

# Banks and the State-Dependent Effects of Monetary Policy

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*The views expressed in this presentation do not represent the views of the Bank of Italy, the Eurosystem, or the BMO Financial Group.*

# Introduction

**October 2022 - Fed rate 3.08%**

US banks gain from Fed rate hikes while keeping deposit interest low

Wall St is charging more for loans but setting aside money for a possible downturn



JPMorgan reported record net interest income — the difference in what it pays on deposits and earns from loans and other assets.  
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**April 2024 - Fed rate at 5.33%**

Net interest income may have peaked for Wall Street banks

The flipside to higher rates is people want more for their savings, too



During the first quarter, Wells paid a rate of 2.34% on its interest-bearing deposits, nearly twice what it paid a year ago  
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▶ More

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  - ▶ Relevant variables: real GDP, consumption, investment, and the stock market.
- Build a simple partial equilibrium banking model that reconciles the state-dependent responses in net interest margins.
- Integrate into a general equilibrium model with heterogeneous agents to show how:
  - ▶ state-dependent bank margins can generate state-dependence in the transmission of monetary policy to real outcomes.

## Net interest margins (NIM)

- Response of banks' NIM to a monetary policy shock is **state-dependent**.
  - ▶ After a period of **low** Fed Funds rates, a contractionary monetary policy shock leads to a **rise** in NIM.
  - ▶ After a period of **high** Fed Funds rates, a contractionary monetary policy shock leads to a **fall** in NIM.
- Challenges conventional wisdom that NIMs are roughly unaffected by changes in the policy rates.
- Primary focus of this paper: understand state-dependent response of NIM to policy rate changes and the implications for the monetary transmission mechanism.

## Related literature

- Role of banks in monetary policy transmission
  - ▶ Curdia and Woodford (2010), Driscoll and Judson (2013), Gertler and Karadi (2015), Piazzesi, Rogers, and Schneider (2019), Bianchi and Bigio (2022), Buchak, Matvos, Piskorski, and Seru (2024).

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- Marginal propensity to consume out of liquid wealth and its implications for monetary policy
  - ▶ Johnson, Parker, and Souleles (2006), Parker, Souleles, Johnson, and McClelland (2013), Jappelli and Pistaferri (2014), Kaplan and Violante (2014), Debortoli and Gali (2017), Kueng (2018), Auclert, Rognlie, and Straub (2024), Ganong et al. (2020), Fagereng, Holm, and Natvik (2021).

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- Importance of social dynamics in changing people's expectations
  - ▶ Kelly and Grada (2000), Carroll (2003), Iyer and Puri (2012), Burnside, Eichenbaum, and Rebelo (2016).

# Outline

- Empirical analysis
  - ▶ Local projections framework
  - ▶ Results (Core NIM, GDP + Robustness)
- Estimated partial equilibrium competitive banking model
  - ▶ Equilibrium deposit interest rates
  - ▶ Social dynamics
  - ▶ Implications for NIM
- Estimated general equilibrium Heterogenous-Agent New Keynesian model
  - ▶ Key elements
  - ▶ Implications for macro-aggregates

## Empirical analysis

- Data from the **Consolidated Reports of Condition and Income** (Call Reports), FDIC.
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- core NIM = average **loan** interest income rate minus average **deposit** interest expense rate.
- overall NIM = average interest income rate on **all assets** minus average interest expense rate on **all liabilities**.
- Quarterly data from 1985:1 to 2019:4.

# Monetary policy shocks

- **Measure 1:** Recursive shock measure

- ▶ Residual from a regression of the Fed Funds rate on contemporaneous and four lags of lagged real GDP, the PCE price index, four lags of the excess bond premium, and yield curve slope.

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- **Measure 2:** Bauer and Swanson (2022) shock measure

- ▶ Movements in one, two, three, and four-month ahead Eurodollar futures contracts (ED1–ED4) in a 30-minute window around FOMC announcements.
  - ▶ Orthogonalize shock wrt contemporaneous, four lags of real GDP, PCE prices, investment, and consumption, four lags of excess bond premium (part of credit spread not explainable by expected default risk), and yield curve slope.

# Estimation

- Local projection equation

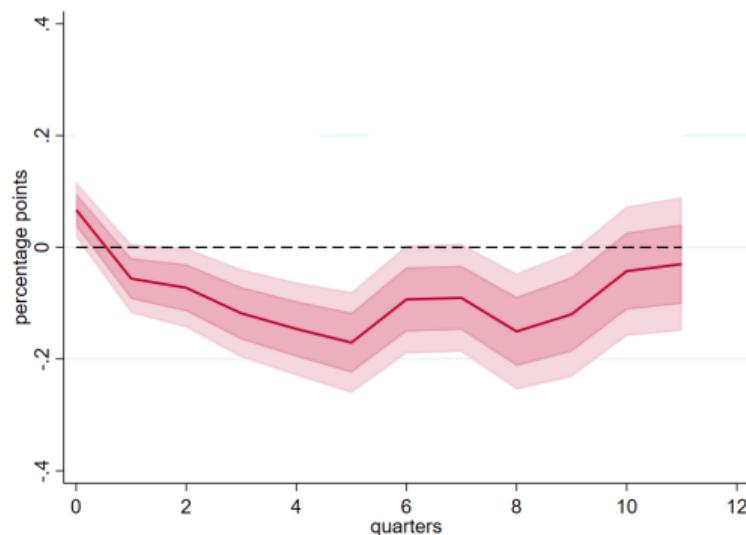
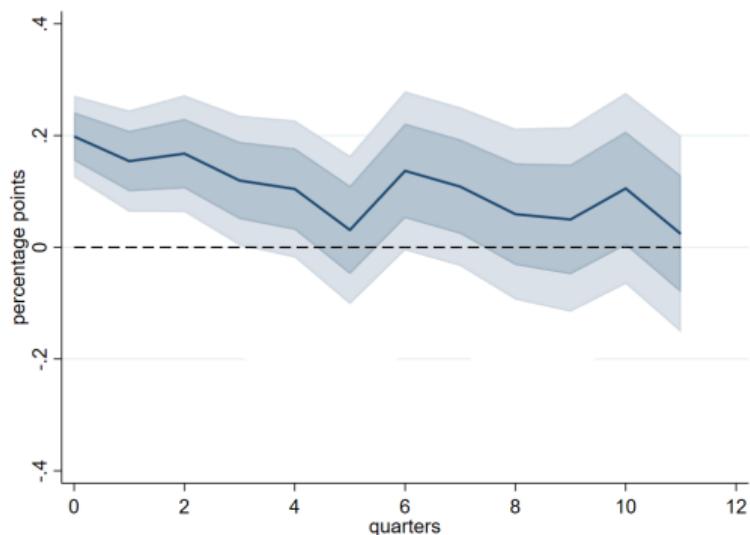
$$\begin{aligned} Y_{t+h} = & \alpha_h + \beta_{0,h} MP_t + \beta_{1,h} \mathbb{I}_{\{MA(R) > \bar{R}\}} + \beta_{2,h} MP_t \times \mathbb{I}_{\{MA(R) > \bar{R}\}} \\ & + A_h(L)Y_t + B_h(L)MP_t + C_h(L)Z_t + \varepsilon_{t+h} \quad h = 1, \dots, H. \end{aligned}$$

- $MP_t$  : time  $t$  value of monetary policy shock.
- $\mathbb{I}_{\{MA(R) > \bar{R}\}}$  : indicator variable that's one when average level of FF rate across last six quarters is higher than  $\bar{R} = 4\%$  and zero otherwise.
- $A_h(L)Y_t$  and  $B_h(L)MP_t$ : values of  $Y_{t-j}$  and  $MP_{t-j}$ ,  $j = 1, 2, 3, 4$ ,  $C_h(L)Z_t$ : contemporaneous, 4 lags of real GDP, PCE prices, investment and consumption, 4 lags of excess bond premium, yield curve slope.

# Core NIM responses to contractionary monetary policy

Response in low rate state

Response in high rate state



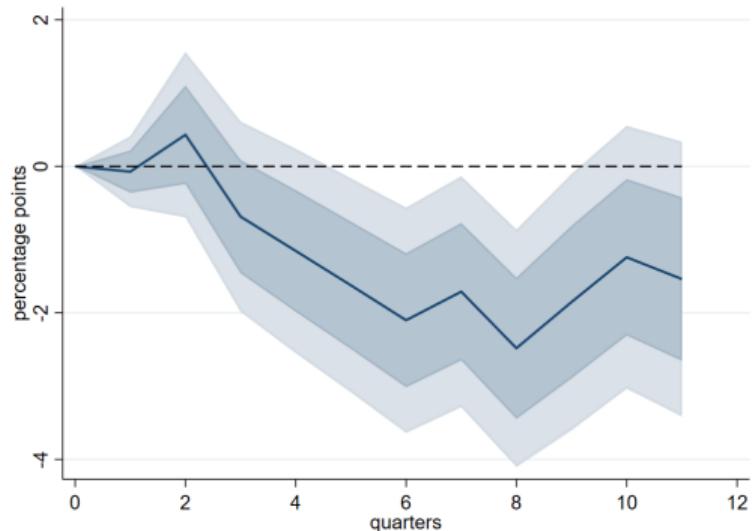
Notes: Cholesky-based policy shock; annualized 1pp rise in FFR.

## Decomposing movements in core NIM

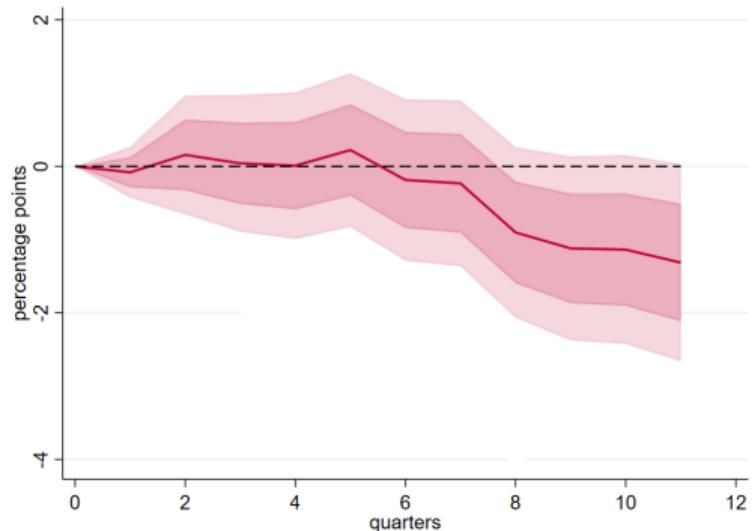
- **Intensive margin:** changes in interest rates on savings and time deposits.
- **Extensive margin:** changes in ratio of time deposits to saving deposits.
- Extensive margin plays a larger role than intensive margin.
  - ▶ a contractionary monetary policy shock induces a switch from savings deposits to time deposits.
- Less evidence of state dependence in extensive margin than intensive margin.
  - ▶ But movements in **extensive margin exacerbates impact of state dependence in intensive margin.**

# Real GDP responses to contractionary monetary policy shock

Response in low rate state



Response in high rate state



Notes: Cholesky-based policy shock; annualized 1pp rise in FFR.

## Taking Stock

- Strong evidence of state-dependence in responses of core NIM and real GDP.
- Response of core NIM switches sign; response of real GDP stronger/weaker.
- Differences between responses statistically significant. Imply 190 bil. difference in NIM between high and low states over three years.
- Results robust to Bauer-Swanson (2022) shock measure, sample through 2023, sample ending 2007, NBER business cycle indicator, ZLB, threshold level and duration, etc.
- More results: consumption, investment, inflation, S&P500 (incl. back-on-the-envelope calcs. on aggregate demand effects), federal funds rate (no state-dependence), and decompositions. 

► More on back of the envelope

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## An estimated partial equilibrium competitive banking model

- Two types of hh's: attentive and inattentive to interest rates offered by banks on deposits.

$$a_t + i_t = 1.$$

- Each household has one dollar of deposits.
- A continuum of banks with measure one.

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- Two types of hh's: attentive and inattentive to interest rates offered by banks on deposits.

$$a_t + i_t = 1.$$

- Each household has one dollar of deposits.
- A continuum of banks with measure one.
- Every period, a fraction  $\delta$  of dollar deposits leave their bank due to exogenous factors.
  - ▶ So, there's  $\delta a_t$  and  $\delta i_t$  dollars belonging to attentive and inattentive hh seeking a new bank at time  $t$ .
- Banks can identify attentive and inattentive and invest resources to attract both types of hh.

