Net Interest Margins and Monetary Policy

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Introduction

- This paper documents a novel source of state dependency in the response of economy activity to a monetary policy shock.
  - If a monetary policy shock occurs after a period of low interest rates, it has a larger impact on aggregate economic activity than if it occurs after a period of interest rates.
  - **Real GDP**, consumption, investment **and stock market fall more sharply** when a contractionary policy occurs **in low interest rate state** versus high interest rate state.
- We document two channels by which the financial system induces state dependency in the monetary transmission mechanism.
  - The stock market
  - Banks' net interest margins

The stock market

- Stock market channel is straightforward.
  - A contractionary monetary policy shock has a more powerful contractionary effect on stock prices when it occurs after a period of low interest rates.
  - Standard asset pricing theory implies that the price of a long-lived asset to a given change in the interest rate will be lower, the higher is the initial interest rate.
  - So the negative wealth effect of a given basis point increase in the policy rate will be larger, the lower is the initial interest rate.

Net interest margins (NIM)

- Response of banks' NIM to a monetary policy shock is *state-dependent*.
- After a period of low FF rates, a contractionary monetary policy shock leads to a significant *rise* in NIM.
- After a period of high FF rates, a contractionary monetary policy shock leads to a *fall* in NIM.
- This finding stands in contrast to 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.

Conjecture

- **Suppose bank profits accrue to people with much lower MPC** out of liquid wealth **than people who receive interest income from banks**.
- Then, **contraction in aggregate demand should be larger** when policy shock occurs in **low interest rate state**.

$\Longrightarrow$ in an economy with nominal rigidities, **state-dependence in NIMs creates state-dependence in response of aggregate economic activity** to a monetary policy shock.

Social Dynamics and Banking

- Develop a PE competitive banking model in which **fraction of hh's that are attentive to deposit interest rates depends on level of the interest rate.**

- **Fraction varies over time because of social dynamics** arising from random encounters between attentive and inattentive hh's.
  - Some inattentive hh's become attentive after meeting attentive hh's.
  - HH's are more likely to take interest in interest rates when rates are high. Search Volumes
  - So more hhs are attentive when rates are high.

- **Main Results: PE model accounts very well quantitatively for the dynamic response of NIM to monetary policy shocks** after prolonged periods of high and low interest rates.Impact of interest rates on social dynamics and joint effect of social dynamics and interest rates on PV would also be present in models of monopolistic competition with free entry.

Aggregate Economic Activity

- Embed **banking model in DSGE TANK model where there's heterogeneous MPCs out-of-liquid wealth**.
- **State dependency** in response of deposit rates and profits (a proxy for stock market) to monetary policy shock interacts with high MPC out-of-liquid wealth hh's .
- **Main Result (very preliminary): GE model accounts well quantitatively for state dependency in response of real GDP** to a contractionary monetary policy shock.

Related Literature

- **Role of Banks in MP transmission:** Cúrdia and Woodford [2010],Gerali et al. [2010], Driscoll and Judson [2013], Gertler and Karadi [2015], Cuciniello and Signoretti [2015], Piazzesi, Rogers, and Schneider [2019], and Bianchi and Bigio [2022]. Particularly: Drechsler, Savov, and Schnabl [2017, 2018, 2021], Begenau and Stafford [2022] and Greenwald et al. [2023].

$\Longrightarrow$ document important source of **state-dependence in banks' policy functions** which **percolates** throughout the **MP transmission to the real economy**.

- **Heterogeneous MPC out of Liquid Wealth:** Johnson, Parker, and Souleles [2006], Parker, Souleles, Johnson, and McClelland [2013], Jappelli and Pistaferri [2014], Kaplan and Violante [2014], Debortoli and Galí [2017], Kueng [2018], Auclert, Rognlie, and Straub [forthcoming], Ganong et al. [2020], and Fagereng, Holm, and Natvik [2021].

$\Longrightarrow$ provide a **tractable quantitative TANK setting** connecting **banks' rate-setting policies**, **heterogeneous MPCs out of liquid wealth** and **MP transmission**.

- **Social Dynamics:** Kelly and Gráda [2000], Carroll [2003], Iyer and Puri [2012], Burnside, Eichenbaum, and Rebelo [2016], Carroll and Wang [2023]

$\Longrightarrow$ introduce and show **relevance of social dynamics** in generating **GE effects of monetary policy**.

Outline

- **Empirical Analysis**
  - **Local Projection Framework**
  - **Results (GDP, Stock market, NIM, Core NIM,)**
- **Simple Competitive Banking Model**
  - **Rate-Setting Policy Functions**
  - **Introduce social dynamics**
  - **Study NIM implications**
- **TANK Model**
  - **Ingredients**
  - **Study implications for macro-aggregates.**

Empirical Analysis

- Use detailed data from the **Consolidated Reports of Condition and Income** (Call Reports) obtained from the FDIC.
- Reports are **filed quarterly** by all **national banks, state-member banks, insured state-nonmember banks, and savings associations**.
- Compute two measures of NIM:
  - (i) **core NIM** = average *loan* interest income rate minus average *deposit* interest expense rate,
  - (ii) **overall NIM** = difference between average interest income rate minus average interest expense rate (*on all assets, liabilities*).
- Quarterly data from 1985:1 to 2019:4.

Monetary Policy Shocks

- **Measure 1:** 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 of time around FOMC announcements.
  - Orthogonalize shock wrt contemporaneous, four lags of real GDP, PCE prices, investment and consumption, four lags of excess bond premium, and yield curve slope.

- **Measure 2:** Recursive shock measure
  - residual in a regression of FF rate on contemporaneous, four lags of lagged Real GDP, the PCE price index, four lags of the Excess Bond Premium and yield curve slope.

Estimation

- Local projection equation:

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

- 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.

Estimation

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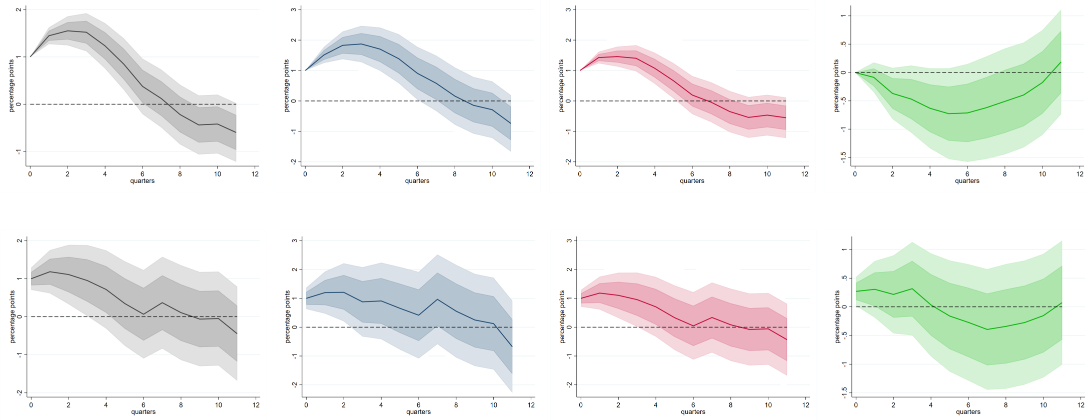
Results: FF

