The Investment Channel of Monetary Policy: Evidence from Norway

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*Norges Bank. The usual disclaimer applies.

Motivation

- What is the absolute and relative importance of channels through which monetary policy affect firms' investment (fixed assets)?

- Why care?
  - Investment movements explain a large share of business cycles
  - Understand monetary transmission
  - In theory, interest rate changes affect investment through many direct and indirect channels.
  - Informative for (heterogeneous?) firm models

What We Do

We use **Norwegian administrative data** on income and balance sheets of the universe of firms to examine monetary transmission at the firm level.

1. Compare macro-level vs. micro-level investment responses
2. Explore the relative (quantitative) role of the most prevalent firm characteristics for the transmission of monetary policy on firm investment
3. Evaluate *indirect* (GE effects from outside of the firm sector, e.g. demand effects) and *direct* effects (interest rate changes) of monetary policy

Our Findings

Main Message: Investment responses to monetary policy are *as if* a representative firm faces investment adjustment frictions.

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1. The magnitude of the firm-level investment responses identical to the macro data
2. Especially earning-based borrowing constraints are associated with monetary transmission ↑
   - However, limited explanatory power
3. Monetary policy works primarily via direct effects (interest rate changes)
4. No role for net interest cost channel

Administrative Data

- Norwegian firm tax record data with supplements
  - Panel, 2000 to 2019
  - Sample: 33,674 unique firms
  - covering 2/3 of annual sales in a given year
- Tax records include (profit tax):
  - Detailed balance sheet information
  - Income statements
  - Firm characteristics
- Romer and Romer (2004) identifaction monetary policy shock

Local Projections

Macro Data:

- $$\frac{k_{t+h} - k_{t-1}}{k_{t-1}} = \alpha^h + \beta^h \varepsilon_t^{MP} + \gamma^h \mathbf{X}_{t-1} + u_t^h$$

- k is fixed assets
- Controls $\mathbf{X}_{t-1}$: lags of the dependent variable & shocks

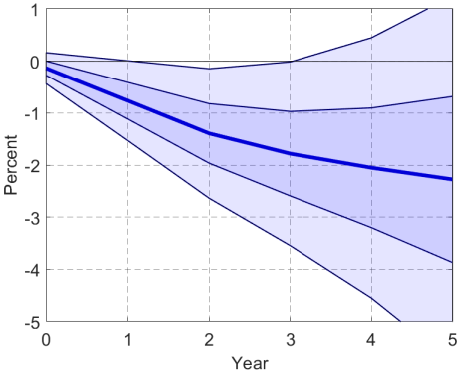
Micro Data:

- $$\frac{k_{i,t+h} - k_{i,t-1}}{k_{i,t-1}} = \alpha_i^h + \beta^h \varepsilon_t^{MP} + \gamma^h \mathbf{X}_{i,t-1} + u_{i,t}^h$$

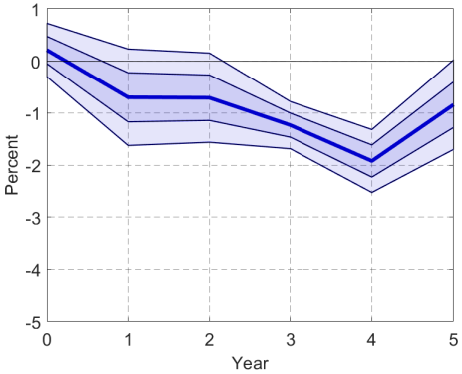
- Controls $\mathbf{X}_{t-1}$: lags of the dependent variable, firm size, leverage, liquidity, & shocks

Investment Response: Micro vs. Macro

▸ Robustness ▸ Other Macro IRFs ▸ HF Shocks



(a) Macro Data, Newey-West standard errors



(b) Micro Data, Driscoll-Kraay standard errors

68 & 95% confidence bands

Which Dimension of Firm Heterogeneity Matters?