► Anecdotal evidence: google trends

## An estimated partial equilibrium competitive banking model

- Banks invest  $\tau_j v_j$  dollars to attract type  $j$  deposits,  $j = a, i$ .
  - ▶ It is more costly to attract inattentive depositors than attentive ones, i.e.,  $\tau_i > \tau_a$ .
  - ▶ Reason: inattentive depositors are less likely to notice bank offers.
- Matches between banks and deposits of attentive and inattentive households form according to

$$m_{at} = \mu (\delta a_t)^\varsigma v_{at}^{1-\varsigma} \quad m_{it} = \mu (\delta i_t)^\varsigma v_{it}^{1-\varsigma}$$

- In equilibrium, all deposits find a match.

## Loan rates

- Central bank sets policy rate,  $R_t$ , which coincides with the inter-bank borrowing and lending rate.
- Banks extend loans to firms so that the latter can meet their working capital needs.
- Marginal cost of lending one dollar is constant and equal to  $\varepsilon^l$ .
- Perfectly competitive banks; equilibrium lending rate,  $R_t^l$ , is

$$R_t^l = R_t + \varepsilon^l$$

## Social dynamics

- Exogenous and endogenous transitions that change number of attentive and inattentive hh's.
- Laws of motion for number of attentive and inattentive hh's:

$$i_{t+1} = i_t(1 - \kappa_i) - \omega(R_t)a_t i_t(1 - \kappa_i) + \kappa_a a_t$$

$$a_{t+1} = a_t(1 - \kappa_a) + \omega(R_t)a_t i_t(1 - \kappa_i) + \kappa_i i_t$$

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- Endogenous transitions:  $a_t i_t$  pairwise meetings between attentive and inattentive households.
  - ▶ Some inattentive hh become attentive by learning about interest rate offers through contact with attentive households.

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- Endogenous transitions:  $a_t i_t$  pairwise meetings between attentive and inattentive households.
  - ▶ Some inattentive hh become attentive by learning about interest rate offers through contact with attentive households.
  - ▶ Conversion rate,  $\omega(R_t)$ , is increasing function of annualized quarterly net interest rate.

$$\omega(R_t) = \chi (4R_t - 4)^2 .$$

rates have been low (high).

## Banking with social dynamics

- Deposit markets perfectly competitive.
- $R_{at}$  and  $R_{it}$ : time  $t$  gross interest on deposits owned by attentive and inattentive customers.

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- Value of a dollar deposit from an attentive household is

$$V_{a,t} = R_t - R_{at} + \frac{1 - \delta}{R_t} [\kappa_a V_{i,t+1} + (1 - \kappa_a) V_{a,t+1}].$$

- Continuation values  $V_{j,t+1}$ , discounted at rate  $R_t$  and multiplied by  $(1 - \delta)$  to account for fraction  $\delta$  of depositors that leave bank.
- Continuation value takes into account that attentive hh may become inattentive ( $\kappa_a$ ).

## Banking with social dynamics

- Value of a dollar deposit from an inattentive consumer is given by

$$V_{i,t} = R_t - R_{it} + \frac{1-\delta}{R_t} ([\omega(R_t)a_t + \kappa_i] V_{a,t+1} + \{1 - [\omega(R_t)a_t + \kappa_i]\} V_{i,t+1})$$

- Takes into account that inattentive household becomes a less-valuable-attentive household ( $\omega(R_t)a_t + \kappa_i$ ).

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- Takes into account that inattentive household becomes a less-valuable-attentive household ( $\omega(R_t)a_t + \kappa_i$ ).
- Zero profits: in equilibrium, cost of attracting a dollar belonging to an attentive or inattentive depositor equals probability of obtaining that dollar of deposit multiplied by its value to the bank.

## State-dependency of NIM with social dynamics

$$\begin{aligned} nim_t &= R_t + \varepsilon^I - (a_t R_{at} + i_t R_{it}) \\ &= \varepsilon^I + \frac{\tau_i - (\tau_i - \tau_a) a_t}{\mu^{1/(1-\varsigma)}} \left(1 - \frac{1-\delta}{R_t}\right) + \frac{1-\delta}{R_t} \frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}} (a_{t+1} - a_t). \end{aligned}$$

- First two terms represent value of  $nim_t$  in economy without social dynamics (constant  $a_t$ ).
  - ▶ Increase in  $R_t$  **increases**  $nim_t$ . Reflects PV effect: current spreads rise to offset higher discount rate on future bank profits.
- Third term (and  $a_t$  in second term) represents impact of social dynamics on  $nim_t$ .
  - ▶ Increase in  $a_t$  and  $R_t$  **decreases**  $nim_t$ .
  - ▶ Interest rate spread earned by banks is lower for attentive hh's.

## Taking stock: key sources of state dependence

- Interest rate effects
  - ▶ When  $R_t$  rises,  $nim_t$  must rise because of the present value effect.
  - ▶ This effect is stronger when interest rates are low.
- Social dynamics effects:  $a_t$  rises
  - ▶  $nim_t$  falls because attentive depositors are less profitable than inattentive ones.
  - ▶ This effect is stronger when interest rates are high.

## Model Solution and Estimation

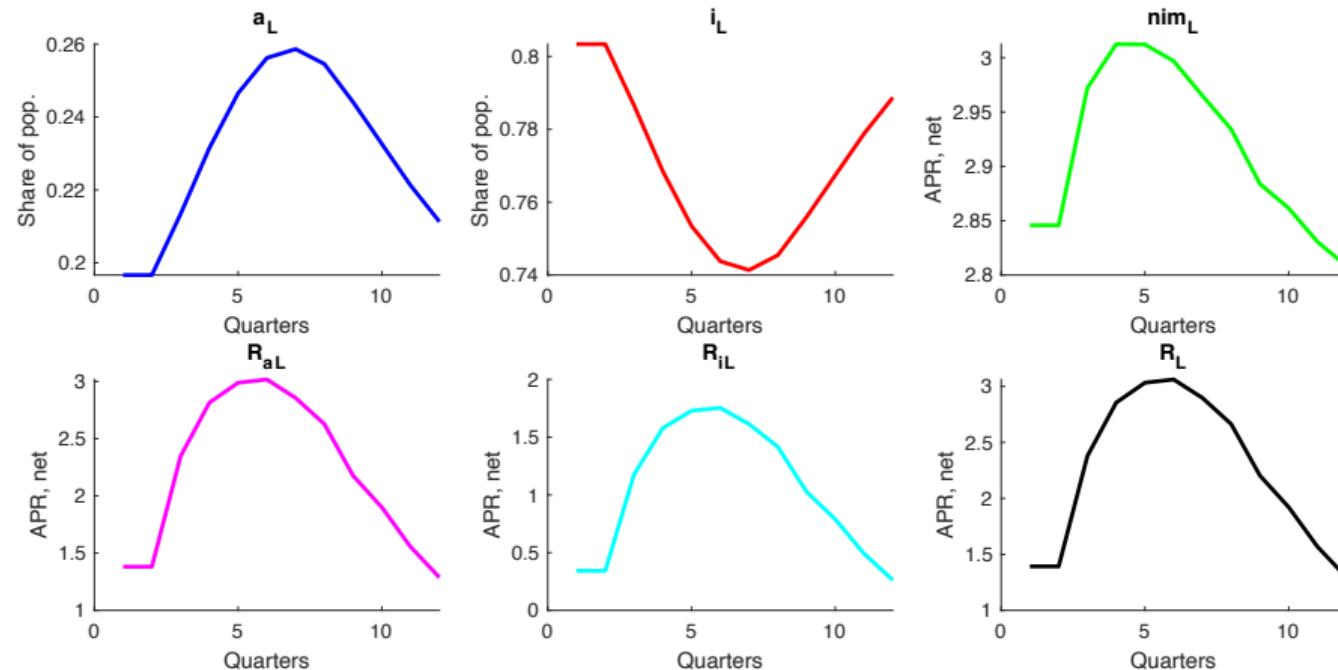
- Consider two steady states: low ( $R_L$ ) and high ( $R_H$ ) policy interest rate.
- Feed in empirical paths,  $R_{L,t}$  and  $R_{H,t}$ , after contractionary policy shock in low and high interest rate steady state model, respectively. Solve for impulse responses of **nonlinear** model.

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- Partition parameters into two sets: i) chosen a priori, and ii) estimated with Bayesian methods through IRFs matching as in Christiano, Trabandt, and Walentin (2010)
- **Parameters set a priori:**

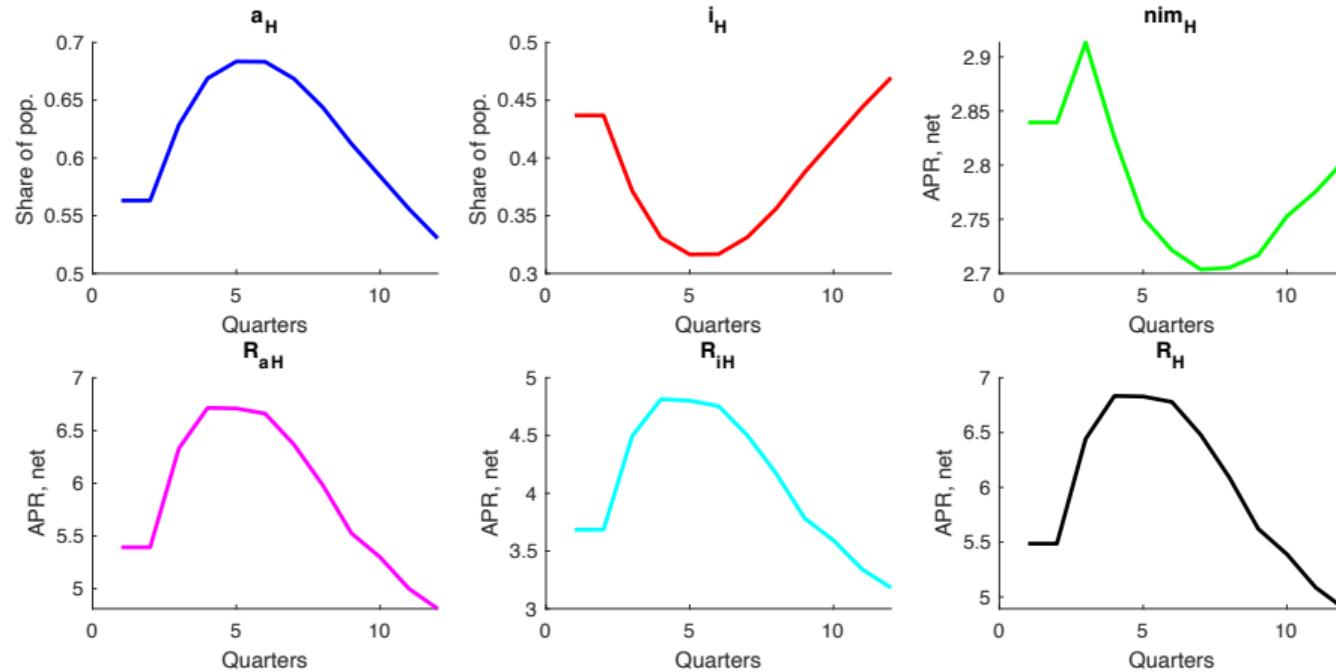
Parameter	Parameter value	Description
$\epsilon_I$	0.0075	Cost per dollar of making loans
$R_L$	1.014	Gross annual interest rate, low interest rate steady state
$R_H$	1.056	Gross annual interest rate, high interest rate steady state
$T_q$	200	Frequency of social interactions in a quarter of time