No State Dependence **Allowing for State Dependence**

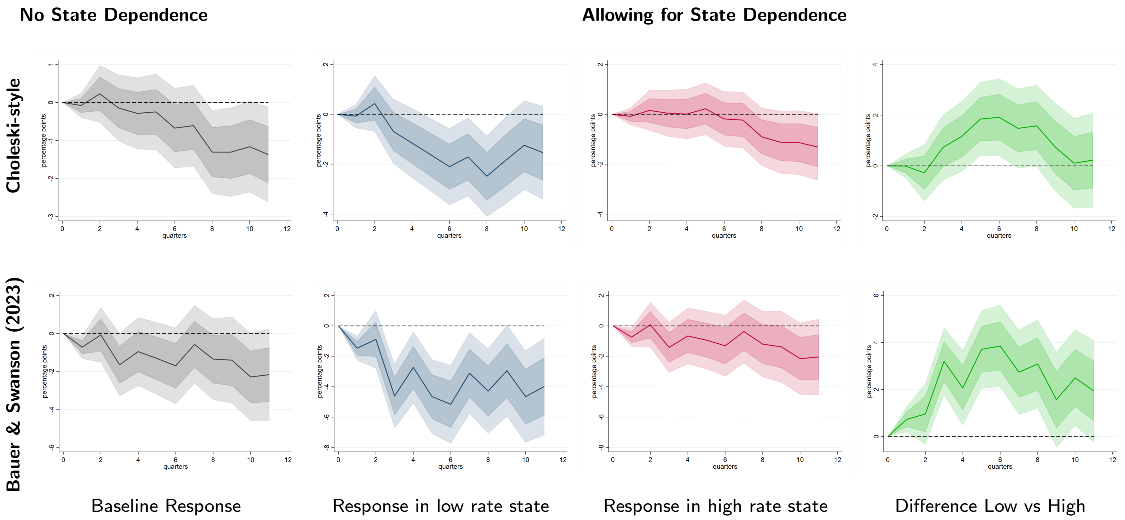
Choleski-style

Bauer & Swanson (2023)



Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

Results: GDP



No State Dependence
Allowing for State Dependence
Choleski-style
Bauer & Swanson (2023)
percentage points
quarters
Baseline Response
Response in low rate state
Response in high rate state
Difference Low vs High

Results: GDP

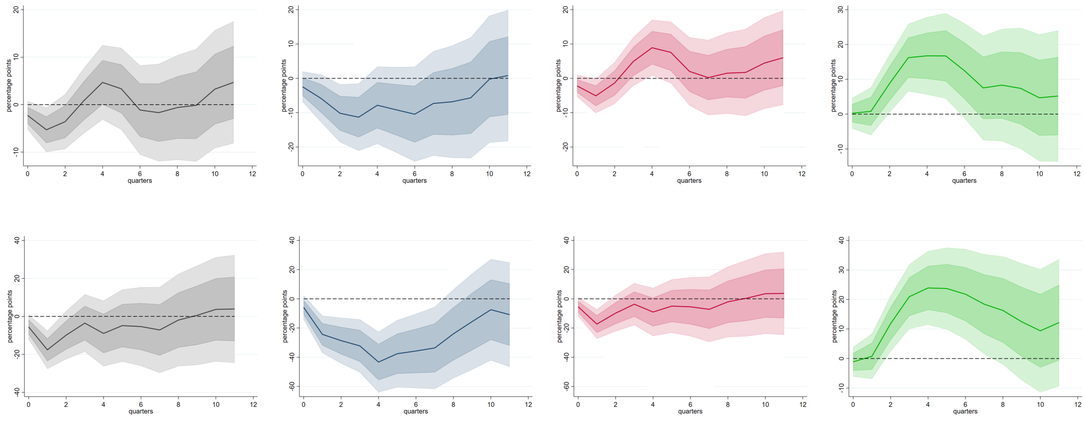
- A **contractionary monetary policy shock induces a persistent decrease in real GDP for two - three years**.
- Strong evidence of state dependence in response of real GDP.
- **Decline in real GDP is larger when shock occurs in low state.**
    - **Difference in response is statistically significant** for both shock measures.
- **More results:** Consumption, Investment and Inflation.

Results: Real S&P500

No State Dependence **Allowing for State Dependence**

Choleski-style

Bauer & Swanson (2023)



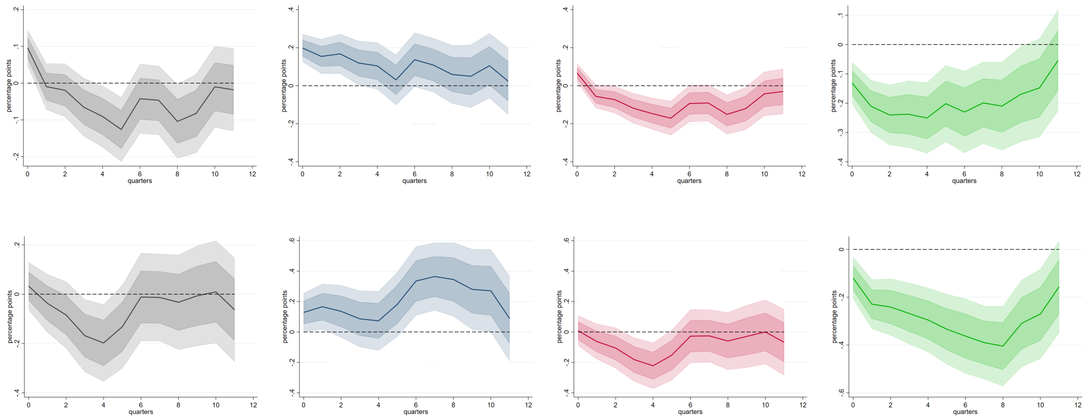
Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

Results: Core NIM

No State Dependence | **Allowing for State Dependence**

Choleski-style

Bauer & Swanson (2023)



Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

Results: 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.

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.**

Back-of-the-envelope calculation: stock market

- After 12 quarters, S&P is down by roughly **10%** after a 100 basis point 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 a 100 basis point 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-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 \$1.5 trillion.

- Di Maggio, Kermani and Majjlesi (2020) and Chodrow-Reich, Nenov and Simsek (2021) estimate the MPC to consume out of stock market wealth is roughy 3%.

- This estimate implies a differential fall in demand of \$45 billion.

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 dollars**.

- If shock occurs in **high interest rate state**, impact on NIM-related profits is a **decrease** of 98.3 **billion dollars**.

- Counterparts of banks save 191 billion dollars in **net interest paid** if shock occurs in **high state rather 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 dollars**

Back-of-the-envelope calculation

- The cumulative difference in low and high interest rate GDP contraction over 12 quarters is roughly 130 billion dollars.

- So there's a very rough 'multiplier' of $130/105 = 1.23$.

A partial equilibrium model of banking

- Key features
  - (i) **some hh's are attentive**, **others are inattentive** to interest rate that they earn on bank deposits.
  - (ii) **banks observe hh type**.
  - (iii) **matching framework** in which competitive banks invest resources to attract attentive, inattentive hh's.
- Initially shut down social dynamics to get intuition for mechanisms in model.
- Then study social dynamics that govern changes in fraction of attentive and inattentive hh's.