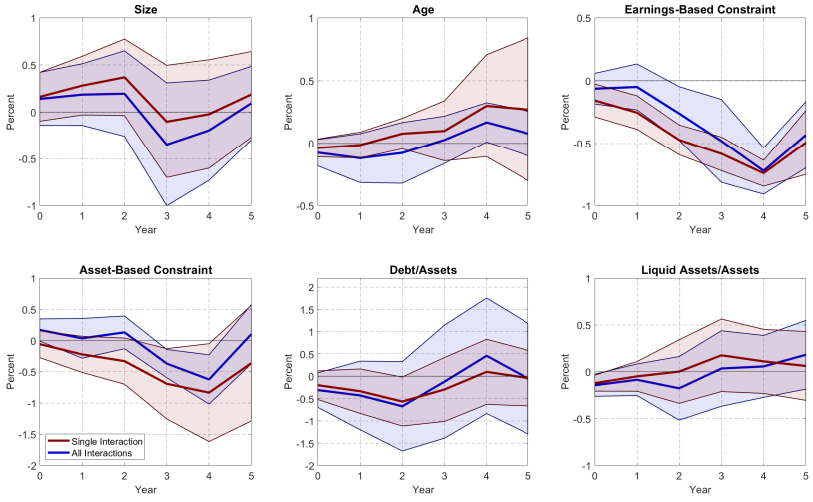
- Estimate local projections

$$\frac{k_{i,t+h} - k_{i,t-1}}{k_{i,t-1}} = \alpha_i^h + \nu_t^h + \beta_z^h \cdot \varepsilon_t^{MP} \cdot z_{i,t-1} + \gamma_z^h z_{i,t-1} + \gamma^h X_{i,t-1} + u_{i,t}^h$$

- $z_{i,t-1}$: standardized interaction terms (along cross-section)
  (size, age, proxies for borrowing constraints, liquidity, leverage)
- Controls: same as before, but includes $z_{i,t-1}$ and time-fixed effects ν_t^h
- Driscoll-Kraay standard errors

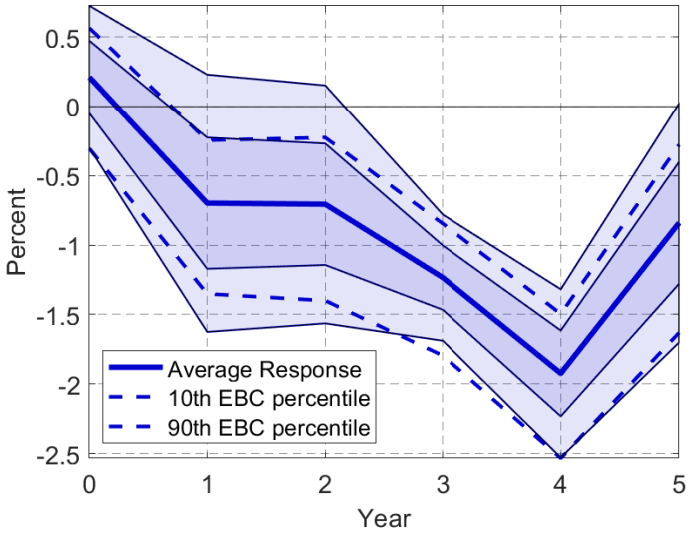
Marginal Effects on the Investment Response

- Within
- HF Shocks
- Macro Controls
- Age/Dividend



95% confidence bands

Quantitative Relevance?



68 & 95% confidence bands

Does Monetary Policy Have a Large Direct Effect on Firm Investment?

Motivation: Monetary policy and household consumption:

- Indirect channel important for household consumption
  (Kaplan, Moll, and Violante (2018); Auclert, Rognlie, and Straub (2020), Holm, Paul, and Tischbirek (2021); ...)

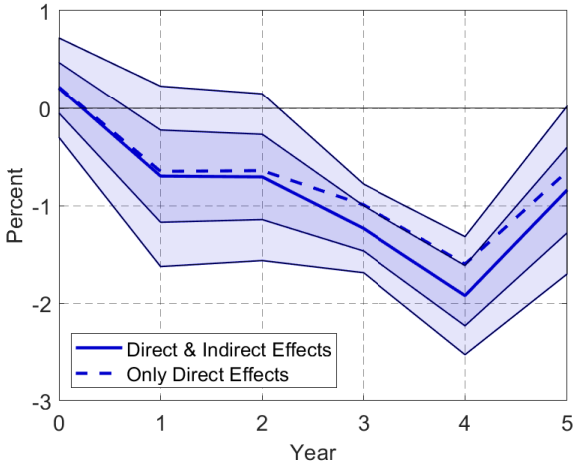
- *Investment is indirectly responsible [...] for consumption responses to monetary policy.*
  (Auclert, Rognlie, and Straub (2020))