## Dynamic responses to contractionary policy shock in low-rate state



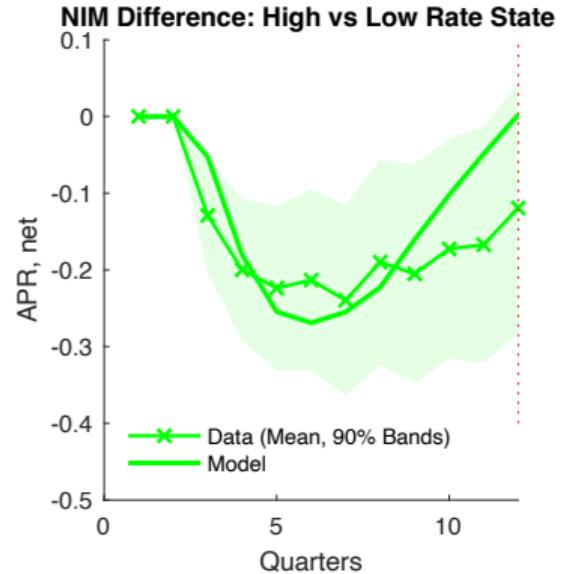
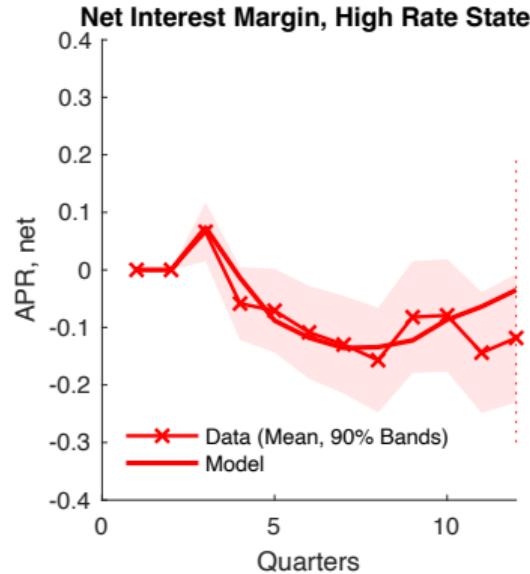
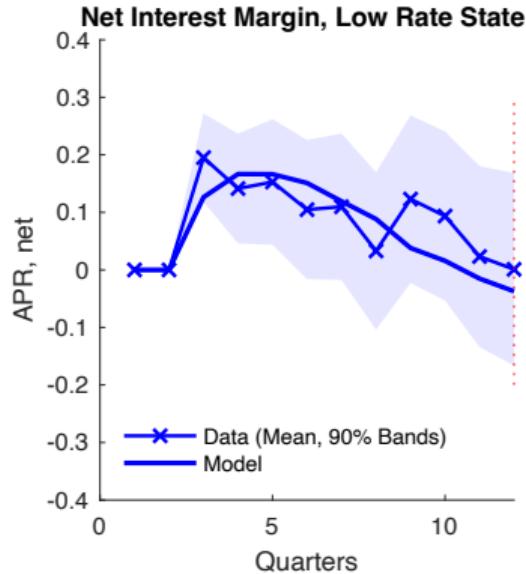
- Initial fraction of attentive depositors low (about 20%) → social dynamics not very important.  
When interest rates rise, PV effect dominates and  $nim_t$  has to rise.

# Dynamic responses to contractionary policy shock in high-rate state



- PV effect weaker. Initial fraction of attentive depositors high (about 55%) → social dynamics very important. Social dynamics dominate PV effect and  $nim_t$  falls.

## NIM - data vs model responses



# NIM - data vs model responses to policy shock without social dynamics $(\chi = 0)$

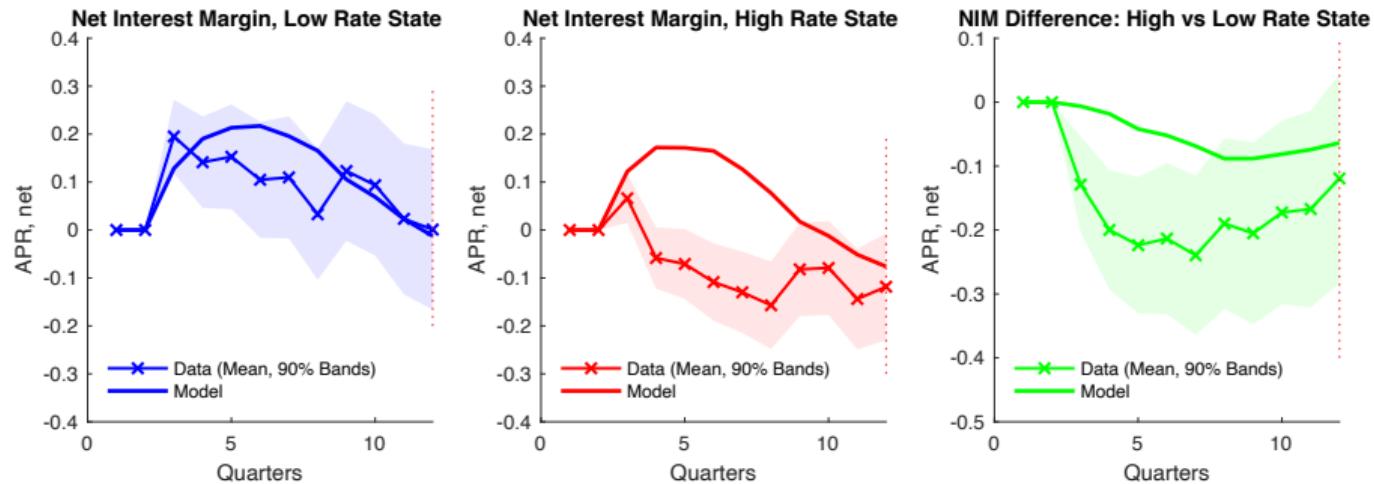


Figure: Dynamic response to monetary policy shock in high and low interest states.

- Key Take-Away: Attentive/Inattentive dynamics rationalizes the state-dependence in NIM responses to monetary policy.

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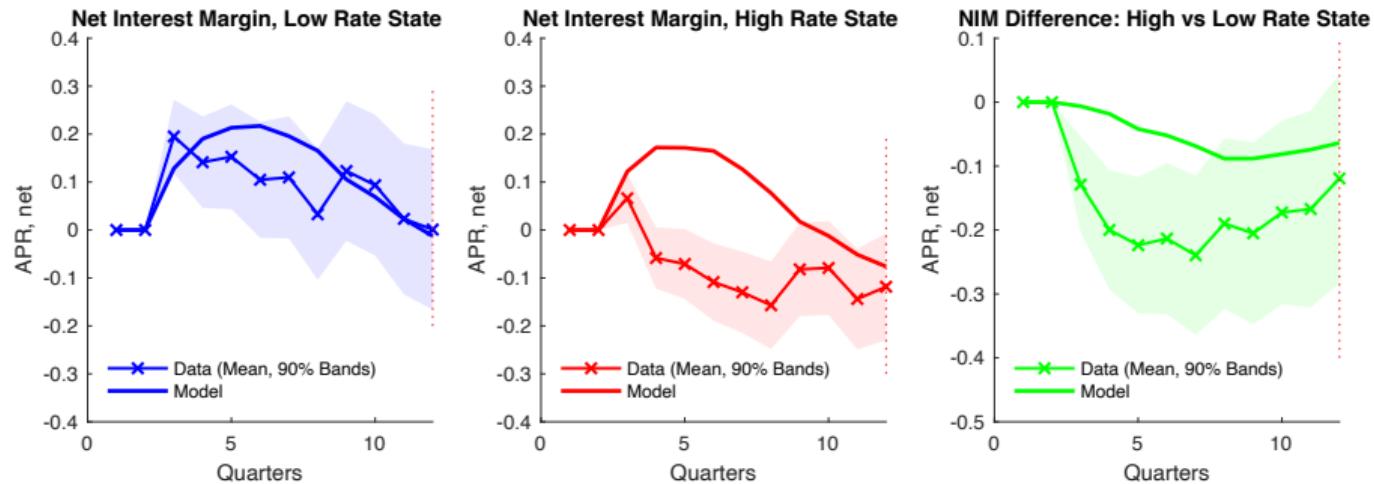


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## Estimated general equilibrium heterogenous-agent New Keynesian model

- Two types of households
  - ▶ Hand-to-mouth and optimizing agents in fixed fractions
  - ▶ Hand-to-mouth agents can be attentive or inattentive while optimizing agents are always attentive.
  - ▶ Optimizing agents have habit formation.

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  - ▶ Optimizing agents have habit formation.
- Production sector of the economy as in Christiano, Eichenbaum, and Evans (2005)
  - ▶ Sticky prices, sticky wages, investment adjustment costs, variable capital utilization.
- To produce in period  $t$ , retailer must borrow nominal wage and capital bills.
- Retailer repays loan at end of period  $t$  after receiving sales revenues.
- HH's wages are deposited at bank, available to be used for consumption at end of period.

## State dependent effects of monetary policy in GE

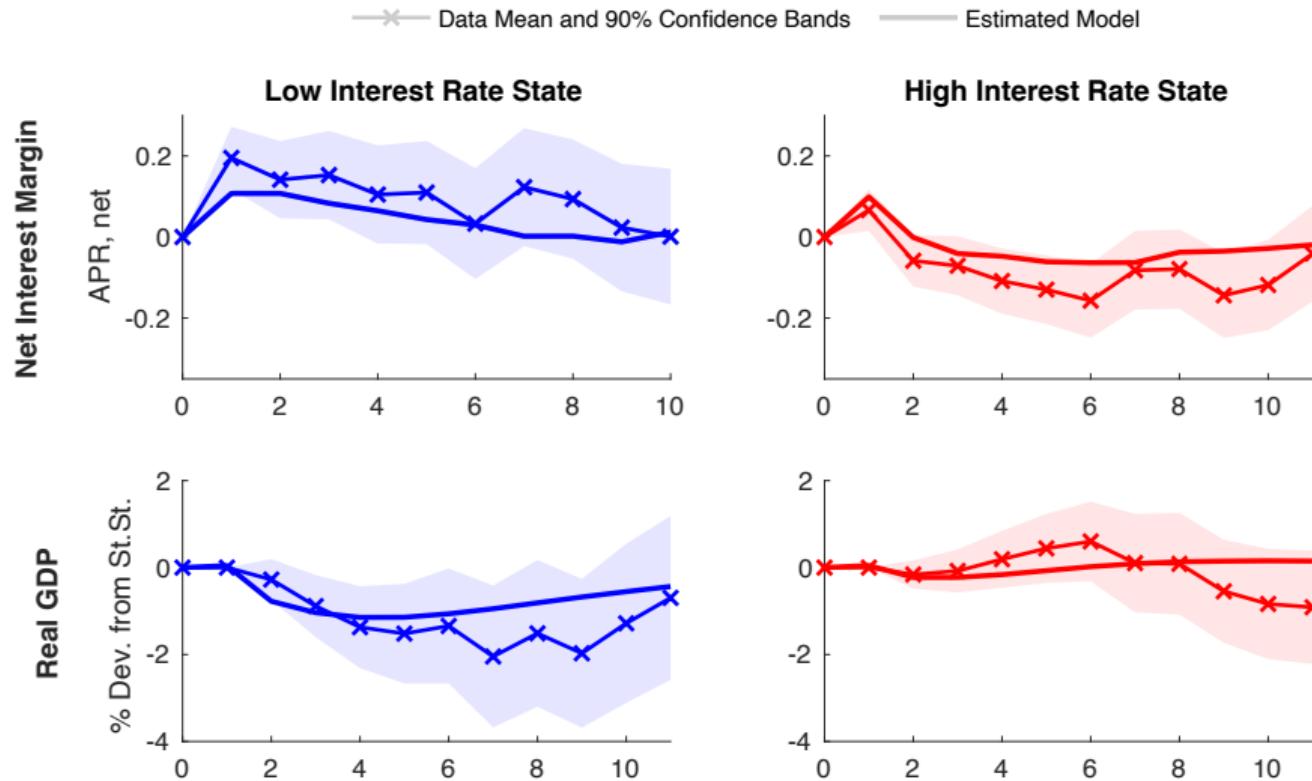
- Calibrate steady-state value of annualized real rate  $r^* = 1.4\%$ , with  $\beta = 0.9963$ .
- Construct “high state” by setting annualized inflation target to 4.2%.
- Construct “low state” by setting annualized inflation target to 0%.
- Steady-state nominal rate is 5.6% for “high state” and 1.4% for “low state”.
  - ▶ These values align with empirical averages of the federal funds rate in high and low-rate states.