A simple 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.

- Every period, a fraction δ of dollar deposits leave their bank due to exogenous factors.
    - So, there's δa_t and δi_t dollars belonging to attentive and inattentive customers seeking a new bank at time t.

- **Banks can identify** who is attentive and inattentive, **can invest resources to attract the two types of depositors**.

A simple competitive banking model

- **Costs** $\tau_j v_j$ dollars **to attract** v_j **dollars of type** j deposits, $j = a, i$.
  - It's **more costly to attract inattentive** depositors than attentive, 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 hh's form according to

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

where $\mu > 0$, and $\varsigma \in (0, 1)$.

A simple competitive banking model

- In equilibrium **all deposits find a match:**

$$\delta a_t = \mu \left(\delta a_t\right)^{\varsigma} v_{at}^{1-\varsigma}$$

$$\delta i_t = \mu \left(\delta i_t\right)^{\varsigma} v_{it}^{1-\varsigma}$$

- So,

$$v_{at} = \mu^{-1/(1-\varsigma)} \delta a_t$$

$$v_{it} = \mu^{-1/(1-\varsigma)} \delta i_t$$

- In equilibrium, **bank's total cost of acquiring deposits** is

$$\mu^{-1/(1-\varsigma)} \delta \left(\tau_a a_t + \tau_i i_t\right).$$

Loan Rates

- Monetary authority sets policy rate, R_t, which coincides with the inter-bank borrowing and lending rate.
- Banks extend loans to firms to meet their working capital needs.
- MC of lending one dollar is constant and equal to ε^l.
- Since banks are perfectly competitive, the equilibrium lending rate, R^l, is

$$R^l = R + \varepsilon^l$$

Value of Deposits

- Deposit markets are perfectly competitive, is R_{at} and R_{it}.

- Value to bank of dollar deposit from attentive household:
$$V_{a,t} = R_t - R_{at} + \frac{1-\delta}{R_t} V_{a,t+1},$$

- R_{at} and R_{it}: time t gross interest on deposits owned by attentive and inattentive customers

- Continuation value $V_{a,t+1}$, is discounted at rate R_t and multiplied by $(1-\delta)$ to account for fraction δ of depositors that leave bank.

- Value to a bank of a dollar deposit from an inattentive household is
$$V_{i,t} = R_t - R_{it} + \frac{1-\delta}{R_t} V_{i,t+1}.$$

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,

$$\tau_{a,t} = \frac{\mu \left(\delta a_t\right)^{\varsigma} v_{at}^{1-\varsigma}}{v_{at}} V_{a,t},$$

$$\tau_{i,t} = \frac{\mu \left(\delta i_t\right)^{\varsigma} v_{it}^{1-\varsigma}}{v_{it}} V_{i,t}.$$

Suppose interest rates are constant

- Value of a dollar of deposits belonging to attentive and inattentive households is given by,

$$V_a = \frac{R}{R+\delta-1}\left(R - R_a\right),$$

$$V_i = \frac{R}{R+\delta-1}\left(R - R_i\right).$$

- Using equilibrium conditions for τ_a and τ_a, we obtain spreads:

$$R - R_a = \frac{\tau_a}{\mu^{1/(1-\varsigma)}}\left(1 - \frac{1-\delta}{R}\right)$$

$$R - R_i = \frac{\tau_i}{\mu^{1/(1-\varsigma)}}\left(1 - \frac{1-\delta}{R}\right)$$

Interest-Rate Spreads

- **Spreads increase with R**

$$\frac{d\left(R-R_j\right)}{dR}=\frac{\tau_j}{\mu^{1/(1-\varsigma)}}(1-\delta)R^{-2}.$$

  - Future profits are discounted by R.
  - When R rises, PV of future profits from a deposit decreases.
  - Zero profits in equilibrium $\Rightarrow$, current spreads must increase to compensate for this discounting effect (the PV effect).

- **Spreads increase more when interest rates are low** than when interest rates are high.
  - Consider an annuity that pays y in every period. PV of annuity is y/R. Change in PV when R rises is $-R^{-2}y$, which is lower when R is high.

- Since $\tau_i > \tau_a$, when R rises, **spread earned by banks on inattentive deposits increases more** than spread on attentive deposits.

Bank's NIM

$$nim_t = R_t + \varepsilon^l - (a_t R_{at} + i_t R_{it})$$

- Using the expressions for interest rate spreads in steady state,

$$nim = \varepsilon^l + \frac{\tau_i - a(\tau_i - \tau_a)}{\mu^{1/(1-\varsigma)}}\left(1 - \frac{1-\delta}{R}\right).$$

- nim_t decreases with fraction of attentive hh's in the economy.
  - interest rate spread earned by banks is lower for attentive hh's.
- Higher interest rates increase *nim*.
  - Reflects PV effect: current spreads rise to offset a higher discount rate on future bank profits.

Social Dynamics

- Laws of motion for number of attentive and inattentive hh's:

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

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

- Beginning of period there's $a_t i_t$ pairwise meetings between attentive and inattentive households.
  - Some inattentive households become attentive by learning about interest rate offers through conversations with attentive households.
  - Conversion rate, $\omega(R_t)$, is increasing function of annualized quarterly net interest rate.

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

  - $\Rightarrow$ a low (high) level of attentive depositors when interest rates have been low (high) for an extended period.

Social Dynamics

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

- Exogenous changes in attention occur at the end of the period.
- A fraction κ_a of households who were attentive in the beginning of the period become inattentive.
- A fraction fraction κ_i of the households that remain inattentive after social interaction become attentive.
- Number of inattentive households who become attentive in period t is:

Social Dynamics

- $a_{t+1} - a_t$ varies with the current level of attentive depositors,

$$\frac{d\left(a_{t+1} - a_t\right)}{da_t} = \omega(R_t)(1 - 2a_t)(1 - \kappa_i) - (\kappa_i + \kappa_a)\,.$$

- First: term represents changes in a_t due to social interactions.
  - Positive when $R_t > 1$ is high and $a_t < 0.5$ since, under these conditions, a high number of inattentive households become attentive.

- Second term is negative for two reasons.
  - When a_t is higher, more attentive households become inattentive $(\kappa_a a_t)$.
  - When a_t is higher, fewer inattentive become attentive $(\kappa_i(1 - a_t))$.

Social Dynamics

$$\frac{d\left(a_{t+1}-a_t\right)}{da_t}=\omega(R_t)(1-2a_t)(1-\kappa_i)-(\kappa_i+\kappa_a)\,.$$

- Strength of interactions related to R_t is maximal when $a_t = 0.5$.
- When a_t is low, social interactions aren't very powerful because there aren't many attentive households that can interact with inattentive households.
- When a_t is high, social interactions aren't very powerful there aren't many inattentive households that can be converted into attentive households.

Banking with Social Dynamics

- Value of a dollar deposit from an attentive household is

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

- Continuation value takes into account the possibility that attentive hh may become inattentive (κ_a).

