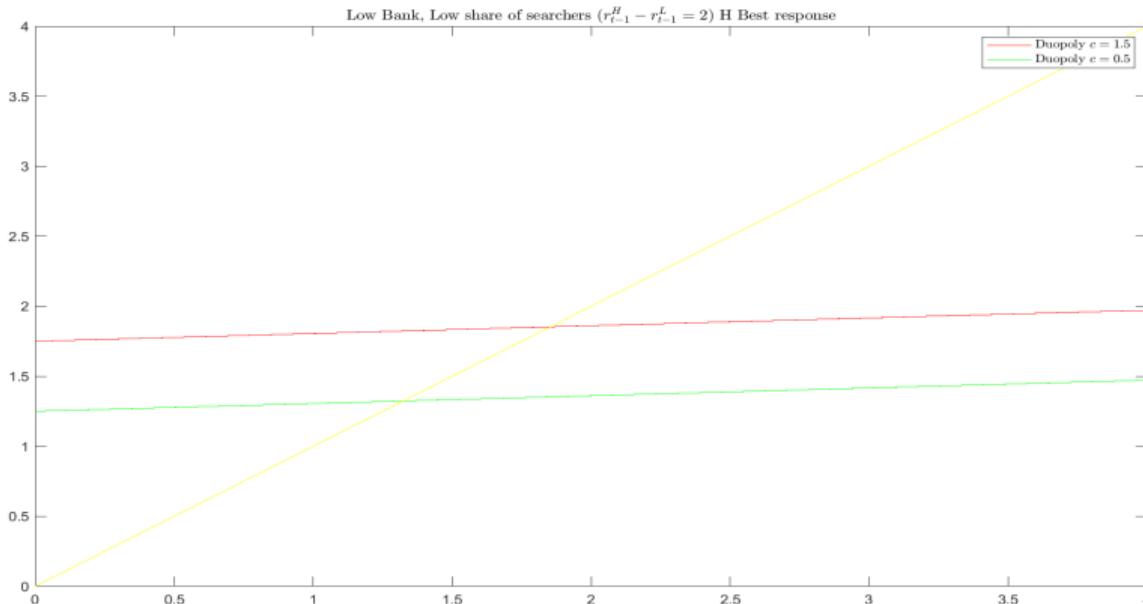
$$\frac{\partial r_L}{\partial c} = \left[ \frac{4\beta_H\beta_L}{4\beta_H\beta_L - \kappa^2} \right] \left[ \frac{\kappa\beta_H + 2\beta_H\beta_L}{4\beta_H\beta_L} + \frac{1}{2} \right] = \left[ \frac{\kappa\beta_H + 2\beta_H\beta_L}{4\beta_H\beta_L - \kappa^2} \right]$$