## State dependent effects of monetary policy in GE

- Calibrate steady-state value of annualized real rate  $r^* = 1.4\%$ , with  $\beta = 0.9963$ .
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- Steady-state nominal rate is 5.6% for “high state” and 1.4% for “low state”.
  - ▶ These values align with empirical averages of the federal funds rate in high and low-rate states.
- Solve non-linear model. Estimate model parameters through impulse response matching (NIM, GDP, consumption, investment, and real wages).

▶ Calibration

# State-dependent effects of monetary policy in GE



# Conclusion

- Impact of monetary policy shocks on economy varies depending on whether they occur after a period of low or high interest rates.
- This state dependence is evident in banking sector profitability measures and key macroeconomic variables (GDP, consumption, and investment).
- Empirical findings can be reconciled in a non-linear GE Het Agent NK model featuring competitive banks with three key characteristics.
  - ▶ Banks optimize their rate-setting policies accounting for attentive and inattentive customers.
  - ▶ Attentive vs inattentive customers change as a function of the level of interest rates.
  - ▶ State dependence affects broader economy due to households with MPC to consume out of liquid wealth.

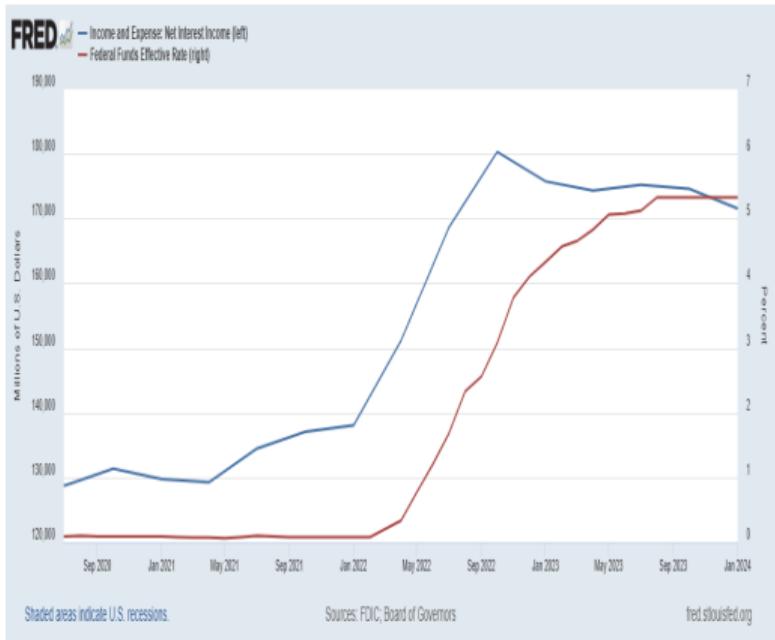
## Appendix

# APPENDIX

## References

# Introduction

## Federal Funds Rate and Banks' NIMs



July 2024 - Fed rate at 5.33%

US banks get Main Street blues as savers balk at low rates

The longer the Fed keeps rates on hold, the more incentive Americans have to move their money to higher-yield products



The four biggest US banks delivered a record high last year of more than \$253bn in combined net interest income — but it is a feat that is unlikely to be repeated © FT montage/Bloomberg/AP/Reuters

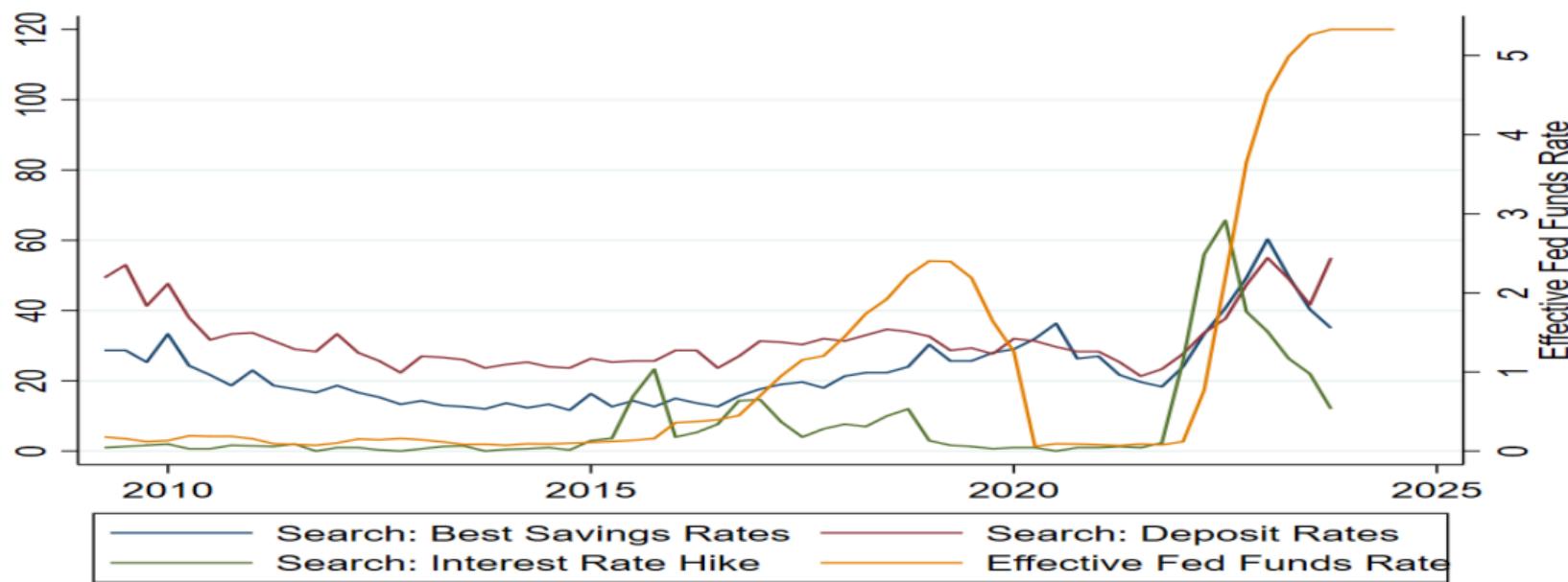
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## Google Trends: Searching Saving Products



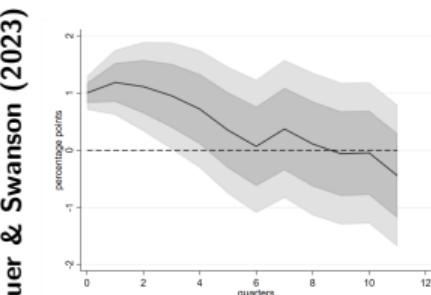
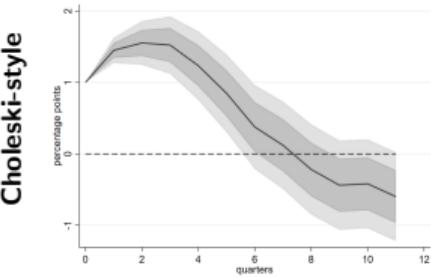
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# Google Trends: Searching Saving Products vs searching for Monetary Policy Stance



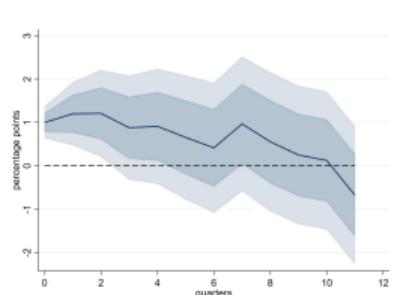
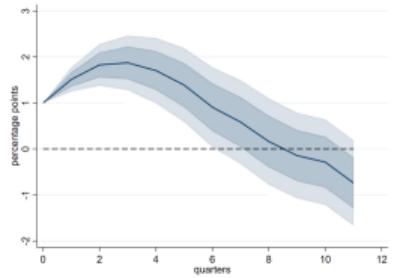
# Results: FF

No State Dependence

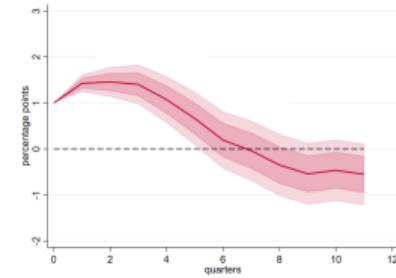


Baseline Response

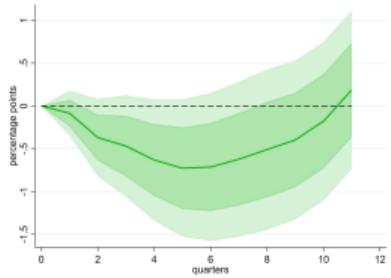
Allowing for State Dependence



Response in low rate state



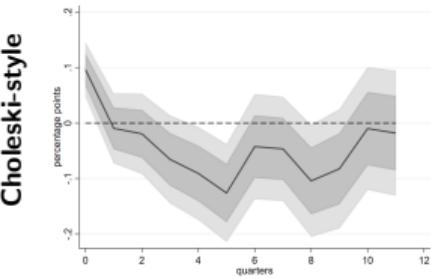
Response in high rate state



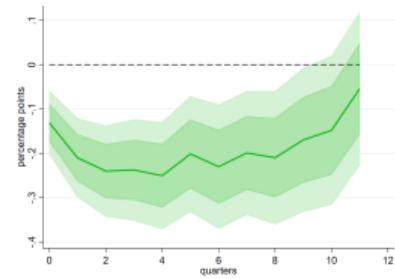
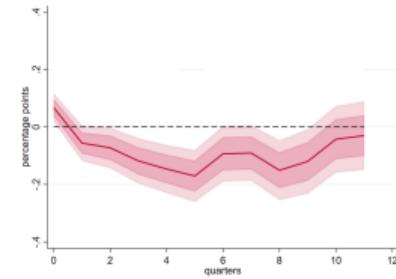
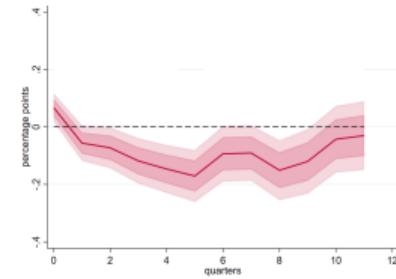
Difference Low vs High

# Results: Core NIM

No State Dependence

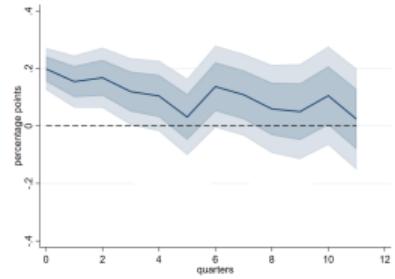
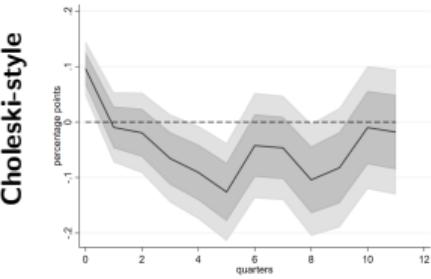


Allowing for State Dependence

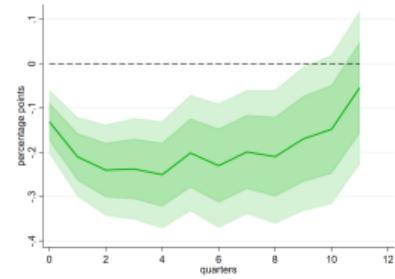
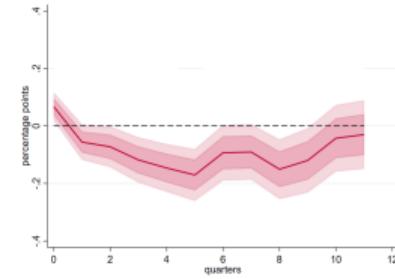