Question: How is monetary transmission at the firm level? Also indirect? Three approaches:

1. Use $\Delta \text{sales}_{t,t+h}$ as a control for GE effects.
2. Investment response more affected for firms that are 'closer' to consumer demand.
3. Tradeable vs. non-tradable

Controlling for Sales

▸ Expected Sales



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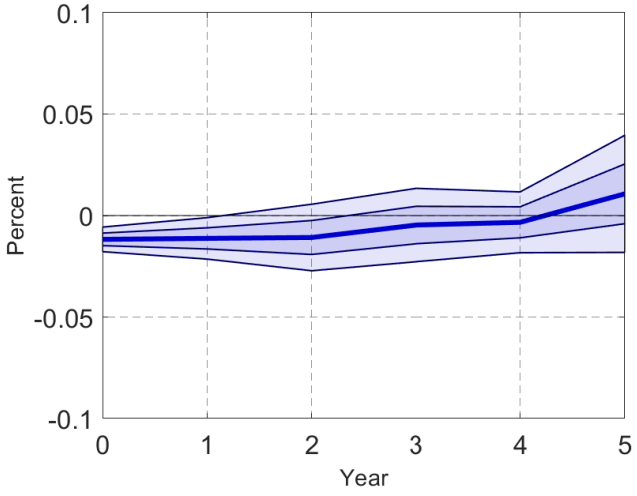
Marginal Effect of ‘Closeness’ to Consumers

▸ Robustness



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Tradeable vs. Non-Tradeables

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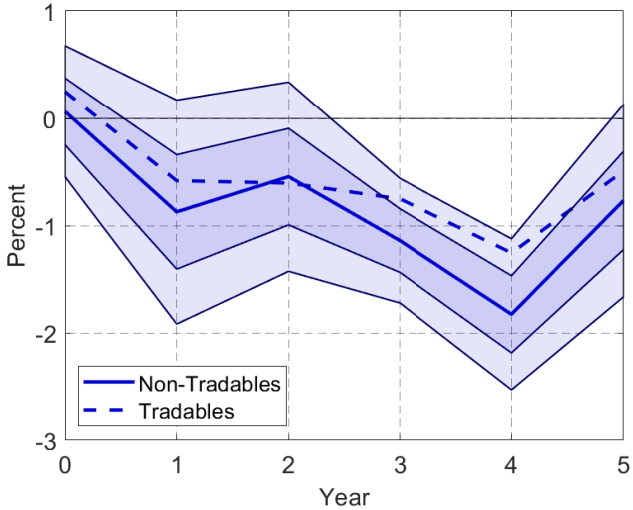

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Role of Net Interest Costs?

▸ Definition of Fixed-Rate Dummy

The direct effects of monetary policy on firm investments may be driven by:

1. Net-interest-cost channel through firms' exposure to interest rates
2. Changes in the net present value (NPV) of investment projects