▶ Back

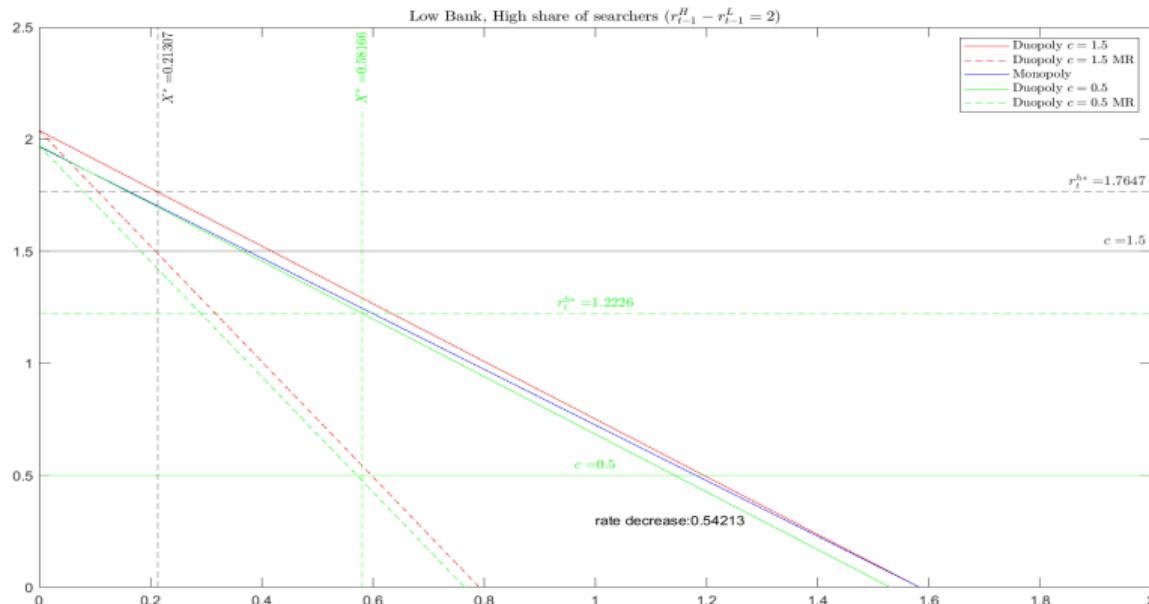
## Graphical Intuition



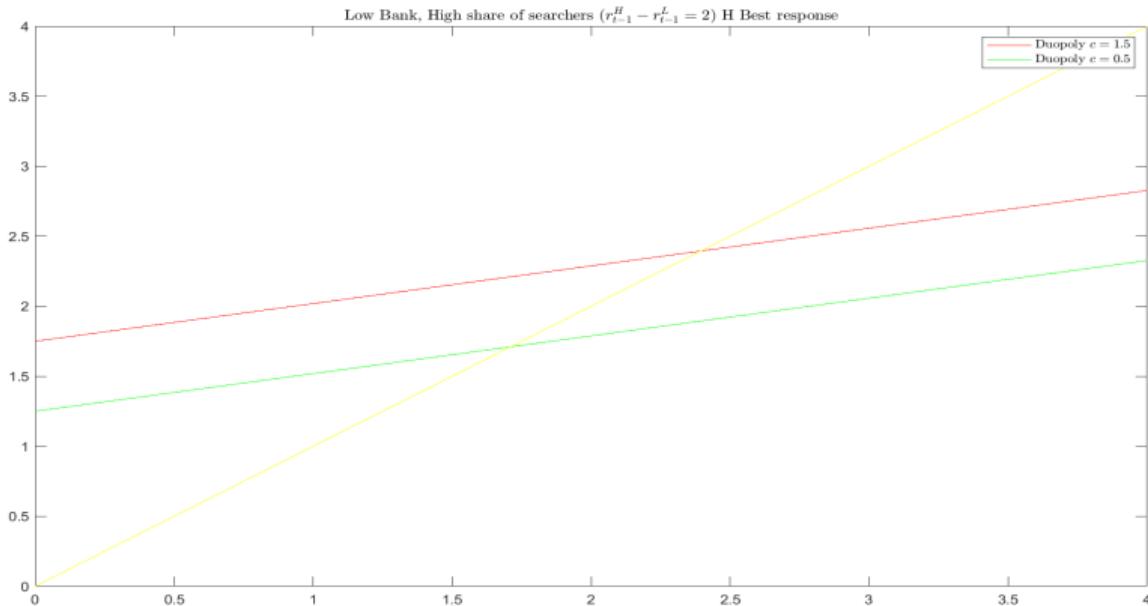
## Graphical Intuition



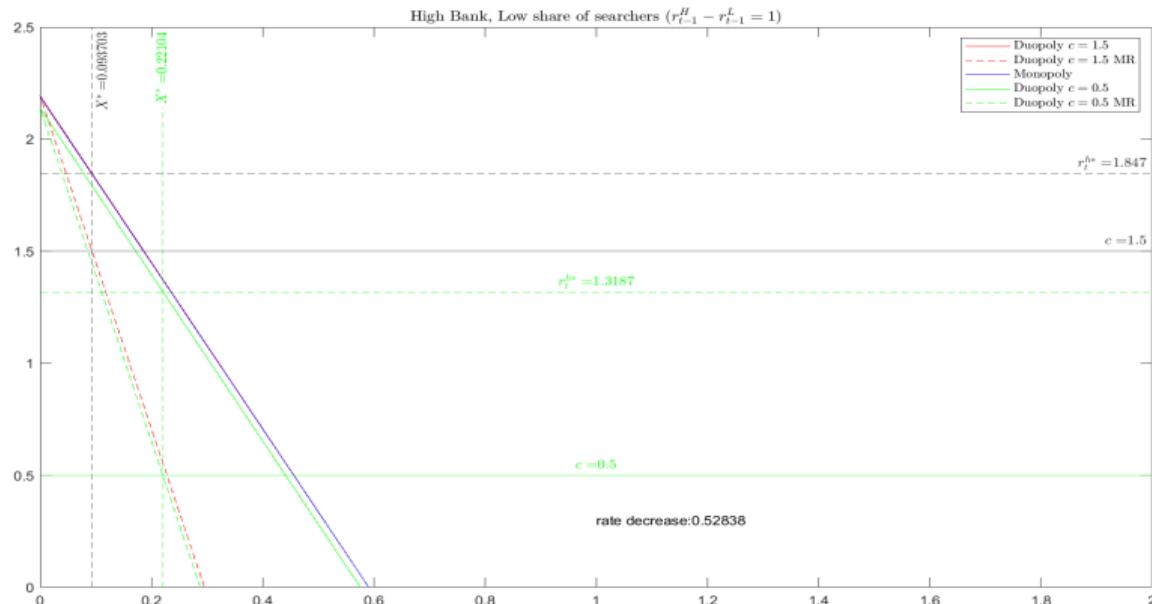