# Results: Core NIM

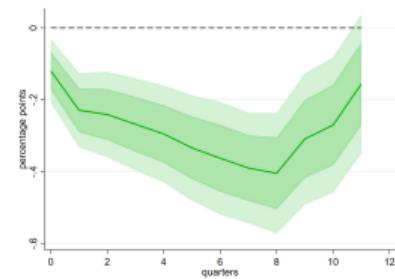
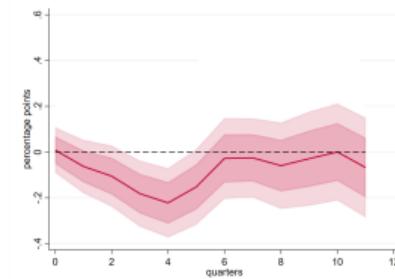
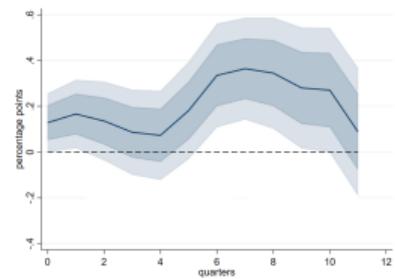
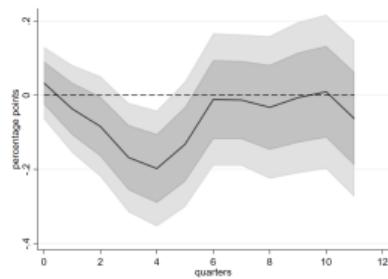
No State Dependence



Allowing for State Dependence



Bauer & Swanson (2023)



Baseline Response

Response in low rate state

Response in high rate state

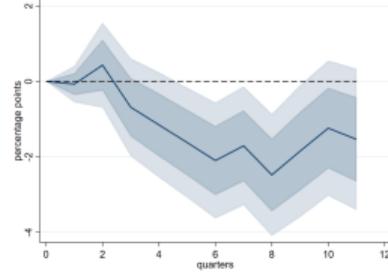
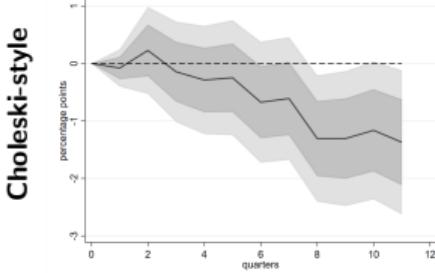
Difference Low vs High

## Core NIM

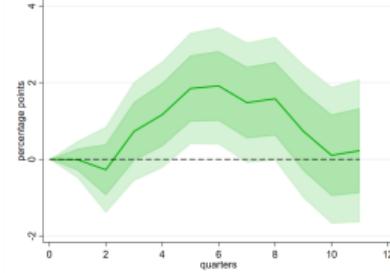
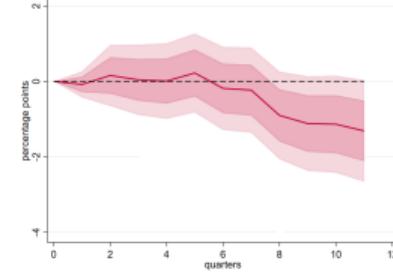
- For both shock measures, Core NIM
  - ▶ Rises when shock occurs in low state.
  - ▶ Falls when shock occurs in high state.
- Peak rise is 20 to 35 basis points, depending on shock measure.
- Peak decline is roughly 17 to 21 basis points, depending on shock measure.
- Difference between response rates is negative and statistically significant.

# Results: GDP

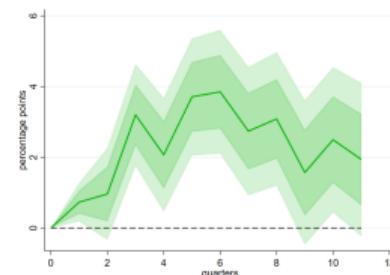
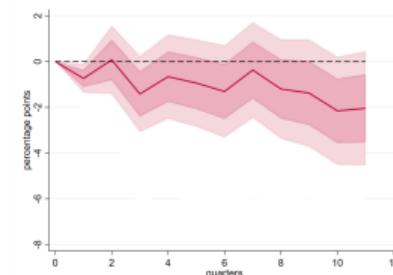
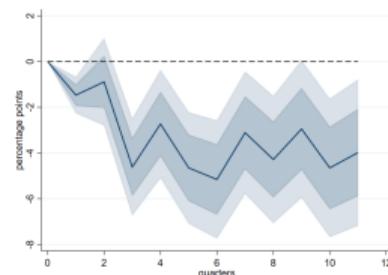
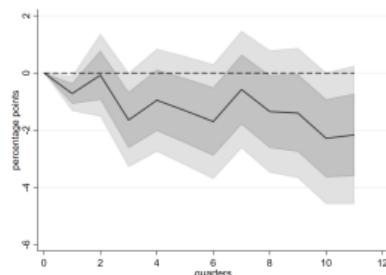
No State Dependence



Allowing for State Dependence



Bauer & Swanson (2023)



Baseline Response

Response in low rate state

Response in high rate state

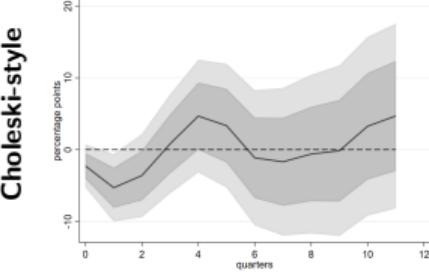
Difference Low vs High

## Real GDP

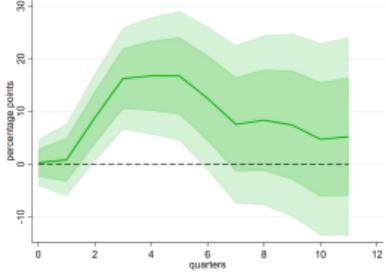
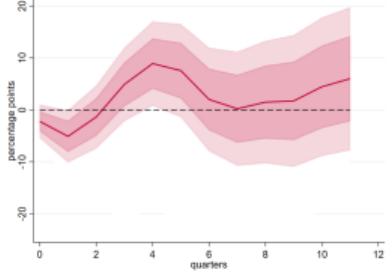
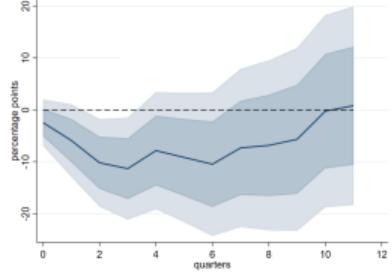
- A contractionary monetary policy shock induces a persistent decrease in real GDP for two to three years.
- Strong evidence of **state dependence** in response of real GDP.
- Decline in real GDP is larger when shock occurs in low interest rate state.
  - ▶ Difference in response is statistically significant for both shock measures.
- More results: consumption, investment, and inflation. Stock Market Index. 

# Real S&P500

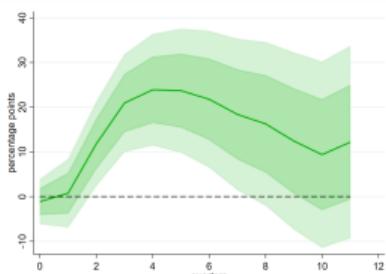
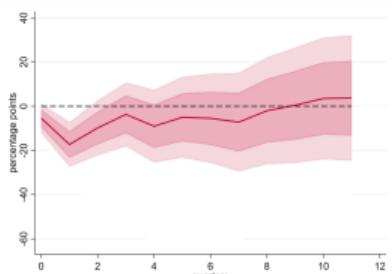
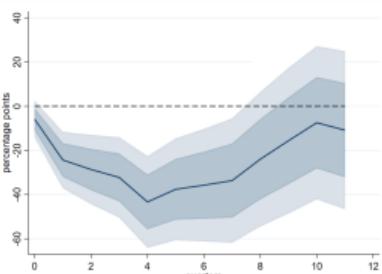
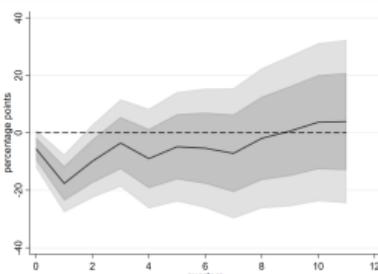
No State Dependence



Allowing for State Dependence



Bauer & Swanson (2023)



Baseline Response

Response in low rate state

Response in high rate state

Difference Low vs High

## Back-of-the-envelope calculation: NIM

- Cumulative effect of a 100 basis point monetary policy shock in low interest rate state over three years is an increase in NIM-related bank profits of roughly \$92 billion.
- If shock occurs in a high interest rate state, the impact on NIM-related profits is a decrease of \$98 billion.
- Counterparts of banks save \$190 billion in net interest paid if shock occurs in the high state rather than the low state.
  - ▶ MPC out of liquid wealth is high, somewhere between 0.20 and around 0.40 (see Carroll et al., 2017, Ganong et al., 2023).
  - ▶ So there's a differential swing in aggregate demand between \$60 billion.

## Back-of-the-envelope calculation: stock market

- After 12 quarters, S&P is down by roughly 10% after a **100 basis points** contractionary monetary policy shock which occurs in the **low** interest rate state.
  - ▶ At the end of 2019, the market capitalization of the S&P was roughly \$28 trillion.
  - ▶ So the fall implies a fall in wealth of roughly **\$2.8 trillion**.
- After 12 quarters, the S&P is down by roughly 4% after **100 basis points** contractionary monetary policy shock which occurs in the **high** interest rate state.
  - ▶ So the fall implies a fall in wealth of roughly **\$1.2 trillion**.

▶ back

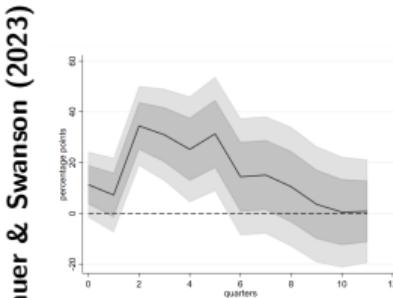
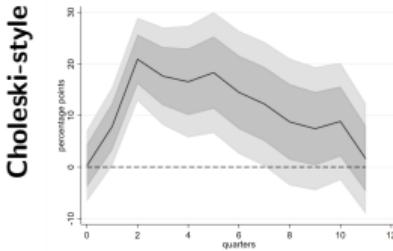
## Back-of-the-envelope calculation: stock market

- Difference in the fall in stock market wealth induced by a policy shock in the low interest versus the high interest state is **\$1.6 trillion**.
- Di Maggio, Kermani and Majlesi (2020) and Chodorow-Reich, Nenov and Simsek (2021) estimate the MPC out of stock market wealth is roughly **3%**.
- This estimate implies a differential fall in demand of **\$48 billion**.

▶ back

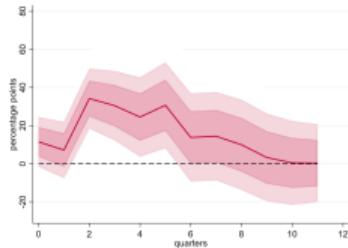
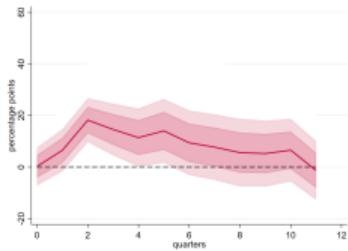
# Extensive Margin

No State Dependence

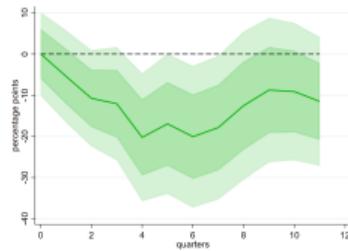


Baseline Response

Allowing for State Dependence



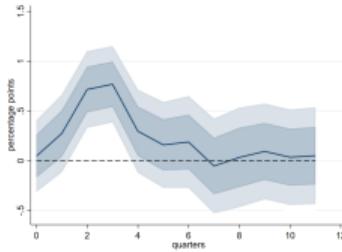
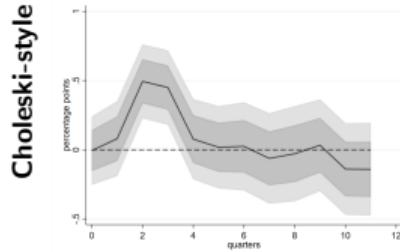
Response in low rate state



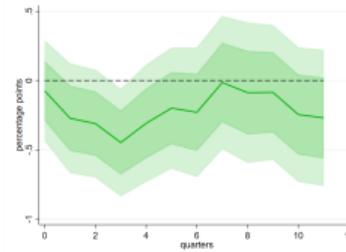
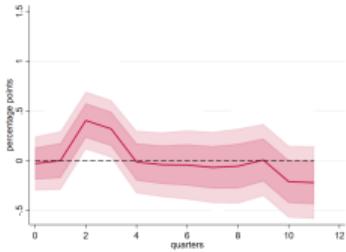
Difference Low vs High