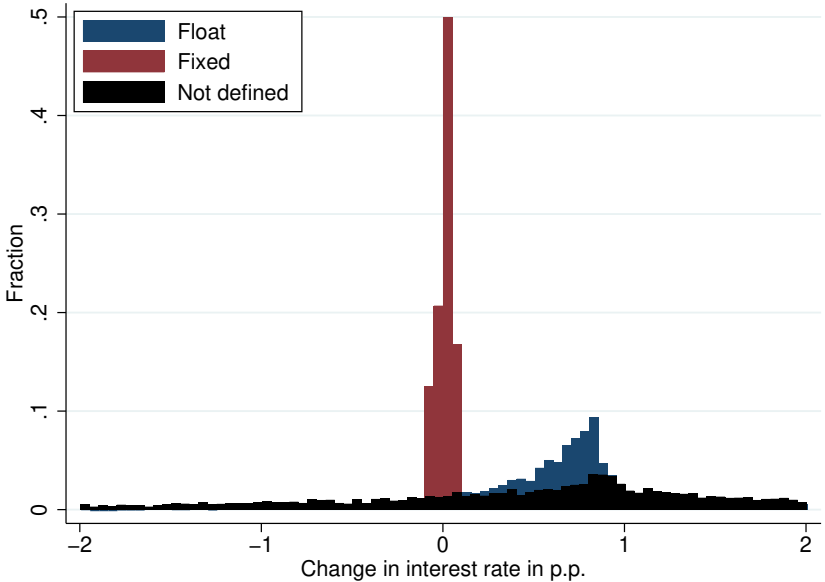
Net-Interest-Cost Channel

We estimate the following event-study:

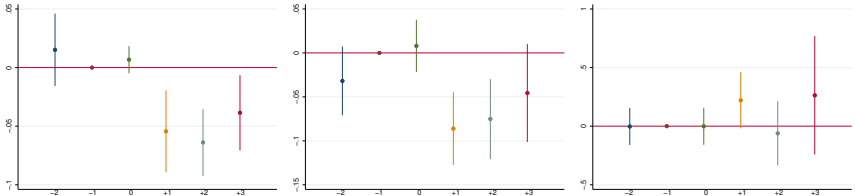
$$\frac{y_{i,t+h} - y_{i,t-1}}{y_{i,t-1}} = \alpha_i^h + \nu_t^h + \beta_{fr}^h(\varepsilon_t^{MP} \cdot \mathbb{1}_{i,t}^{fr}) + \gamma^h \mathbb{1}_{i,t}^{fr} + \beta^h \varepsilon_t^{MP} + u_{i,t}$$

where $\mathbb{1}_{i,t}^{fr}$ is an indicator variable for firms having fixed-rate loan contracts between $t-1$ and t.

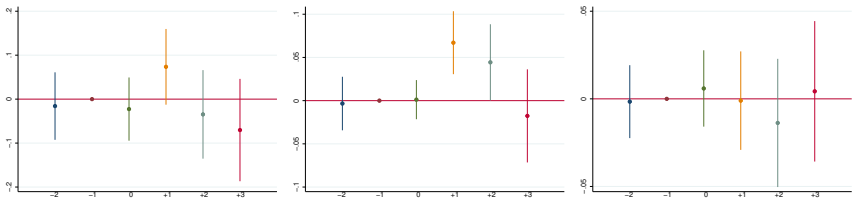
Fixed and Adjustable Rate Debt Contracts



Net Interest Costs are not Driving Investment



(a) Interest rate **(b)** Net financial costs **(c)** Dividends



(d) Cash **(e)** Equity **(f)** Investment

95% confidence bands

Summary of main findings

1. Firm heterogeneity matters but not the most important driver
2. Direct effects are important, indirect effects are not important
3. Direct effects are not due to net interest costs
4. Direct effects might be due to discount factor channel affecting net present value of investment projects

$\Rightarrow$ Representative firm that responds to changes in the net present value of investment projects

- Representative firm model with adjustment costs in line with monetary policy investment responses and small indirect effects.
  - In line with e.g. Eberly et al. (2012)

Conclusions

1. Our micro-level investment responses are similar to the aggregate responses.

2. We explore the importance of a large variety of firm characteristics for the monetary transmission.
   - The interest-costs-to-earning ratio (proxy for earning-based constraint) is associated with monetary transmission ↑
   - Limited explanatory power
   - Firms respond relatively similar to monetary policy.

3. Indirect vs. direct effects of monetary policy
   - Monetary policy works primarily via direct effects (interest rate changes).