## Graphical Intuition



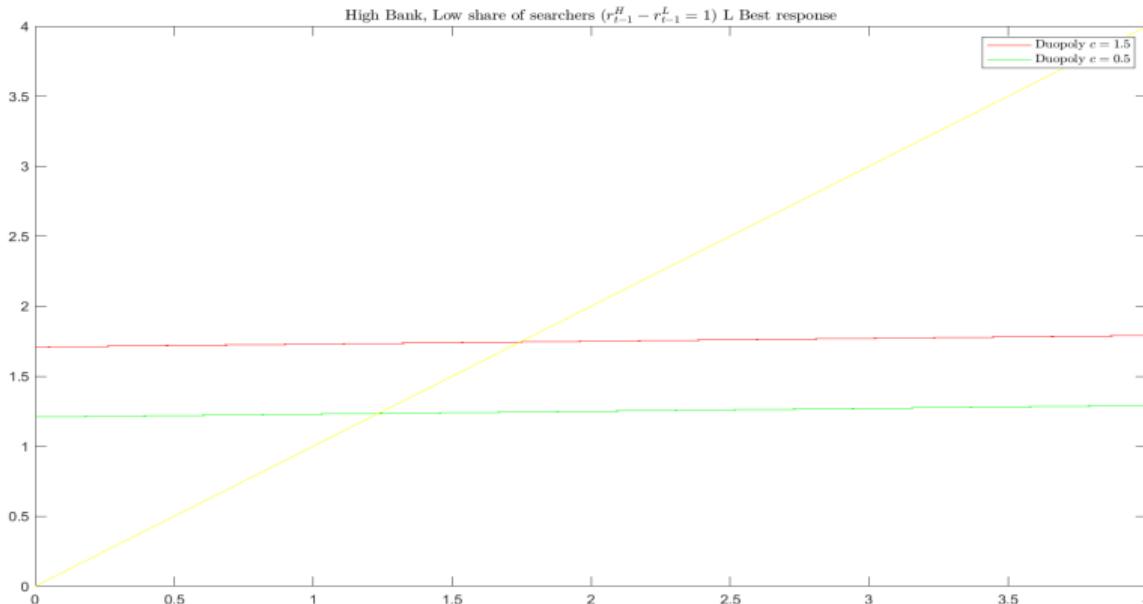
## Graphical Intuition



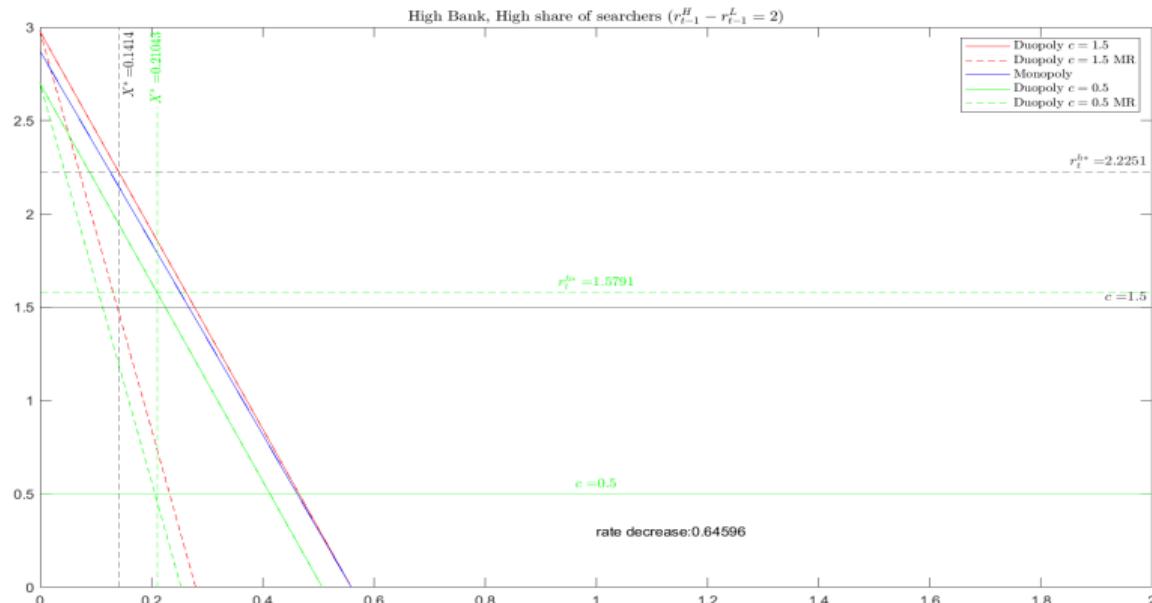
# Graphical Intuition



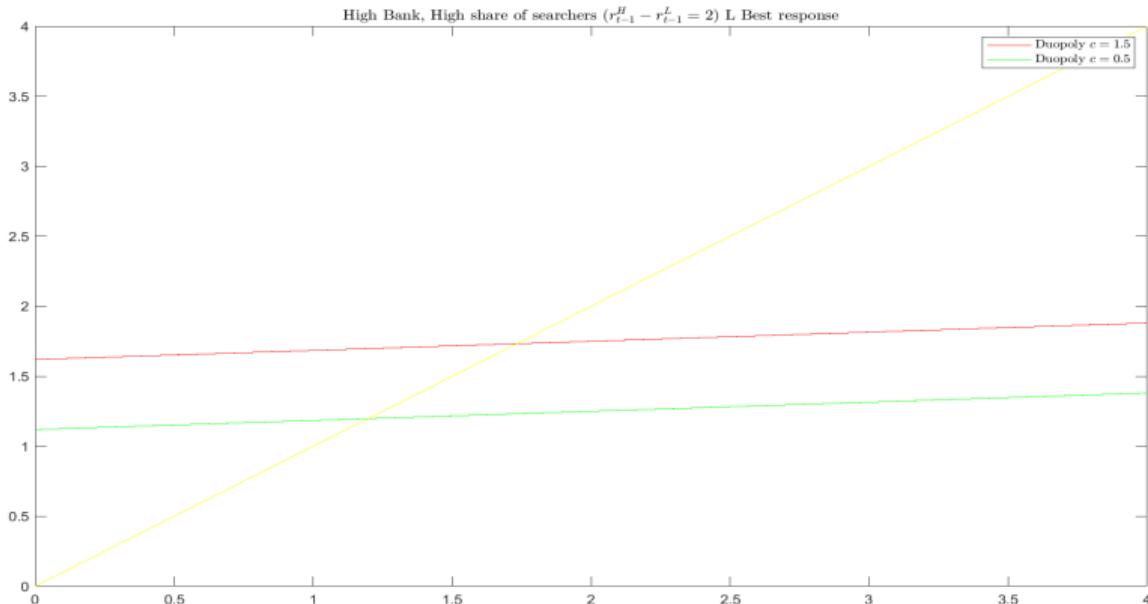