# Intensive Margin

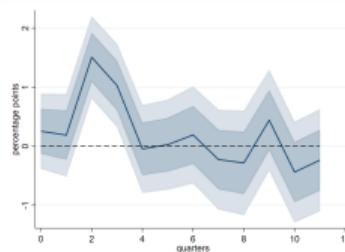
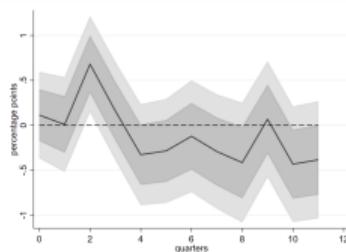
No State Dependence



Allowing for State Dependence

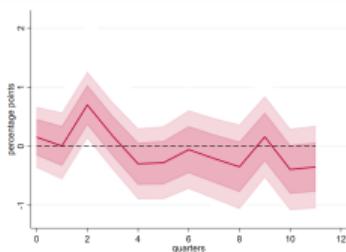


Bauer & Swanson (2023)

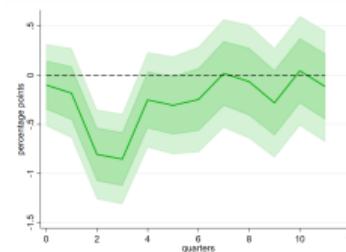


Baseline Response

Response in low rate state



Response in high rate state

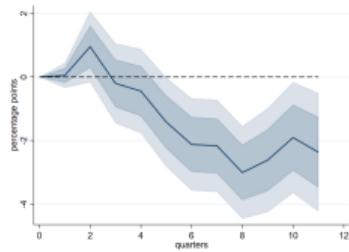
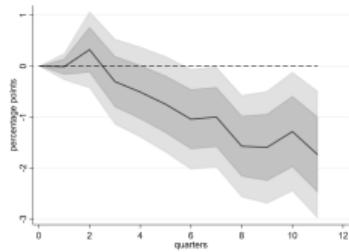


Difference Low vs High

# Consumption

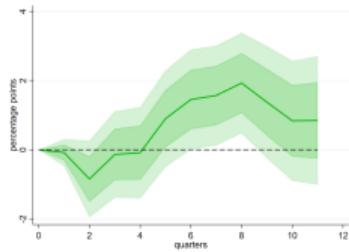
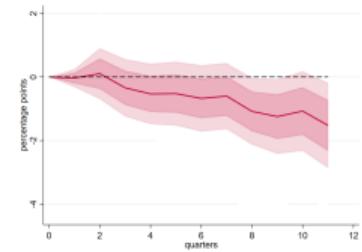
## No State Dependence

Choleski-style



## Allowing for State Dependence

Bauer & Swanson (2023)



Baseline Response

Response in low rate state

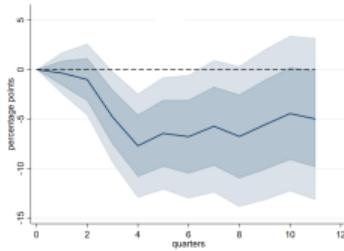
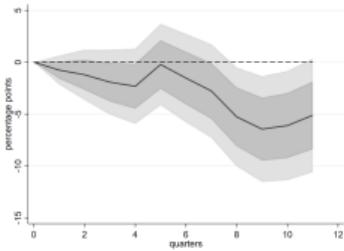
Response in high rate state

Difference Low vs High

# Investments

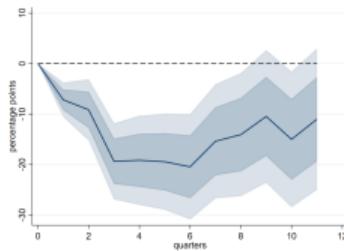
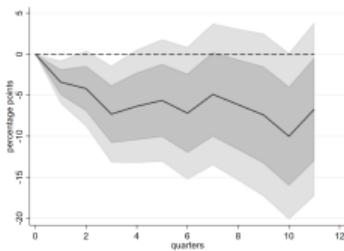
## No State Dependence

Choleski-style



## Allowing for State Dependence

Bauer & Swanson (2023)

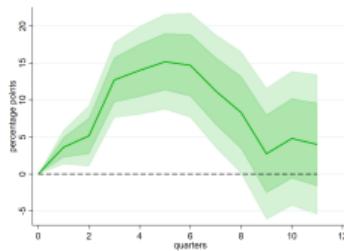
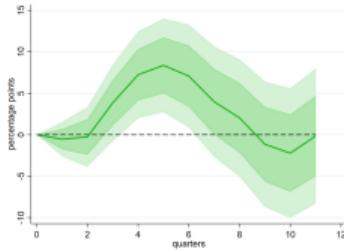
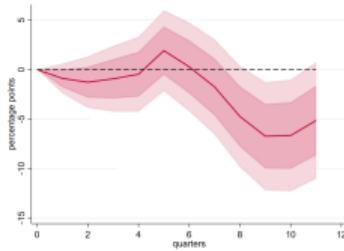


Baseline Response

Response in low rate state

Response in high rate state

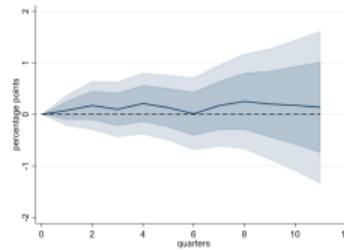
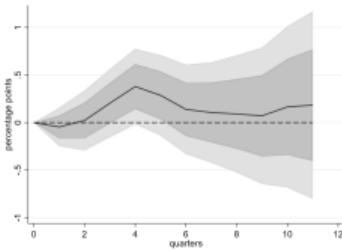
Difference Low vs High



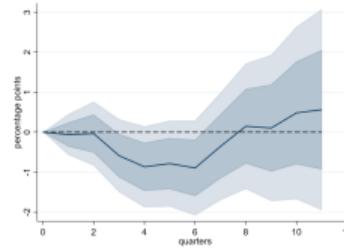
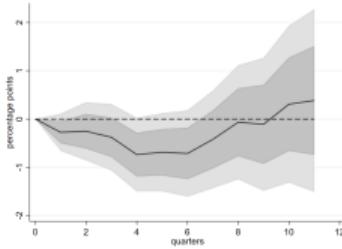
# Inflation

## No State Dependence

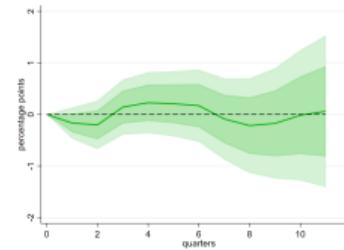
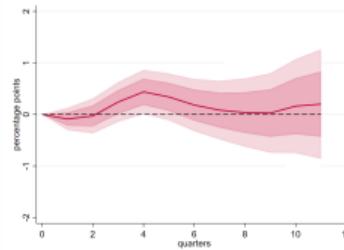
Choleski-style



Bauer & Swanson (2023)



## Allowing for State Dependence



Baseline Response

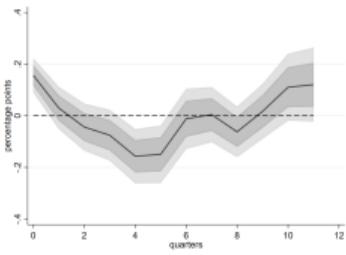
Response in low rate state

Response in high rate state

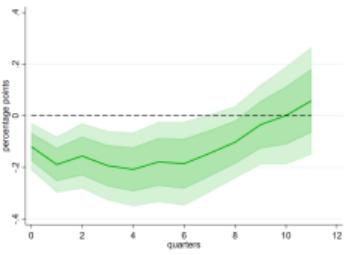
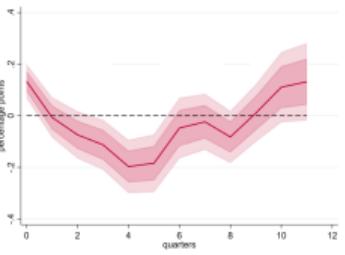
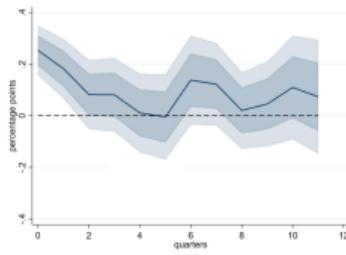
Difference Low vs High

# Core NIM Robustness: Sample 1985-2007

No State Dependence

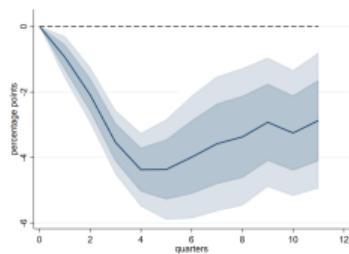
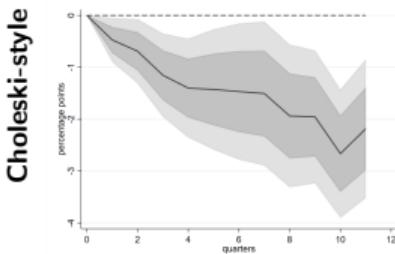


Allowing for State Dependence

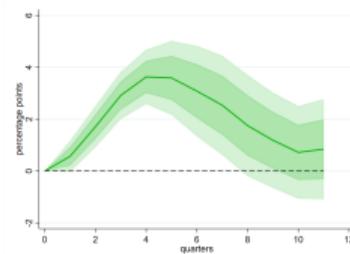
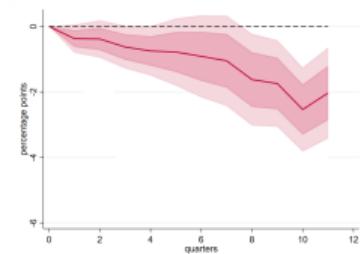


# Real GDP Robustness: Sample 1985-2007

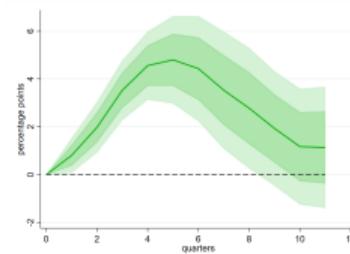
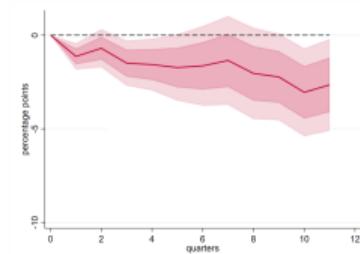
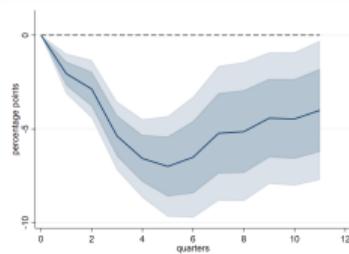
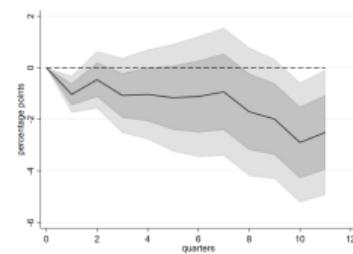
No State Dependence



Allowing for State Dependence



Bauer & Swanson (2023)



Baseline Response

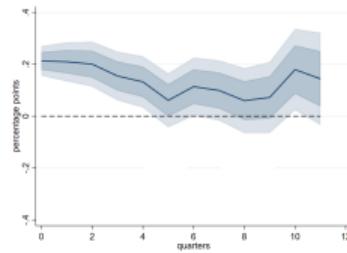
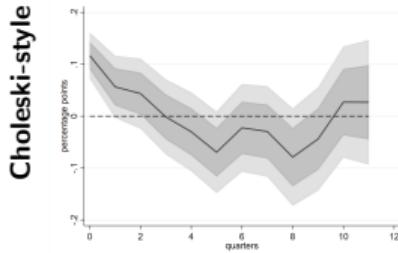
Response in low rate state

Response in high rate state

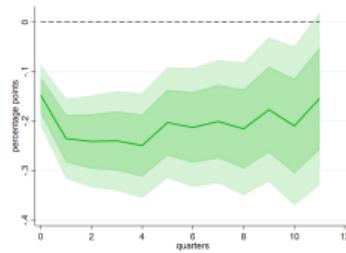
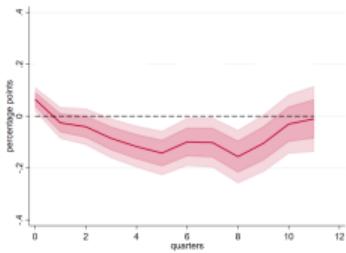
Difference Low vs High