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

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

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

Spreads with social dynamics

- Interest rate spread for **attentive depositors** is:

$$R_t - R_{at} = \frac{\tau_a}{\mu} - \frac{1-\delta}{R_t}\left(\kappa_a \frac{\tau_i - \tau_a}{\mu} + \frac{\tau_a}{\mu}\right).$$

- **Spread is lower** than in model **without social dynamics.**
- With probability κ_a **attentive depositors** become more-valuable-inattentive in the future.
- Zero profit condition $\Rightarrow$ **current spread on attentive depositors must decline.**

Banking with Social Dynamics

- The interest rate spread for **inattentive depositors** is:

$$R_t - R_{it} = \frac{\tau_i}{\mu^{1/(1-\varsigma)}} - \frac{1-\delta}{R_t}\left\{\frac{\tau_i}{\mu^{1/(1-\varsigma)}} - [\omega(R_t)a_t(1-\kappa_i)+\kappa_i]\frac{\tau_i-\tau_a}{\mu^{1/(1-\varsigma)}}\right\}.$$

- **Spread is higher than** in model **without social dynamics**
  - With probability, $\omega(R_t)a_t(1-\kappa_i)+\kappa_i$ inattentive depositors become attentive in the future, so current spreads must be higher to compensate for the decline in expected future profitability.

- **This effect is stronger effect with higher interest rates** which induce a rise in $\omega(R_t)$.

NIM with social dynamics

$$nim_t = \varepsilon^I + \frac{a_t \tau_a + (1 - a_t)\tau_i}{\mu^{1/(1-\varsigma)}} \left(1 - \frac{1-\delta}{R_t}\right) + \frac{1-\delta}{R_t} \frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}} (a_{t+1} - a_t).$$

- **First two terms equal** the value of nim_t in an economy **without social interactions**.
- **Third term:** impact of social interactions on nim_t.
  - An increase in number of attentive depositors, $a_{t+1} - a_t$, increases nim_t because the equilibrium spread on inattentive depositors rises to compensate for the higher probability that inattentive depositors will become attentive.

NIM with social dynamics

$$\frac{dnim_t}{da_t} = -\frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}}\left(1 - \frac{1-\delta}{R_t}\right) + \frac{1-\delta}{R_t}\frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}}\left[\omega(R_t)(1-2a_t)(1-\kappa_i) - (\kappa_i + \kappa_a)\right]$$

- **First effect** of a rise in a_t is **negative**:
  - Increase in a_t lowers average interest rate spread because spread on deposits of attentive households is smaller than spread on deposits from inattentive households

- **Second effect** fundamental for **state dependence** in nim_t.
  - Effect is positive when $a_t < 0.5$ and R_t is high: many inattentive hh's will become attentive.
  - Implies that some inattentive customers will generate lower profits in the future.
  - Zero profit condition implies current margins must rise to compensate for that effect.

NIM with social dynamics

- Marginal impact of R_t on nim_t:

$$\frac{dnim_t}{dR_t} = \frac{a_t\tau_a + (1-a_t)\tau_i}{\mu^{1/(1-\varsigma)}}(1-\delta)R_t^{-2} - R_t^{-2}(1-\delta)\frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}}(a_{t+1} - a_t) + \frac{1-\delta}{R_t}\frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}}\frac{da_{t+1}}{dR_t}$$

where

$$\frac{da_{t+1}}{dR_t} = \omega'(R_t)a_t(1-a_t) = 32\chi(R_t - 1)a_t(1-a_t).$$

- **First effect is positive:** a rise in R_t reduces PV of future profits.
  - Zero profits $\Rightarrow$ current interest rate spreads **must rise** to offset this impact.

NIM with social dynamics

$$\frac{dnim_t}{dR_t} = \frac{a_t\tau_a + (1-a_t)\tau_i}{\mu^{1/(1-\varsigma)}}(1-\delta)R_t^{-2} - R_t^{-2}(1-\delta)\frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}}(a_{t+1} - a_t) + \frac{1-\delta}{R_t}\frac{\tau_i - \tau_a}{\mu^{1/(1-\varsigma)}}\frac{da_{t+1}}{dR_t}$$

- **Second effect is negative:**
  - Consider future losses occurring when some inattentive depositors become attentive.
  - PV of these losses declines when R_t increases.
  - So current spread on inattentive deposits **must increase by less** in the preset to compensate.
  - That effect decreases nim_t.

- **Third effect is positive:**
  - Higher R raises $\omega(R_t)$, raise the rate at which inattentive households become attentive due to social interaction
  - Reduces future profits from inattentive households.
  - So, current spread on inattentive consumers **must rise to compensate** for that effect.

Estimating the PE model

- Partition the parameters of our model into two sets: first is set a priori, second is estimated with Bayesian methods.

Table: Parameter values set a priori

Parameter	Parameter value	Description
ϵ_l	0.005	Cost per dollar of making loans
R_L	1.015	Gross annual interest rate, low interest rate state
R_H	1.056	Gross annual interest rate, high interest rate state
T_q	200	Frequency of social interactions in a quarter of time

- $\epsilon_l = 0.005 \Rightarrow$ difference between lending rate to firms and FF is two percent per annum
- Set $R_L = 1.015$ in the low interest rate SS and $R_H = 1.056$ in the high interest rate steady state.
- Set $T_q = 200$ so that households have multiple social interactions per day.

Estimation

- In the equilibrium equations, τ_a, τ_i, μ and ς only appear in form of the ratios $\tau_a/\mu^{\frac{1}{1-\varsigma}}, \tau_i/\mu^{\frac{1}{1-\varsigma}}$.
- 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 $\hat{\psi}$: point estimates (first 12 quarters) of impulse responses of NIM in high and low interest rate state, based on the Choleski decomposition.
  - θ_0 : true values of the model parameters,
  - $\psi(\theta)$: mapping from θ to point estimates of impulse responses of NIM in high, low interest rate states.
  - Our analysis treats $\hat{\psi}$ as observed data.

Estimation

- Specify uniform priors for all the elements of θ and then compute the posterior distribution for θ given $\hat{\psi}$ using Bayes' rule.
    - Uniform $(0,100)$ prior for χ, $\tau_a/\mu^{\frac{1}{1-\varsigma}}$ and $\tau_i/\mu^{\frac{1}{1-\varsigma}}$ and $(0,1)$ priors for κ_a,κ_i and δ.
- Only consider parameter values θ in model estimation such that
    - $R_{i,t}, R_{a,t}$ are never lower than one after a monetary policy shock in either of the two states considered,
    - Spreads $R_t - R_{i,t}$, $R_t - R_{a,t}$ are also always non-negative, $\mathrm{R}_{a,t} \geqslant R_{i,t}$

Estimation

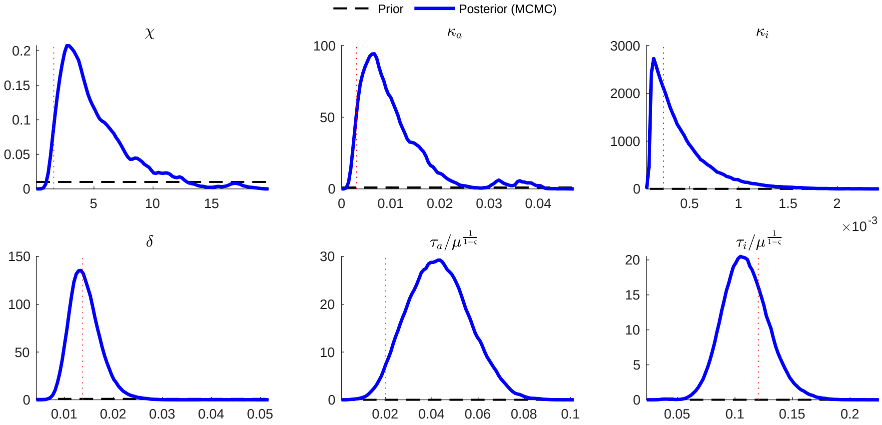


Figure: Priors and Posteriors of Estimated Parameters.