## Graphical Intuition



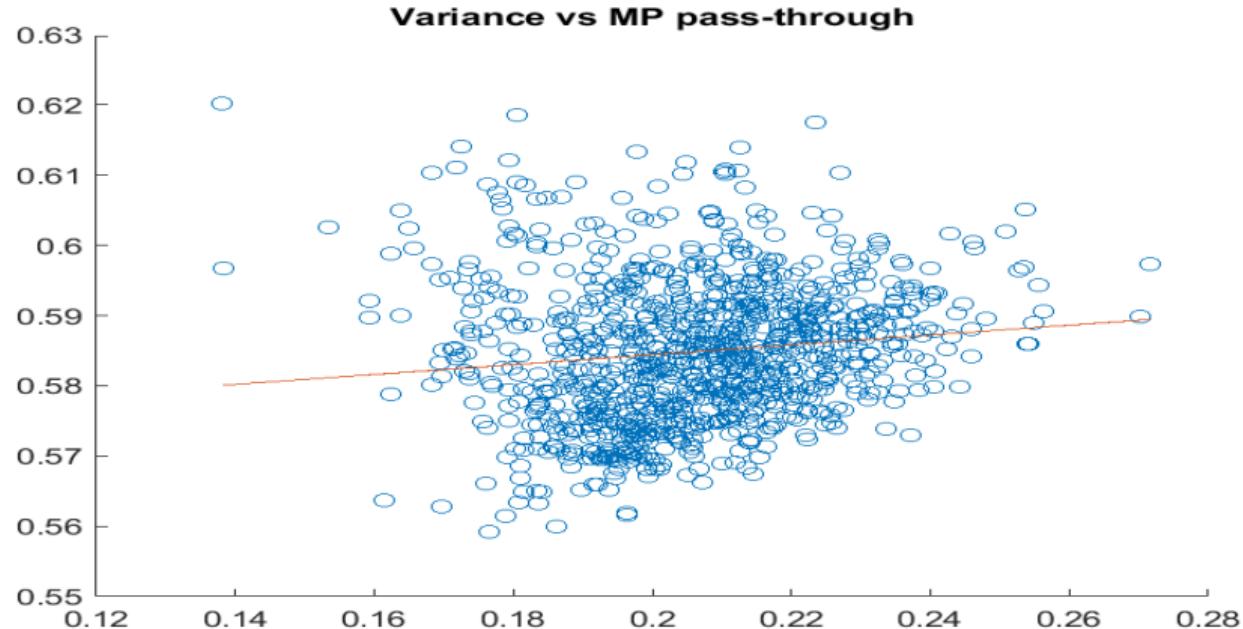
## Graphical Intuition



## Graphical Intuition



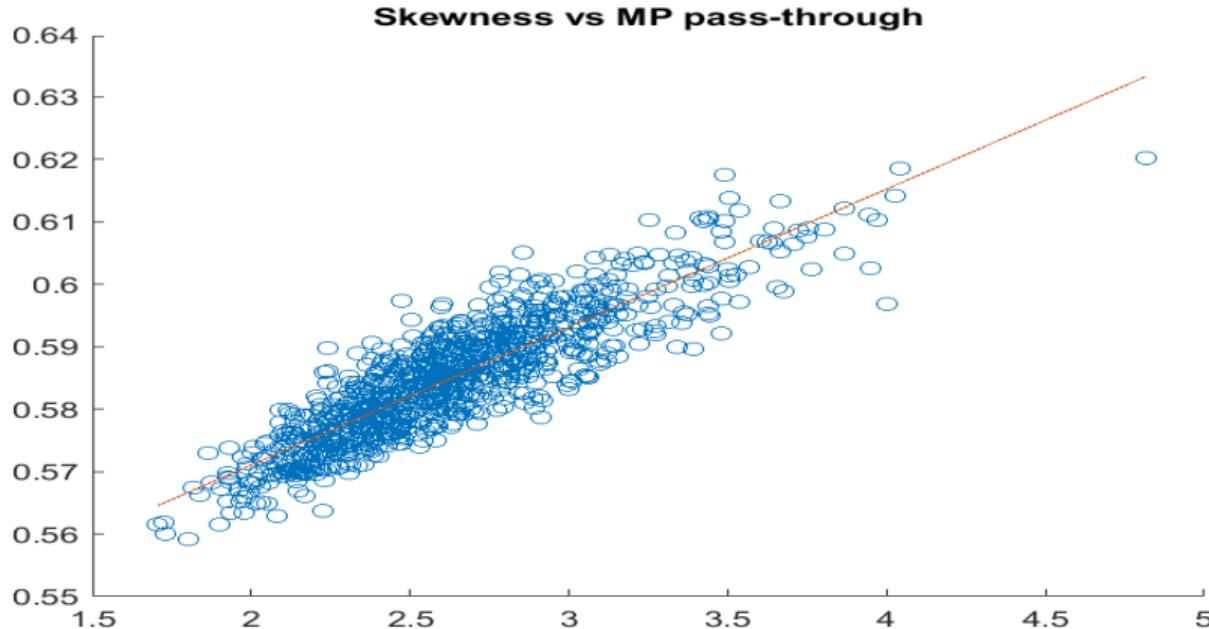
## Model Simulation: Variance vs Skewness