4. Consistent with a standard representative firm model

Literature

Back

- Monetary transmission to investments

  Gertler-Gilchrist (1994), Kashyap-Stein (1995), Jimenez-Ongena-Peydro-Saurina (2012), Greenwald (2018), Ippolito-Ozdagli-Perez-Orive (2018), Jeenas (2019), Ottonello-Winberry (2020), Caglio-Darst-Kalemli-Özcan (2021), Greenwald-Krainer-Paul (2021), Jungherr-Meier-Reinelt-Schott (2022), Gnewuch-Zhang (2022), Cloyne-Ferreira-Froemel-Surico (2023)

- Importance of investments for monetary transmission in HANK models

  Auclert-Rognlie-Straub (2020), Bilbiie-Känzig-Surico (2020)

Variable Definitions and Descriptive Statistics

▸ Sample Restrictions ▸ back

	mean	sd
Investment (percent growth in fixed assets)	-0.19	19.99
Sales (percent growth)	6.04	37.26
Size (log of total assets)	7.42	1.35
Firm age (years)	17.05	12.87
Leverage	0.30	0.24
Liquidity	0.16	0.15
Interest costs to EBITA	0.38	0.74
Debt to tangible assets	0.70	0.21

All variables are CPI adjusted

Sample Restrictions

Back

1. We drop firms within utilities, financial sector, real estate, and public administration
2. We drop firms with fixed assets < USD 100k.
3. We drop firms with 3-year average of earnings < 0.
4. We drop firms with (Long-term debt)/assets > 10
5. We trim the 1st and 99th percentile of main explanatory variables (interacted variables).
6. We drop top/bottom 5% investment growth.
7. We drop firms with negative sales, total assets, debt, and deposits.

Sample: 33,674 unique firms

Interest Rate Pass-Through to Non-Financial Firms

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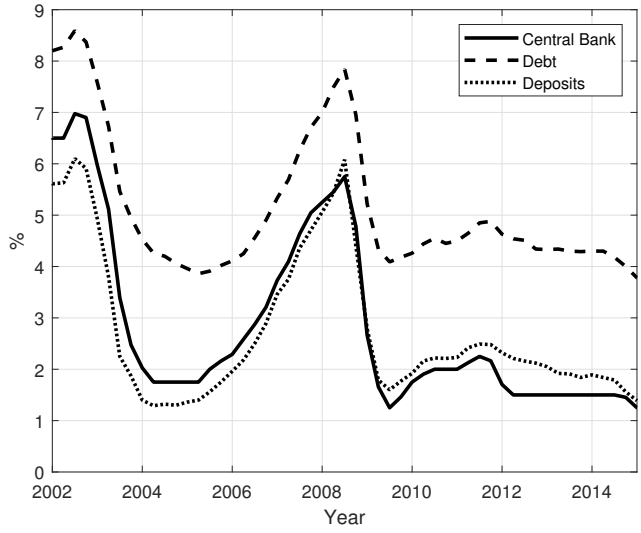
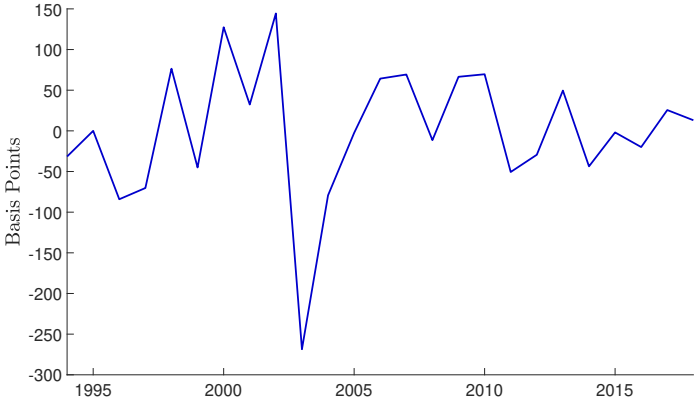


Note: average interest rate on outstanding debt/deposits

Monetary Policy Shocks (Holm-Paul-Tischbirek, 2021)

▸ Interest Pass-Through ▸ back

- Identification follows Romer-Romer (2004):
  "... changes in the [...] funds rate not taken in response to information about future economic developments."