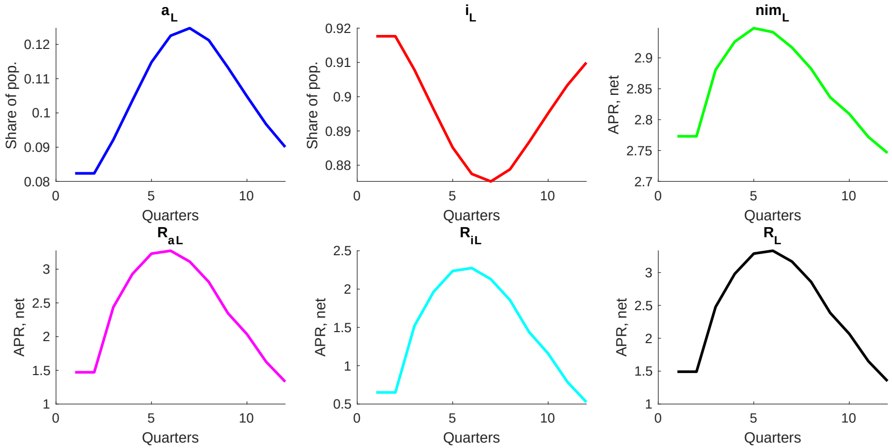
Estimation

Table: Priors and Posteriors of Parameters.

Parameter	Prior Distribution	Posterior Distribution
	U, Mean, [2.5-97.5%]	Mode, [2.5-97.5%]
Social dynamics interaction parameter, χ	U, 50 , [2.5 97.5]	1.604 [1.133 11.59]
Rate at which attentive become inattentive, κ_a	U, 0.5, [0.025 0.975]	0.003, [0.001 0.024]
Rate at which inattentive become attentive, κ_i	U, 0.5, [0.025 0.975]	0.0002,[0.000 0.001]
Fraction of depositors who leave banks, δ	U, 0.5, [0.025 0.975]	0.014, [0.008 0.021]
Cost of attracting attentive depositors, $\tau_a/\mu^{\frac{1}{1-\varsigma}}$	U, 50 , [2.5 97.5]	0.020, [0.018 0.068]
Cost of attracting inattentive depositors, $\tau_i/\mu^{\frac{1}{1-\varsigma}}$	U, 50 , [2.5 97.5]	0.120, [0.072 0.150]

Estimation

Figure: Dynamic response to monetary policy shock in low-interest-rate state.



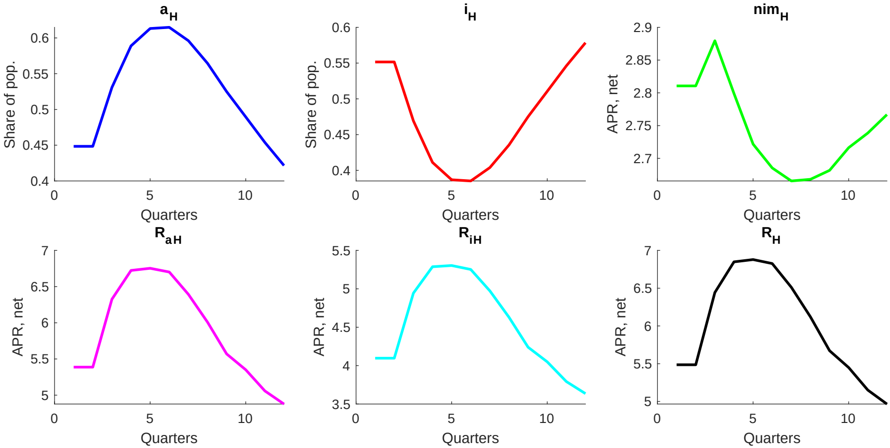
Model responses beginning from low interest rate state

- A rise in R_t leads to a substantial increase in fraction of attentive hh's.
- Deposit rates rise but by less than loan interest rate.
- Policy shock induces a substantial increase in nim_t.

- Intuition
  - PV effect is stronger when R_t is low.
  - There's a high level of inattentive depositors, a substantial fraction of which will become attentive in the future.
  - Those types of customers will be less profitable in future.
  - Creates substantial upward pressure on current nim_t to ensure zero profits in equilibrium.

Estimation

Figure: Dynamic response to monetary policy shock in high-interest-rate state.



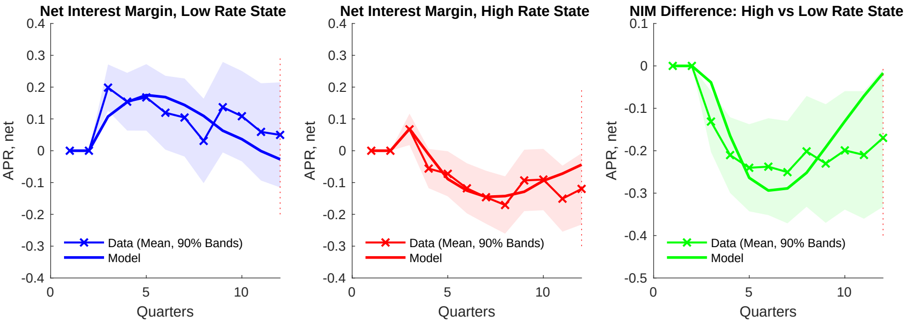
Model responses beginning from high interest rate state

- Intuition
  - Impact of a rise in R on PV on PV future profits is weaker when R_t is high.
  - Since most depositors are attentive, banks have few inattentive depositors who will turn attentive in future.
  - So a small number of customers will become attentive in future.
  - Those types of customers are less profitable for the bank in future, creating upward pressure on current nim_t to counteract that effect.
  - Since there's few such customers, rise in nim_t that's required to have zero profits in equilibrium is small.

- Rise in R_{at} is very large.
  - Since nim_t is dominated by the high share of attentive hh's, nim_t doesn't react much to change in FF rate.

Model and Data Responses

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



General equilibrium

- Two types of hh's: **Hand-to-Mouth and Optimizing agents**. Fractions are fixed.
- Production sector of the economy as in Christiano, Eichenbaum, and Evans [2005]. **Calvo - sticky prices** (no indexing to previous or steady state inflation).
- **Retailer must borrow nominal wage and capital services bills** from banks at the beginning of the period. Repay loans at end of period t after receiving revenues.
- i^{ith} firm's real marginal cost is

$$s_{i,t} = \left(\frac{1}{1-\alpha}\right)\left(\frac{1}{\alpha}\right)^{\alpha}\left(\mathbf{R}_t^{\mathbf{d}} r_t^k\right)^{\alpha}\left(\mathbf{R}_t^{\mathbf{d}} w_t\right)^{1-\alpha}$$

Wages

- Real wages evolve according to

$$w_t = \vartheta w_{t-1} + (1-\vartheta) w^{SS} + (1-\vartheta)\frac{N_t}{N},$$

- The nominal wage is given by

$$W_t = w_t P_t.$$

. (See Christiano et al. [2016] for equivalence with micro-founded alternatives.)