Initial Variance vs Pass-Through

▶ Back

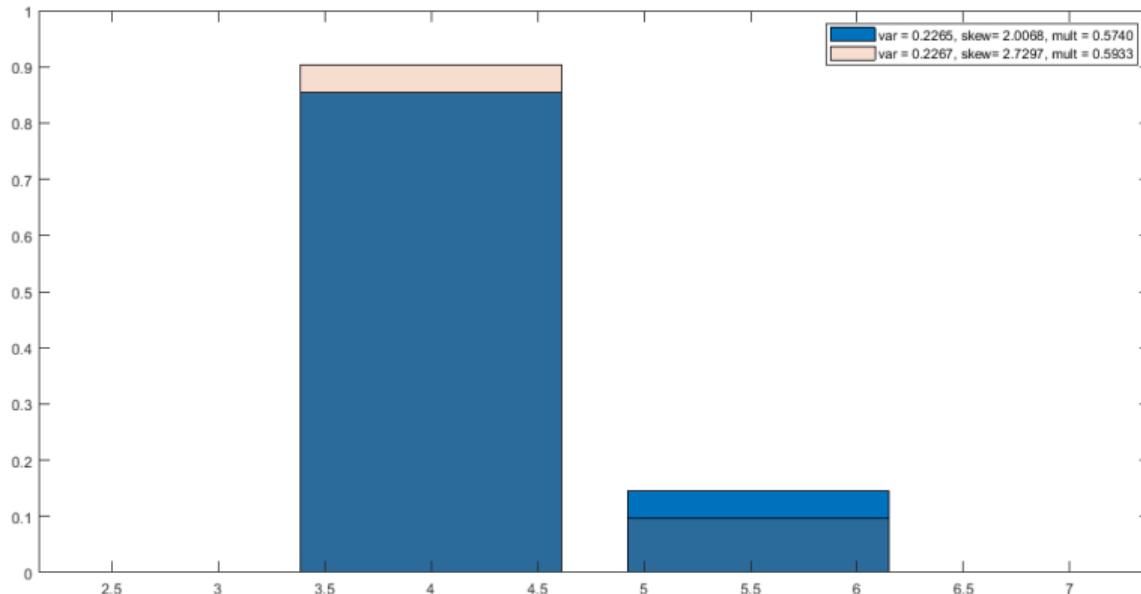
## Model Simulation: Variance vs Skewness



Initial Skewness vs Pass-Through

▶ Back

## Model Simulation: Variance vs Skewness



Example: 2 parameters draws, different pass-through, different initial skewness, same initial variance.