Investment in Macro and Micro Data

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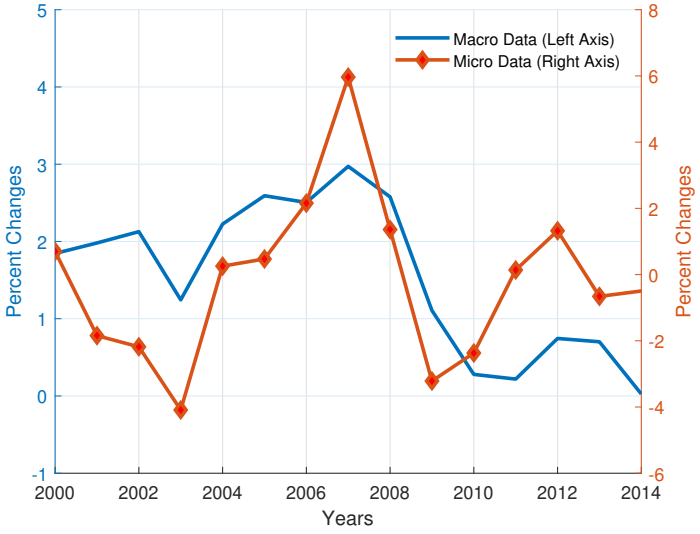

Average Responses in Aggregate Data (1999–2014)

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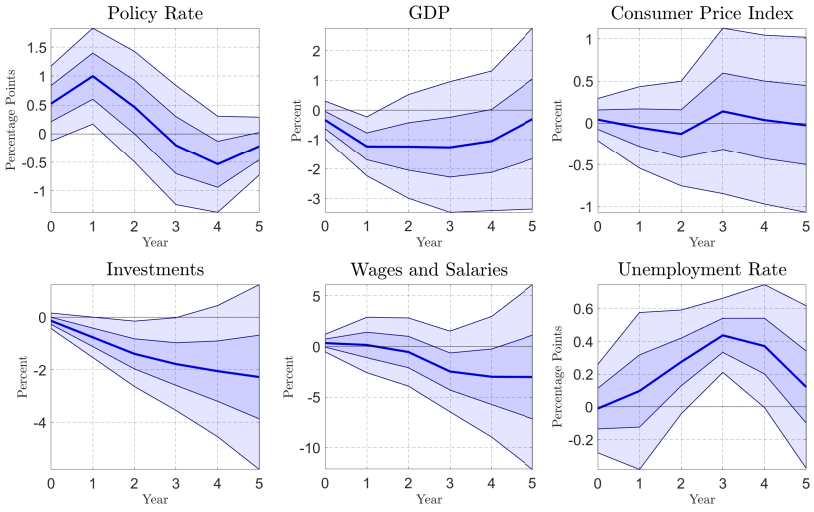

68% & 95% confidence bands

Robustness: Additional Control Variables

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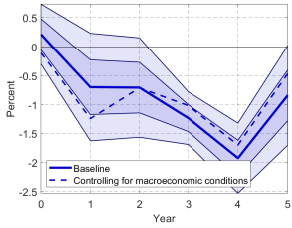
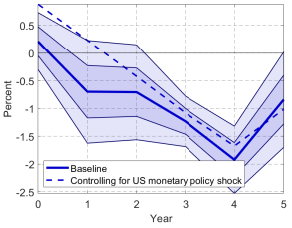
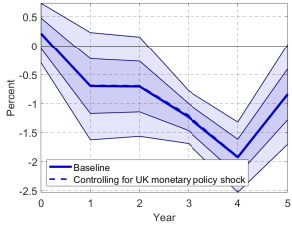