- Employment is demand determined and the three types of households vary their work in proportion to their steady state values to satisfy labor demand.

Hand-to-mouth Households

- The economy has a fraction ϕ of hand-to-mouth hh's who **may be attentive or inattentive**.

- Hand-to-mouth hh of type $j = \{i, a\}$ maximizes

$$E_t \sum_{l=0}^{\infty} \beta^t \left\{ \left[ln(C^H_{j,t+l} - bC^H_{j,t+l-1}) \right] - \psi \frac{(N^H_{j,t+l})^{1+\eta}}{1+\eta} \right\}$$

  subject to the budget constraint

$$P_t C^H_{jt} = \left(W_t N^H_{jt} - D^H_{jt} \right) + D^H_{jt} R_{jt},$$

- D^H_{jt} are deposits of hand-to-mouth households type j, can't exceed funds that hh's receive at beginning of period

$$D^H_{jt} \leq W_t N^H_{jt}.$$

Hand-to-mouth Households

- Firms deposit wages, $W_t N_{jt}^H$ at beginning of the period.
- HH's consume at end of the period so there's no opportunity cost associated with depositing funds received in beginning of the period.
- Given that $R_{jt} \geq 1$, $D_{jt}^H = W_t N_{jt}^H$ so resource constraint is,

$$P_t C_{jt}^H = R_{jt} W_t N_{jt}^H.$$

- Since employment is demand determined and the budget constraint holds with equality, preferences of hand-to-mouth hh's are irrelevant.

Optimizing Households

- Simplifying assumption: all PIH hh's are attentive. **Results not sensitive** due to **consumption smoothing**.

- Maximizes lifetime utility:

$$U_t = E_t \sum_{l=0}^{\infty} \beta^t \left\{ \left[ln(C^P_{t+l} - bC^P_{t+l-1}) \right] - \psi \frac{(N^P_{t+l})^{1+\eta}}{1+\eta} \right\}, \tag{1}$$

subject to budget constraint:

$$P_t \left(C^P_t + I_t \right) + B_{t+1} - R_{t-1} B_t + \Psi_t = \left(W_t N^P_t + R^K_t u_t \bar{K}_t - D^P_t \right) + D^P_t R_{a,t} + \int_0^1 \pi_{jt} dj$$

$$D^P_t = W_t N^P_t + R^K_t u_t \bar{K}_t.$$

- $\int_0^1 \pi_{jt} dj$: nominal profits from monopolistically competitive firms.
- Changes in these profits proxy for changes in stock market wealth
- Capital utilization; Depreciation depending on utilization; Quadratic Investment Adj Costs.

Timing

- At start of period, firms borrow their wage bill and capital rental costs from banks.
- Banks issue firms checks which they use to pay the households.
- Households, deposit these funds in banks.
- At the end of the period, banks receive the funds they lent to the firms plus interest at a rate $R^l - 1$.
- Banks pay hhs their deposits plus interest.

Social dynamics

- Total number of attentive, a_t:

$$a_t = a_t^H + \phi,$$

where a_t^h are the number of attentive HTM households.

$$a_t^H + i_t^H + \phi = 1,$$

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

$$\omega(R_t)(\phi + a_t^H)(1-\kappa_i) + \kappa_i.$$

- Modify banking model to take these social dynamics into account.

Experiment

- **Replicate** PE **experiment** in GE model **to study macro-aggregate effects**.
- **Issue: Taylor Rule** determines R_t, can't directly feed two different interest rate paths.
- Construct an **observationally equivalent specification**.
  - **Constant** steady state **real** rate, determined by β.
  - Generate **two** steady-state **nominal** rates corresponding to **different steady state inflation rates**.
  - **Level of nominal interest rate only matters for the social dynamics** and **the banking block**.

Monetary policy and our experiment

- Construct our **"high state"** by setting annualized inflation target to 4%.
- Construct our **"low state"** by setting or annualized inflation target to 0%.
- **Calibrate steady state value of annualized real rate $r^* = 1.5\%$, $\beta = 0.9963$.**
- Delivers a **steady state nominal rate of 5.5% and 1.5%** , respectively, for the "high state" and "low state".
  - Empirical averages of FF rate in high, low rate subsamples.
- Then feed in sequence of MIT shocks to Taylor rule so that R_t in the high and low scenarios are the same as those estimated using Choleski monetary policy shock.

Calibration

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 **GE TANK 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 hhs with MPC to consume out of liquid wealth.

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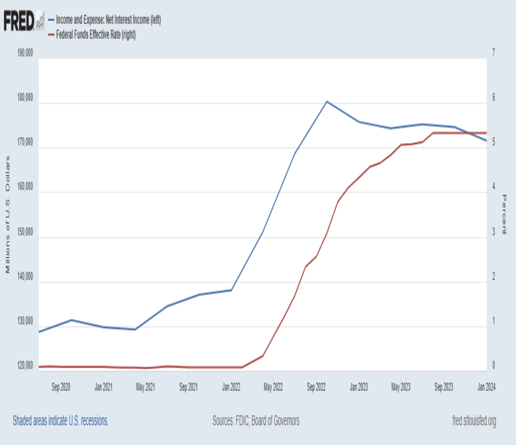
APPENDIX

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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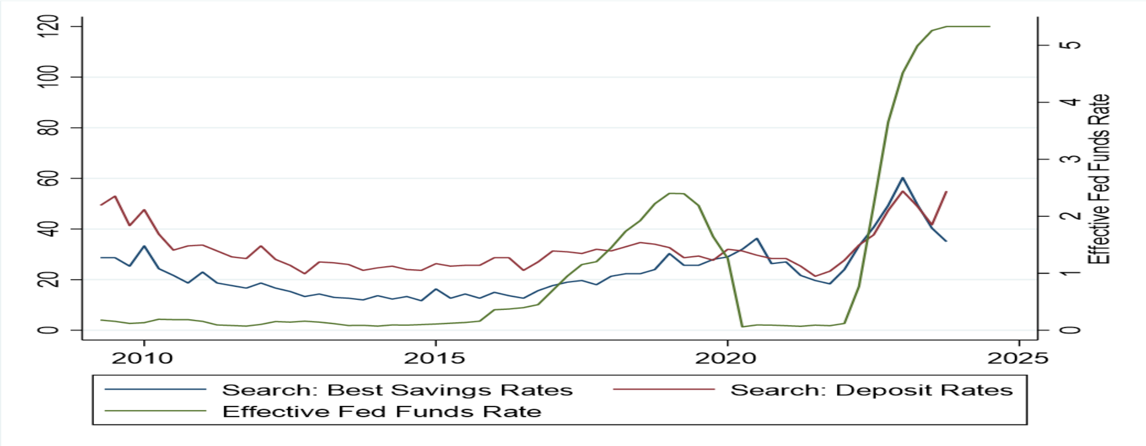
Google Trends: Searching Saving Products