▶ Back

## Graphical Intuition

Old picturessss

## Graphical Intuition

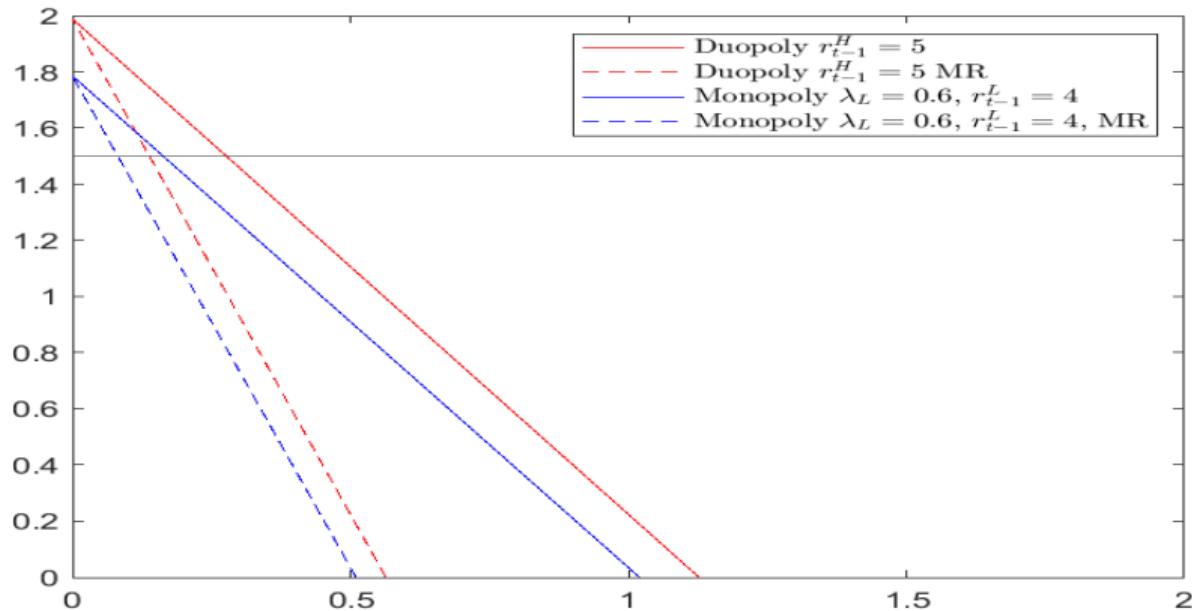


Figure: Monopoly vs Duopoly

## Graphical Intuition

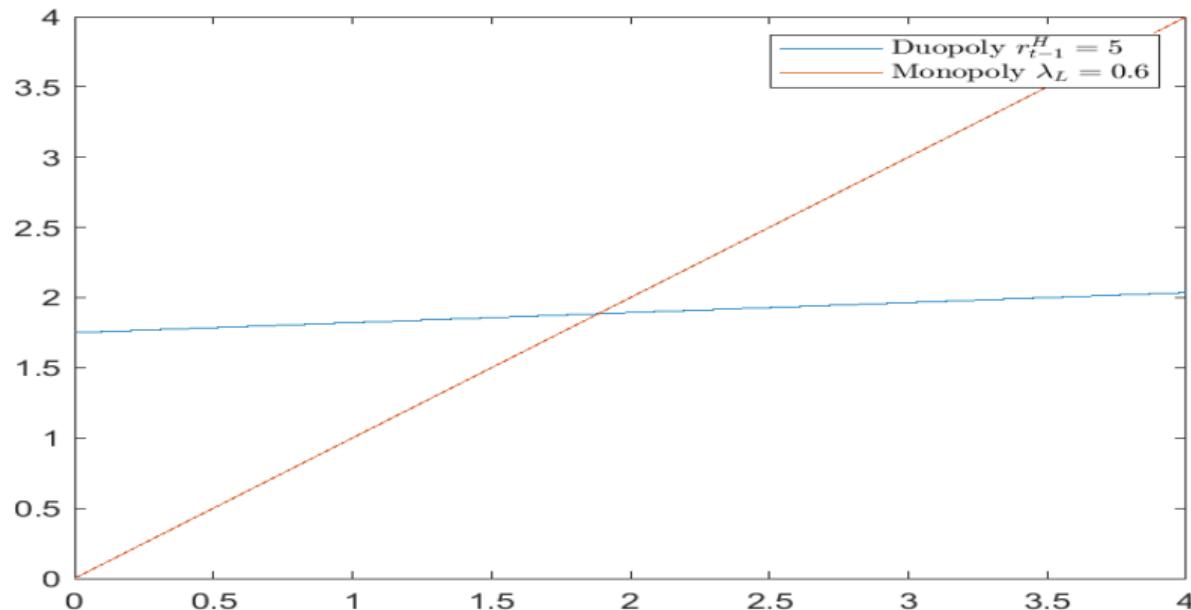


Figure: Monopoly vs Duopoly, Rates

## Graphical Intuition

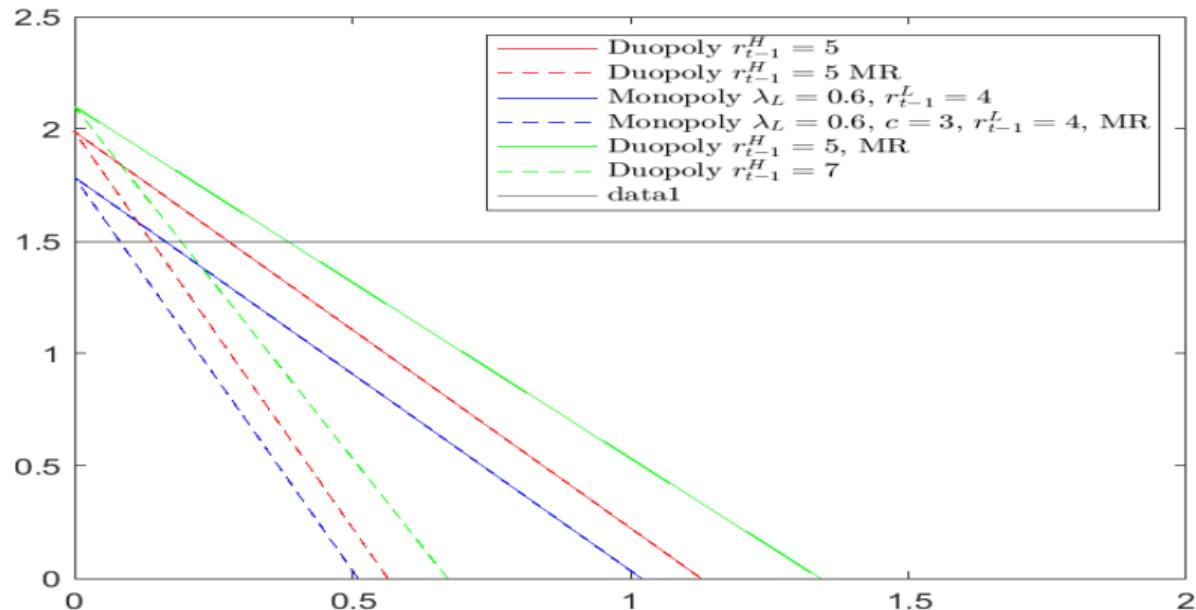


Figure: Monopoly vs Duopoly vs Increased Duopoly

## Graphical Intuition

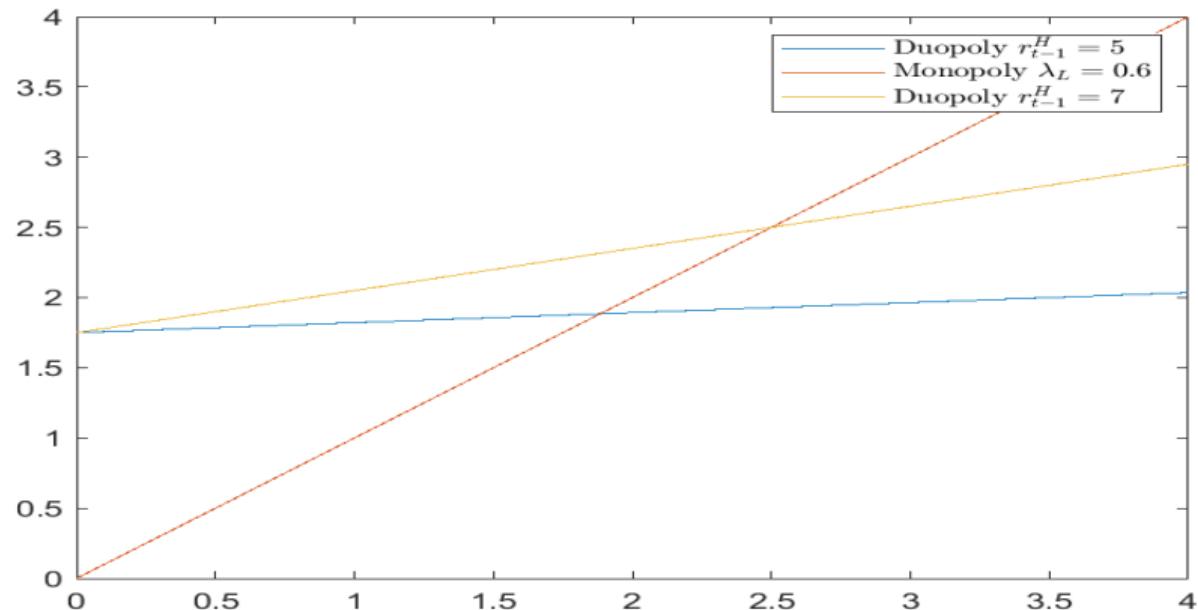


Figure: Monopoly vs Duopoly vs Increased Duopoly

## Graphical Intuition

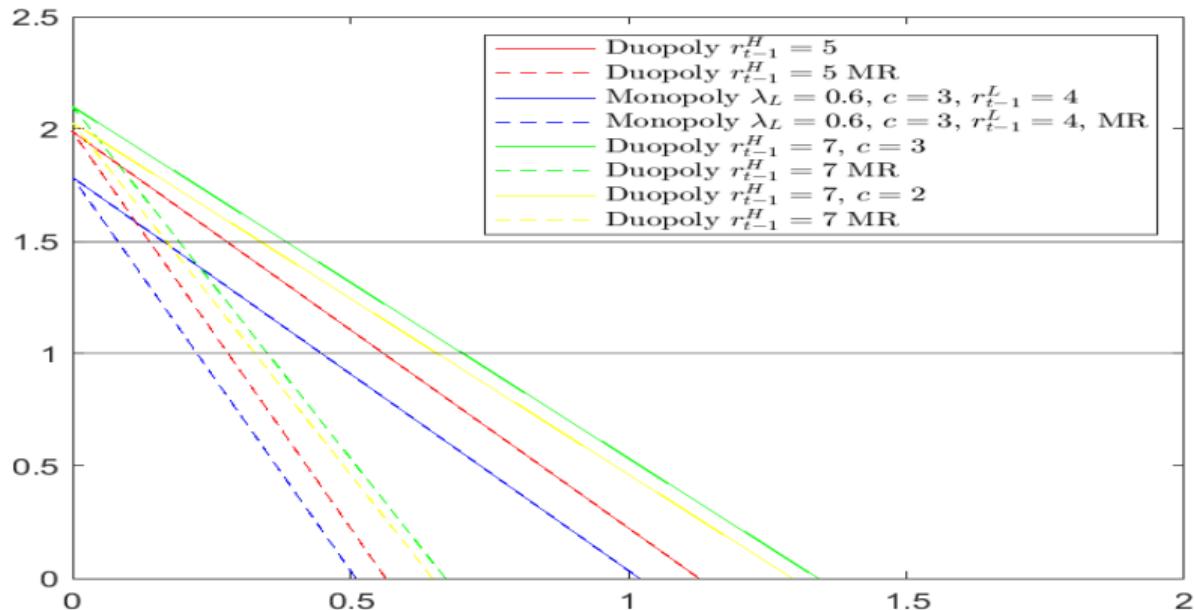


Figure: Monopoly vs Duopoly vs Increased Duopoly vs new MP shock

## Graphical Intuition

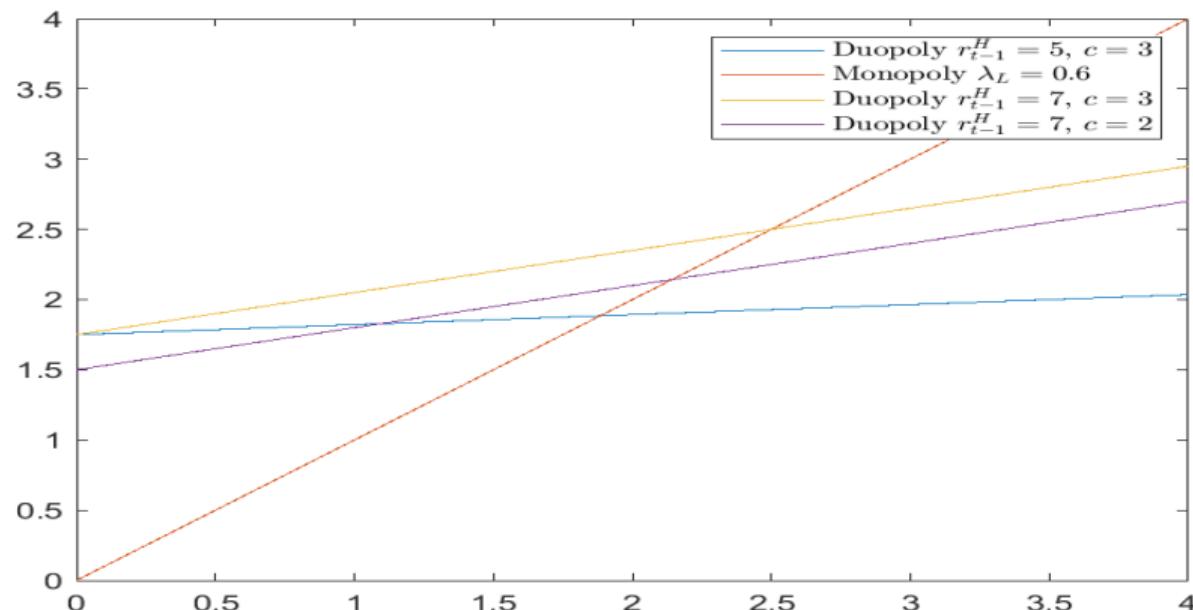


Figure: Monopoly vs Duopoly vs Increased Duopoly vs new MP shock

## Consumer Problem: stage 0 to 3

- Consider the case  $r_{t-1}^A > r_{t-1}^B$  then:
- For each  $z$  only consumers with  $\theta$ :  $v - \mathbb{E}[r_t^A - z] \geq v - \mathbb{E}[r_t^B - (2 - z) - \theta]$  will stay Type 1.
- Hence  $v - r_{t-1}^A - 1 \geq v - r_{t-1}^B - 1 - \theta \Leftrightarrow \theta \geq [r_{t-1}^A - r_{t-1}^B]$
- Finally for each  $z$   $\int_0^{\bar{\theta}} \frac{1}{\bar{\theta}} \mathbb{1}_{\{\theta > gap_{t-1}\}} = \left[ \frac{\bar{\theta} - gap_{t-1}}{\bar{\theta}} \right] = P(gap_{t-1})$
- After  $z$  is realized the number of type 1 consumers for each  $z$  will be  $P$ .