# Core NIM Robustness: Sample 1985-2023

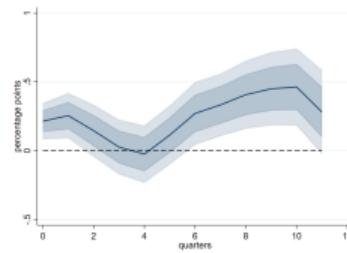
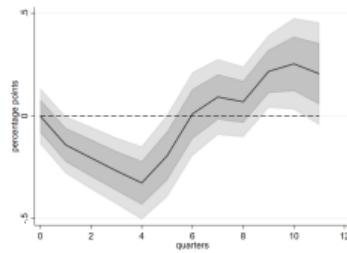
No State Dependence



Allowing for State Dependence

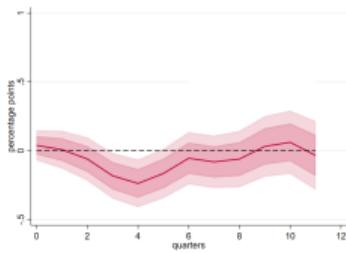


Bauer & Swanson (2023)

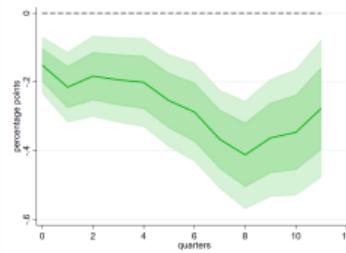


Baseline Response

Response in low rate state



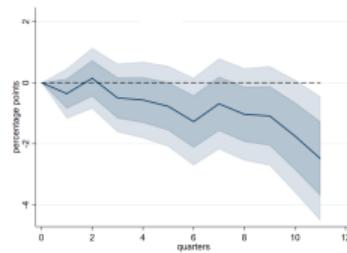
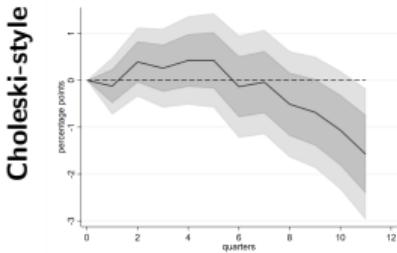
Response in high rate state



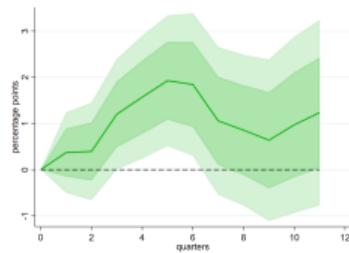
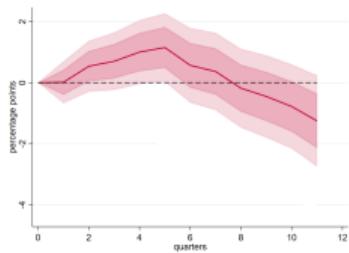
Difference Low vs High

# Real GDP Robustness: Sample 1985-2023

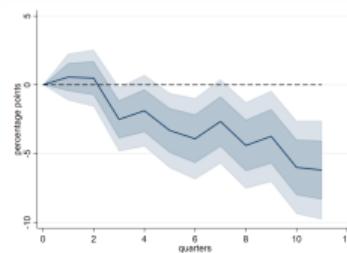
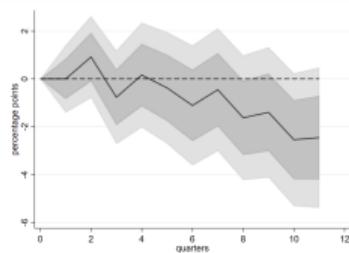
No State Dependence



Allowing for State Dependence

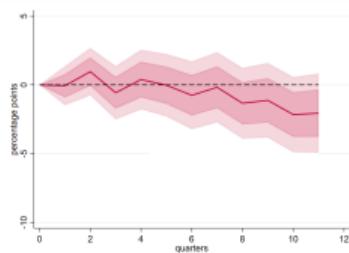


Bauer & Swanson (2023)

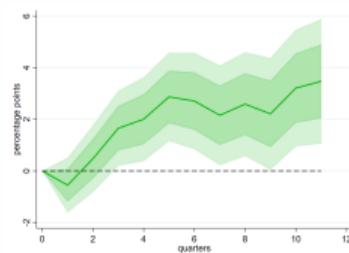


Baseline Response

Response in low rate state



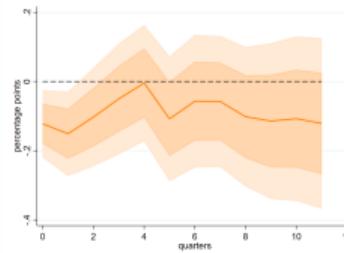
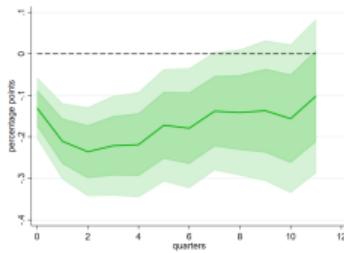
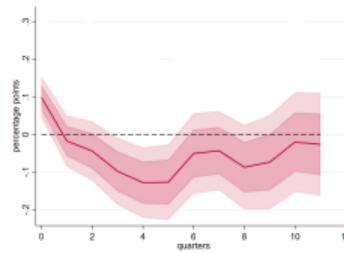
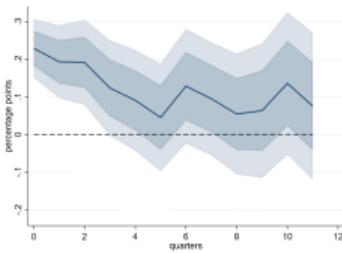
Response in high rate state



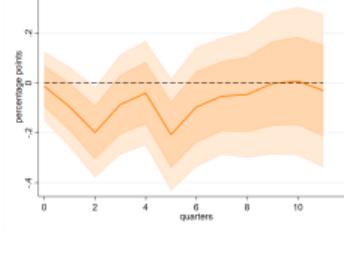
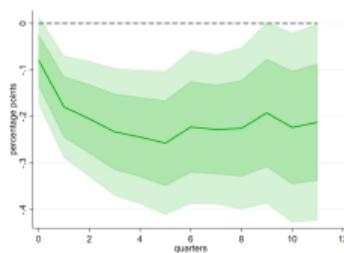
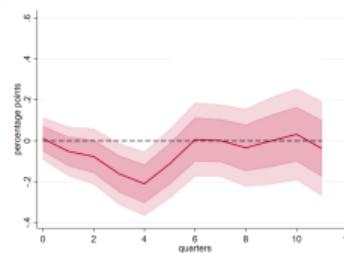
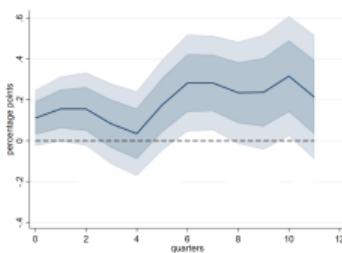
Difference Low vs High

# Core NIM Robustness: Business Cycles

Choleski-style



Bauer & Swanson (2023)



Response in low rate state

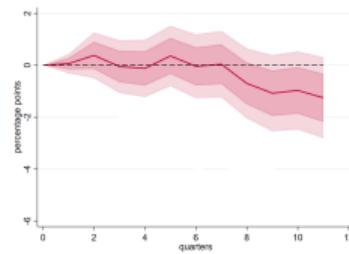
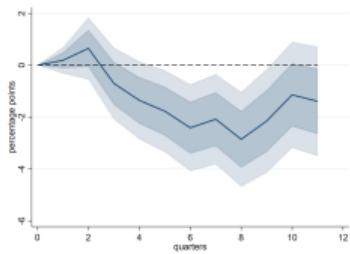
Response in high rate state

Difference Low vs High

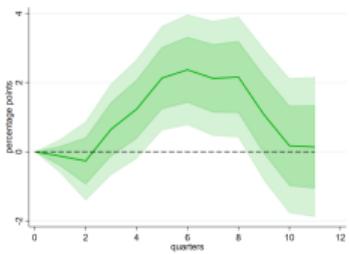
Difference Recession vs Expansion

# Real GDP Robustness: Business Cycles

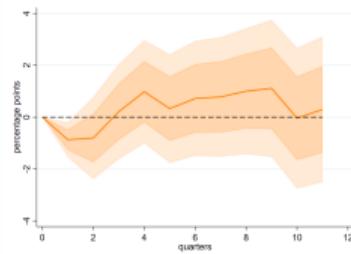
Choleski-style



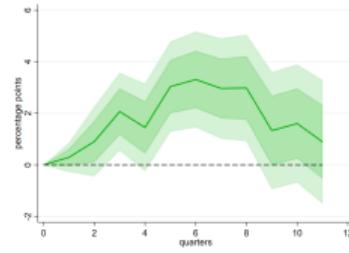
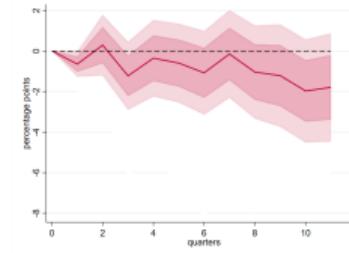
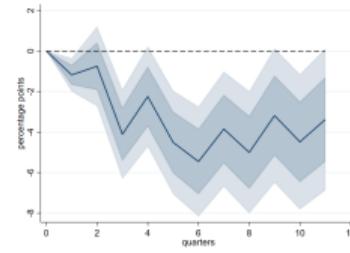
**Level Interaction Term**



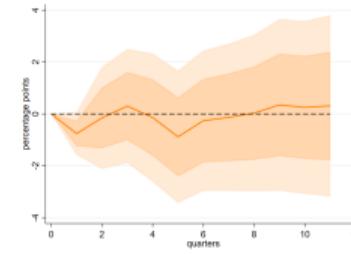
**NBER Recession Interaction Term**



Bauer & Swanson (2023)



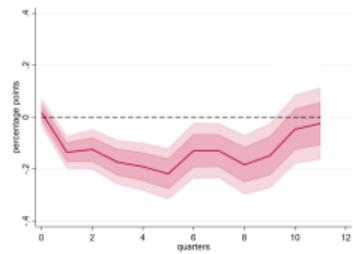
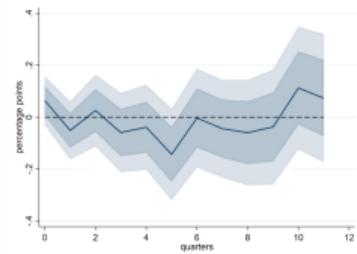
**Difference Recessions vs Expansion**



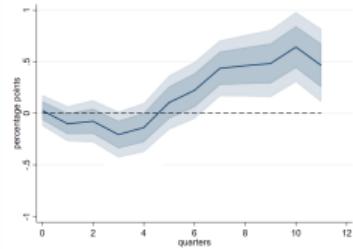
back

# Core NIM Robustness: Ups and Downs

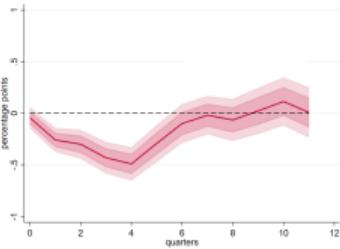
**State Dependence from the Interest Rate Level**



**Bauer & Swanson (2023)**

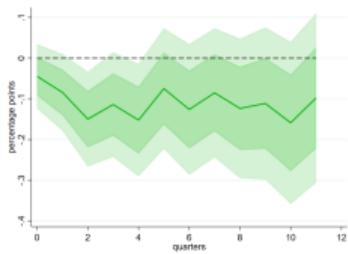


Response in low rate state

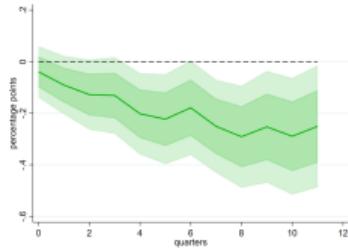
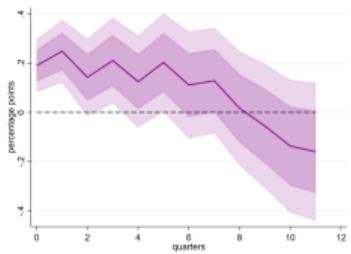