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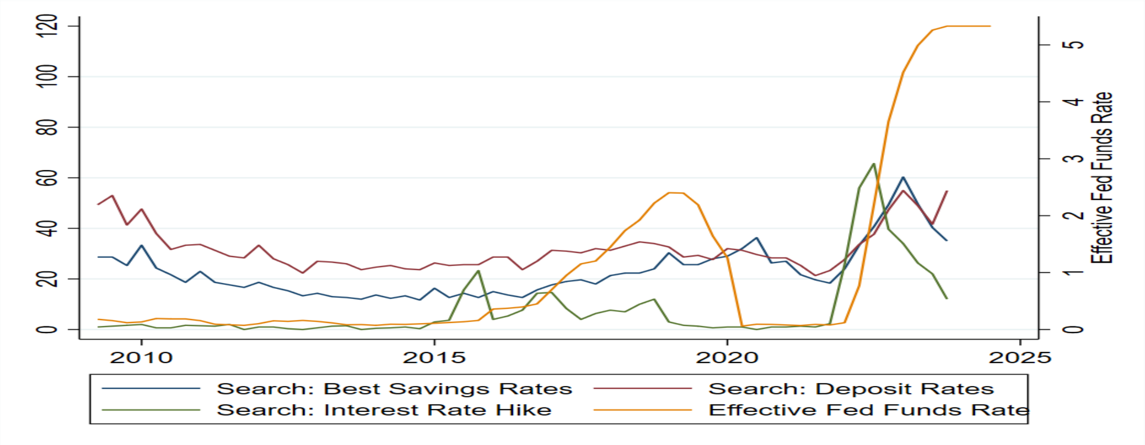
Google Trends: Searching Saving Products vs searching for Monetary Policy Stance



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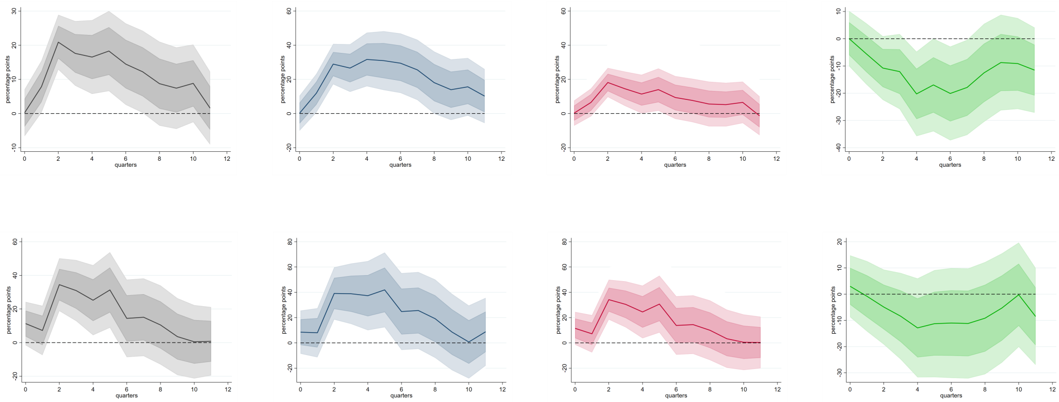
Extensive Margin

No State Dependence | **Allowing for State Dependence**

Choleski-style

Bauer & Swanson (2023)



Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

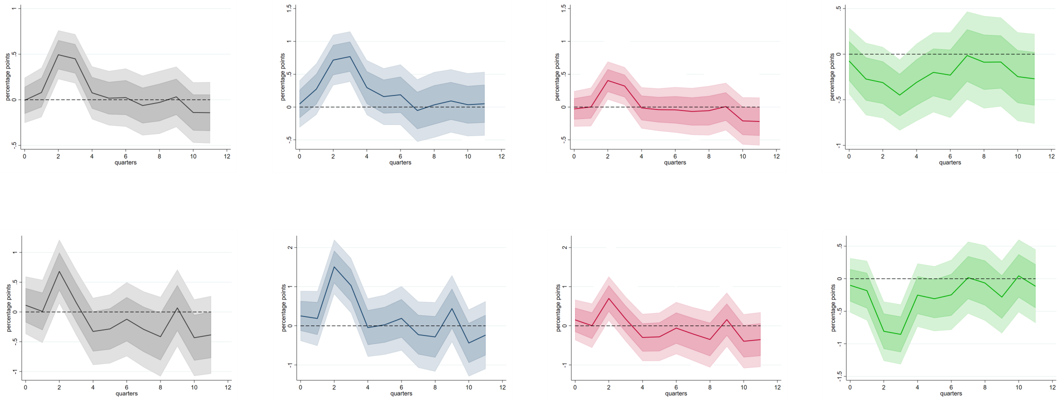
Intensive Margin

No State Dependence

Allowing for State Dependence

Choleski-style

Bauer & Swanson (2023)



Baseline Response

Response in low rate state

Response in high rate state

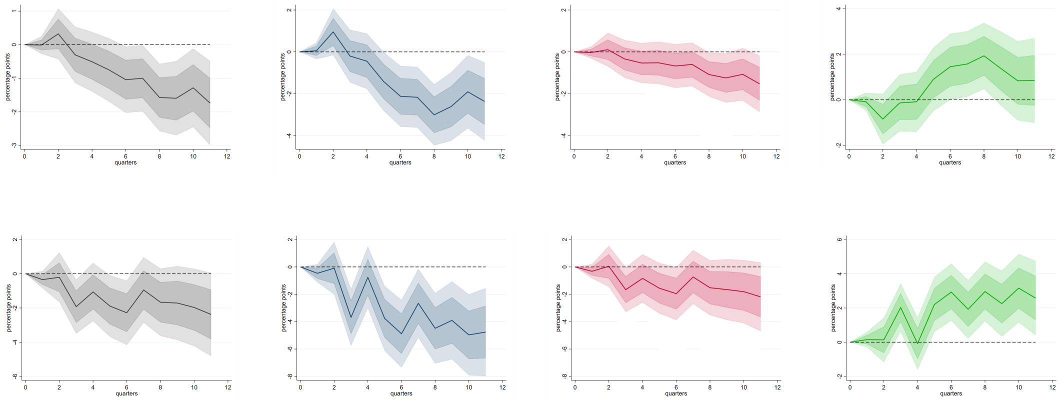
Difference Low vs High

Consumption

No State Dependence **Allowing for State Dependence**

Choleski-style

Bauer & Swanson (2023)



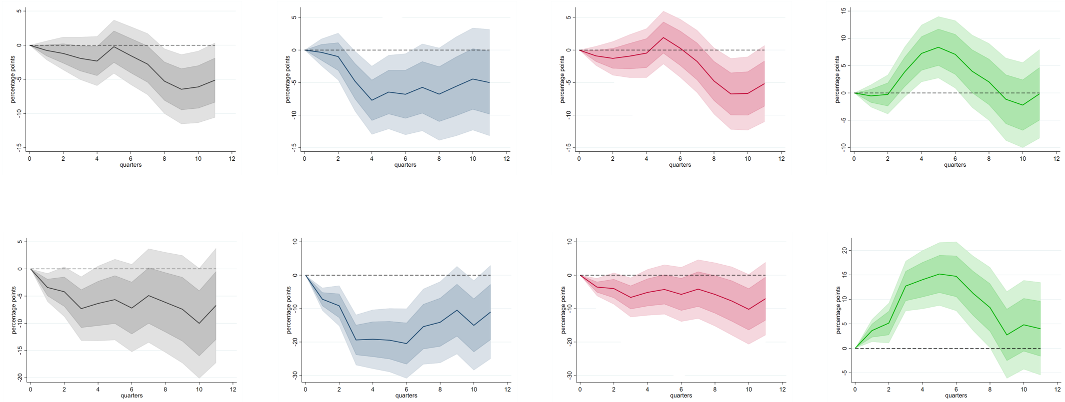
Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