- Once  $c$  is realized banks chose  $r_t$ . The final demand of type 1 to Bank A will hence be:

$$\begin{aligned} X_A^1(r_t^A) &= \int_0^2 \lambda_1 \int_0^{\bar{\theta}} \frac{1}{\bar{\theta}} \mathbb{1}_{\{v-z-r_t^A>0 \mid \text{Type 1 choice}\}} \mathbb{1}_{\{\theta > gap_{t-1}\}} d\theta dz \\ &= \lambda_1(v - r_t^A) \mathbb{P}(gap_{t-1}) \end{aligned}$$

- Demand of type 3 to Bank A should hence be:  $X_A^3(r_t^A, r_t^B) = \lambda_1(1 - \mathbb{P})(\frac{r_t^B - r_t^A}{2} + 1)$
- Finally Total demand of type 2 and 3 to Bank B should be:

$$X_B(r_t^A, r_t^B) = X_B^2(r_t^B) + X_B^3(r_t^A, r_t^B) = \lambda_2(v - r_t^B) + \lambda_1(1 - \mathbb{P})(\frac{r_t^A - r_t^B}{2} + 1)$$

▶ back

### **z is known since stage 0, and $\theta$ is fixed**

- Recall in stage 0 people switch iff  $v - z - \mathbb{E}[r_t^A | I_t] < v - (2 - z) - \mathbb{E}[r_t^A | I_t] - \theta$
- Marginal switcher is  $\theta = [r_{t-1}^A - r_{t-1}^B] + [2\hat{z} - 2]$
- $\hat{z}$  is increasing in  $\theta$ , so there is a  $\theta$  for which nobody switches. Say that  $\theta$  is smaller than that:
- Define  $z^1 = v - r_t^A$ , marginal loyal-to-A consumer.
- Define  $z^3 = \frac{r_t^B - r_t^A}{2} + 1$ .
- If  $\hat{z} > z^1$ :
  - Bank A is not trying to get back any customers,  $\frac{\partial r_t^A}{\partial c} = \frac{1}{2}$