Response in high rate state

**Level Interaction Term**

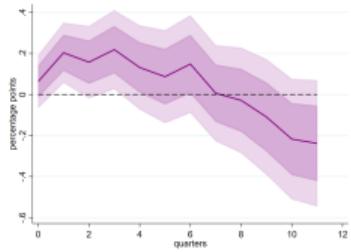


**Sign Interaction Term**



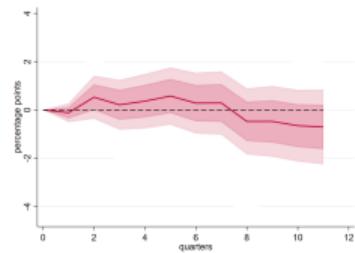
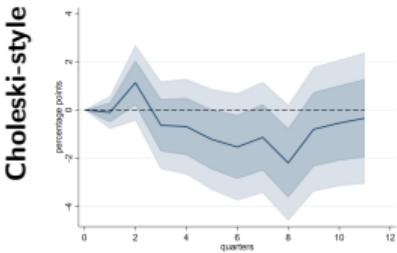
Difference Low vs High

**Difference Recessions vs Expansion**

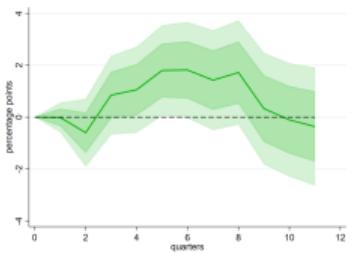


# Real GDP Robustness: Ups and Downs

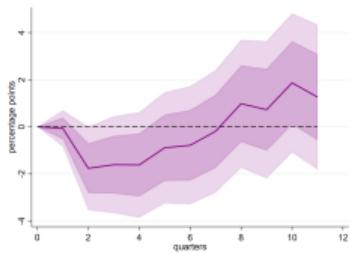
**State Dependence from the Interest Rate Level**



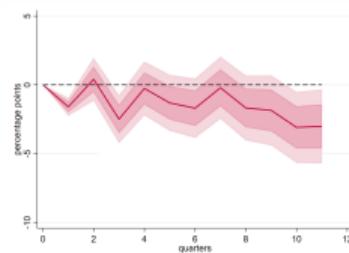
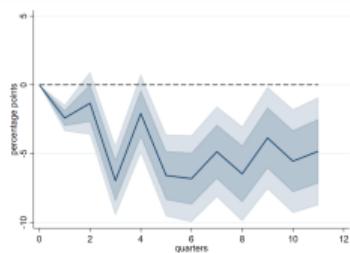
**Level Interaction Term**



**Sign Interaction Term**

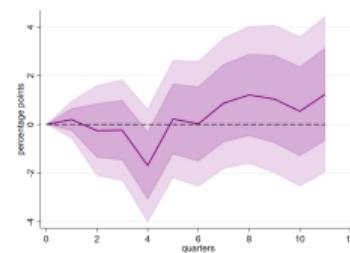
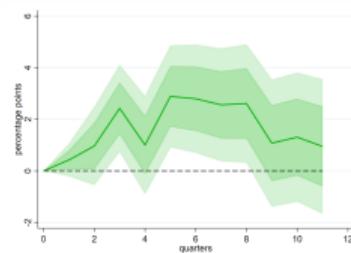


**Bauer & Swanson (2023)**



**Response in low rate state**

**Response in high rate state**



**Difference Low vs High**

**Difference Ups vs Downs**

## Model Solution and Estimation cont'd

- Estimate the following parameters:

$$\chi, \kappa_a, \kappa_i, \delta, \tau_a/\mu^{\frac{1}{1-\varsigma}}, \tau_i/\mu^{\frac{1}{1-\varsigma}}$$

- Logic of the Bayesian estimation procedure is conceptually the same as in Christiano, Trabandt, and Walentin (2010)
  - ▶ Vector  $\hat{\psi}$ : empirical estimates of impulse responses of NIM in high and low interest rate state
  - ▶ Vector  $\psi(\theta)$  : mapping from model parameters  $\theta$  to model impulse responses of NIM.
  - ▶ Estimate  $\theta$  such that  $\psi(\theta)$  is as close as possible to  $\hat{\psi}$ .

▶ More on Estimation

▶ Priors and Posterios

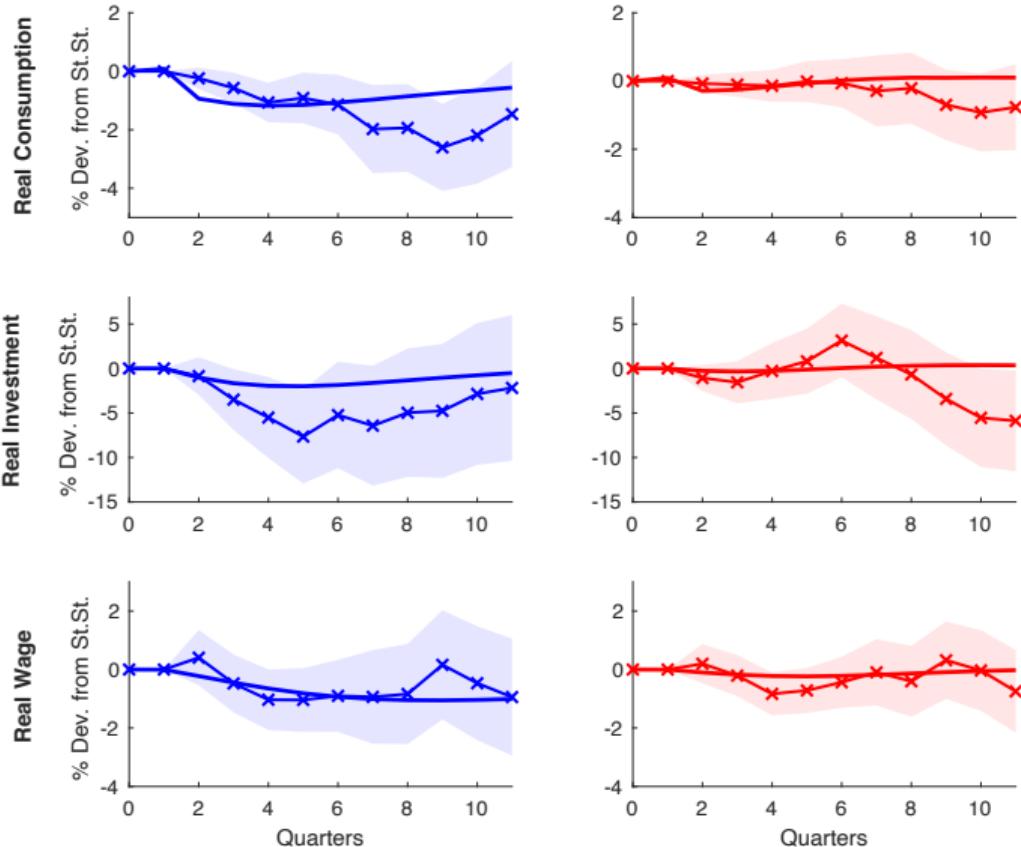
▶ back

## Estimation: Priors and Posteriors of Parameters

Table: Priors and Posteriors of Parameters.

Parameter	Prior Distribution	Posterior Distribution
	D, Mean, [2.5-97.5%]	Mode, [2.5-97.5%]
Social dynamics interaction parameter, $\chi$	G, 2.0, [0.242 5.572]	1.3880, [1.081 4.852]
Rate at which attentive become inattentive, $\kappa_a$	U, 0.5, [0.025 0.975]	0.0022, [0.002 0.011]
Rate at which inattentive become attentive, $\kappa_i$	U, 0.5, [0.025 0.975]	0.0005, [0.000 0.007]
Fraction of depositors who leave banks, $\delta$	U, 0.5, [0.025 0.975]	0.0127, [0.008 0.020]
Cost of attracting attentive depositors, $\tau_a/\mu^{\frac{1}{1-\varsigma}}$	U, 50 , [2.5 97.5]	0.0197, [0.018 0.053]
Cost of attracting inattentive depositors, $\tau_i/\mu^{\frac{1}{1-\varsigma}}$	U, 50 , [2.5 97.5]	0.1210, [0.074 0.154]

# GE IRFs: Consumption Investments and Wages



# Estimation

- Specify uniform priors for all elements of  $\theta$  and then compute the posterior distribution for  $\theta$  given  $\hat{\psi}$  using Bayes' rule.
  - ▶ Use a Gamma prior for  $\chi$  and Uniform (0, 100) priors for  $\tau_a/\mu^{\frac{1}{1-\varsigma}}$  and  $\tau_i/\mu^{\frac{1}{1-\varsigma}}$ , as well as Uniform (0, 1) priors for  $\kappa_a$ ,  $\kappa_i$ , and  $\delta$ .
- Only consider parameter values  $\theta$  in model estimation such that:
  - ▶  $R_{i,t}$  and  $R_{a,t}$  are never lower than one after a monetary policy shock in either of the two states considered.
  - ▶ Spreads  $R_t - R_{i,t}$  and  $R_t - R_{a,t}$  are always non-negative, and  $R_{a,t} \geq R_{i,t}$ .

◀ back

# Priors and Posteriors

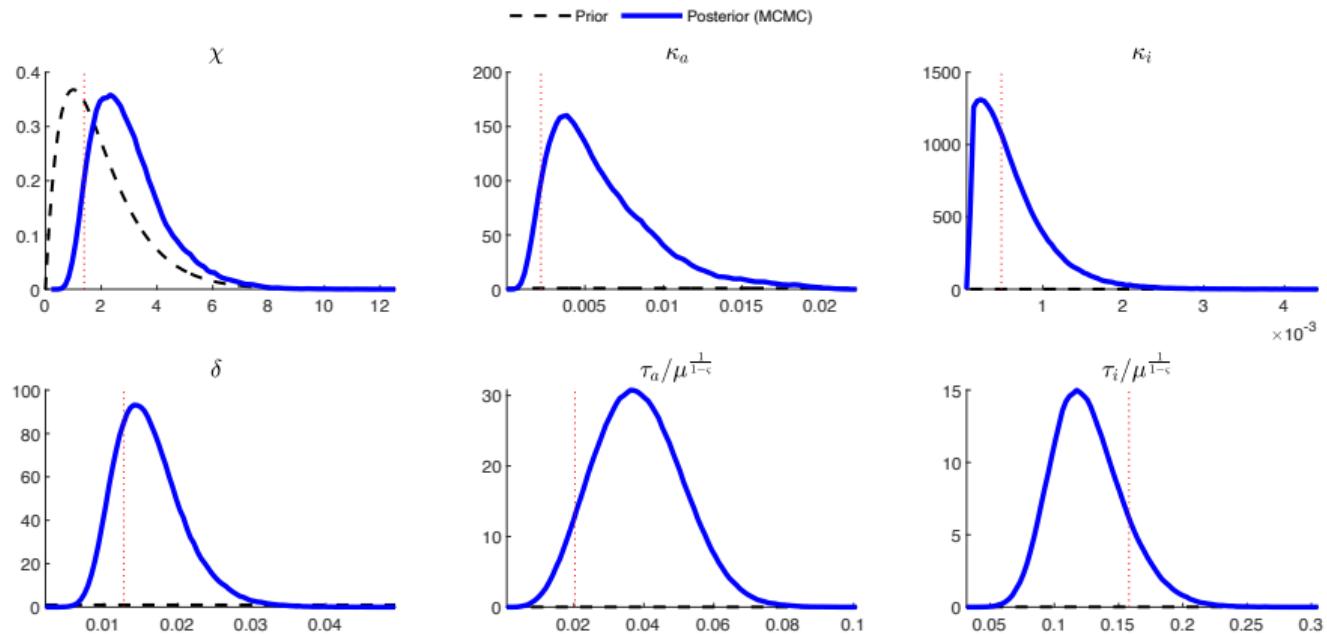


Figure: Priors and Posteriors of Estimated Parameters.

End of Appendix

THANKS!!