Investments

No State Dependence **Allowing for State Dependence**

Choleski-style

Bauer & Swanson (2023)

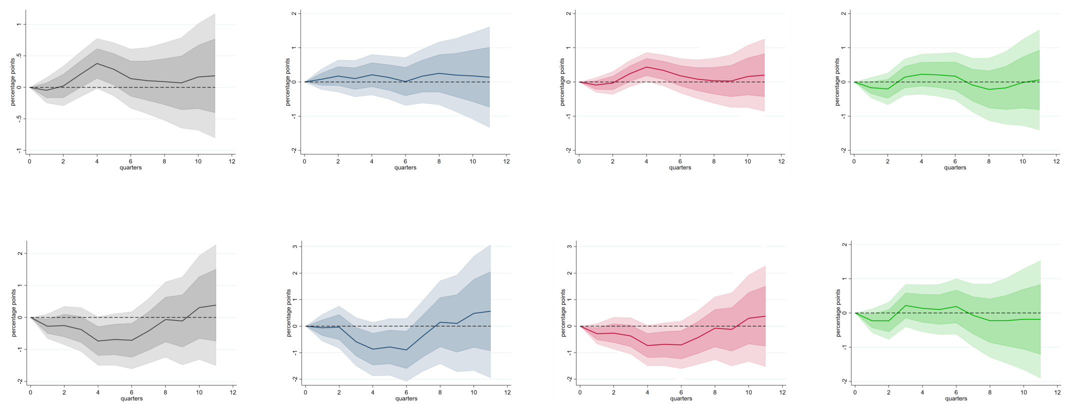


Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

Inflation

No State Dependence | **Allowing for State Dependence**

Choleski-style / **Bauer & Swanson (2023)**



Baseline Response | Response in low rate state | Response in high rate state | Difference Low vs High

Lending Rate

- Monetary authority sets policy rate, R_t, which coincides with inter-bank borrowing and lending rate.
- Banks extend loans to firms to meet their working capital needs.
- Marginal cost of lending one dollar is ε^l.
- Since banks are perfectly competitive, equilibrium lending rate, R^l, is

$$R^l = R + \varepsilon^l. \tag{2}$$

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Banking model calibration

Parameter	Parameter value	Description
κ_i	0.0008	Rate at which inattentive become attentive
κ_a	0.0029	Rate at which attentive become inattentive
χ	1.2173	Social dynamics interaction parameter
τ_a/μ	0.0123	Cost of attracting attentive depositors/matching function parameter
τ_i/μ	0.1333	Cost of attracting inattentive depositors/matching function parameter
δ	0.0237	Fraction of depositors who leave banks for exogenous reasons
R_L	1.015	Gross annual interest rate, low interest rate state
R_H	1.056	Gross annual interest rate, high interest rate state
ϵ_l	0.005	Cost per dollar of making loans
T_q	200	Frequency of social interactions in a quarter of time

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Wage determination

- CET (2016): estimated versions of three models of wage determination have virtually identical implications for macroeconomic aggregates:
  - Search and matching matching model with Hall and Milgrom wage bargaining.
  - Calvo-style sticky wages.
  - Reduced-form specification of nominal wages embodying inertia.

- We adopt last model and assume that after a shock, nominal wages evolve according to

$$w_t = \gamma w_{t-1} + (1-\gamma) w^{SS} + (1-\gamma) Ld_t / Ld^{SS}.$$

- Employment is demand determined, hh's vary their work in proportion to their steady state values to satisfy demand.

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Capital and Investment

- $\bar{K}_t$: beginning of period physical capital stock. Standard capital low of motion. Note: $K_t = u_t \bar{K}_t$
- Φ_t and Ψ_t: profits from monopolistically competitive firms and lump-sum taxes, respectively.
- $\delta(u_t)\bar{K}_t$: cost, in units of consumption goods, of setting utilization rate to u_t. Quadratic Investment adjustment costs.

$$\bar{K}_{t+1} = (1 - \delta(u_t))\bar{K}_t + F(I_t, I_{t-1}). \tag{3}$$

$$F(I_t, I_{t-1}) = \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t$$

where

$$S\left(\frac{I_t}{I_{t-1}}\right) = \frac{s_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2.$$

Model responses beginning from low interest rate state

- A rise in R_t leads to a substantial increase in fraction of attentive hh's.
- Deposit rates rise but by less than loan interest rate.
- Policy shock induces a substantial increase in nim_t.

- Intuition
  - PV effect is stronger when R_t is low.
  - There's a high level of inattentive depositors, a substantial fraction of which will become attentive in the future.
  - Those types of customers will be less profitable in future.
  - Creates substantial upward pressure on current nim_t to ensure zero profits in equilibrium.

back

Model responses beginning from high interest rate state

- Intuition
  - Impact of a rise in R on PV on PV future profits is weaker when R_t is high.
  - Since most depositors are attentive, banks have few inattentive depositors who will turn attentive in future.
  - So, a small number of customers will become attentive in future.
  - Those types of customers are less profitable for the bank in future, creating upward pressure on current nim_t to counteract that effect.
  - Since there's few such customers, rise in nim_t that's required to have zero profits in equilibrium is small.

- Rise in R_{at} is very large.
  - Since nim_t is dominated by the high share of attentive hh's, nim_t doesn't react much to change in FF rate.

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B-TANK Calibration

Parameter	Parameter value	Description	Parameter	Parameter value	Description
β	0.9963	discount factor	ϕ^P	0.85	Calvo stickiness for retail firms
bb	0.8	habit formation	γ_1	0.99	wage stickiness
ϕ	0.75	share of Non-Hand-to-Mouth	ρ_1^r	0.4	Taylor rule: persistence first coefficient
χ^N	0.5	labour disutility scale	ρ_2^r	0.4	Taylor rule: persistence second coefficient
η	1	inverse Frish Elasticity	θ^Π	1.5	Taylor rule: inflation gap reaction
ψ_K	1.25	investment adjustment cost scale	θ^y	0	Taylor rule: output gap reaction
δ_0	0.025	capital depreciation	σ^r	0.0025	Taylor rule: shock standard deviation
δ_1	0.047	capital depreciation due to utilization (linear)	$\bar{\Pi}$	1.01 or 1	Taylor rule: inflation Target (High and Low)
δ_2	0.001	capital depreciation due to utilization (quadratic)	ρ^A	0.9	Technology process: persistance
α	1/3	capital share	σ^A	0.01	Technology process: shock standard deviation
ε^P	11	demand elast. for retail firms	G/Y	0.18	Steady State ratio of Government Spending to Output

back