  - $\frac{\partial r_t^A}{\partial c} >$  or  $= \frac{1}{2}$  depending on the level of  $c$ .
- If  $\hat{z} < z^1$ :
  - Bank A is trying to get back customers,  $\frac{\partial r_t^A}{\partial c} > \frac{1}{2}$
  - $\frac{\partial r_t^A}{\partial c} > \frac{1}{2}$ .

▶ back

$z$  is known since stage 0, and  $\theta$  is fixed, results:

- if  $[r_{t-1}^A - r_{t-1}^B]$  is low than nobody switches in stage zero and hence both MP multipliers are  $\frac{1}{2}$ .
- if  $[r_{t-1}^A - r_{t-1}^B]$  is high than a few people pay the fixed cost  $\theta$  in stage zero and check  $r_t^B$ , turns out both MP multipliers are  $> \frac{1}{2}$ .

▶ back

### There is no distance $z$ just a switching cost and a refinancing cost

- Then there is a continuum  $[0, \bar{\theta}]$  of people with different switching costs.
- Marginal person that is going to switch is  $\mathbb{E}[v - r_t^A] > \mathbb{E}[v - r_t^B] - \theta \rightarrow \hat{\theta} = [r_{t-1}^A - r_{t-1}^B] = P$
- If  $r_t^A > r_t^B$  then all those people are switching to B
- If  $r_t^A < r_t^B$  then all those people are staying with A. **Result:** Again depending on the level of  $c$  it might be worth for A to either pursue those customers or not.

▶ back

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