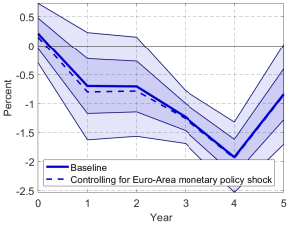
(a) Macroeconomic variables



(b) US monetary policy



(c) UK monetary policy



(d) Euro-area monetary policy

High-Frequency Monetary Policy Shocks

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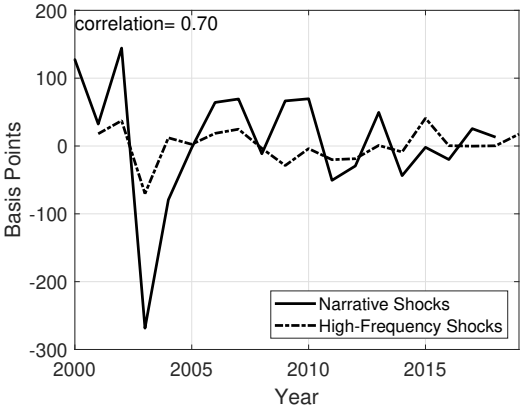
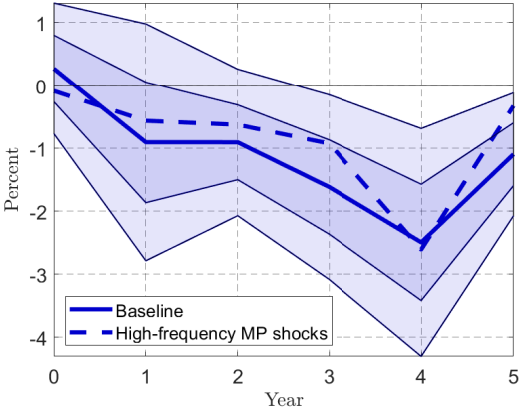


(a) Comparison of shocks



(b) Average investment responses

Robustness: Standardization Within Sector

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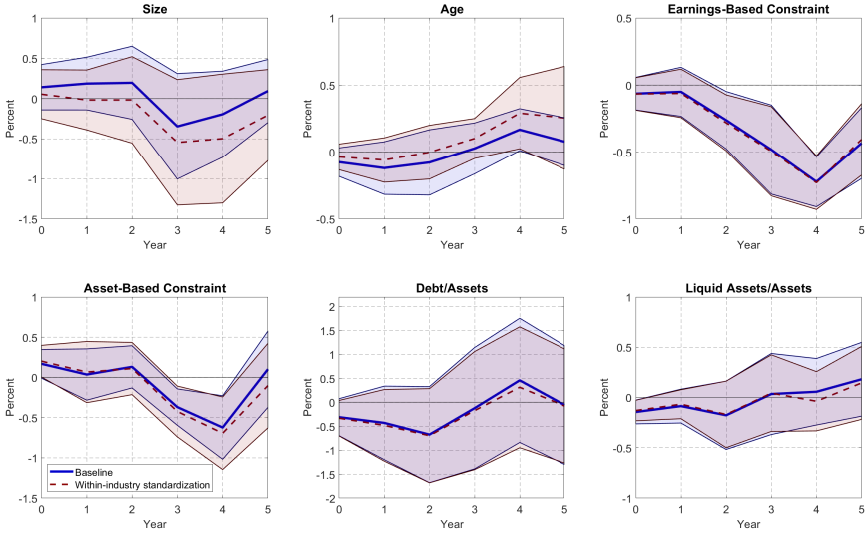

95% confidence bands

Robustness: High-Frequency Monetary Policy Shocks

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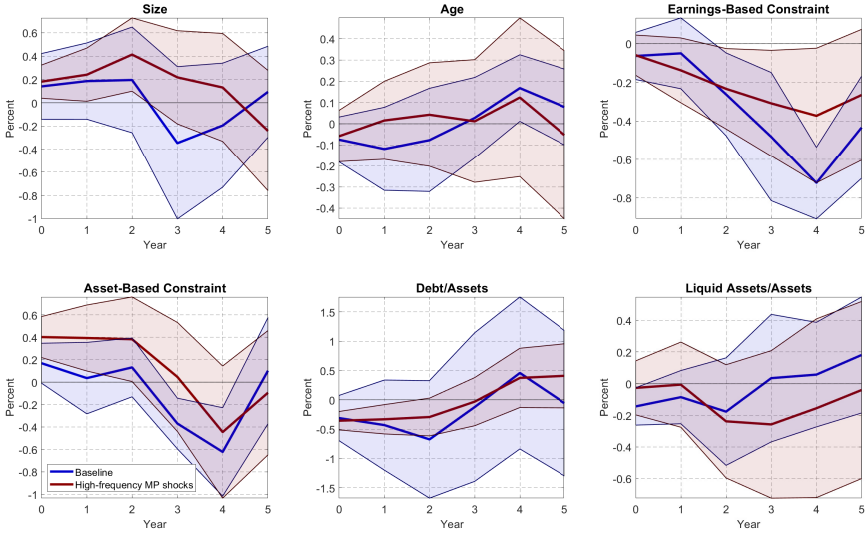

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Robustness: Macro Controls

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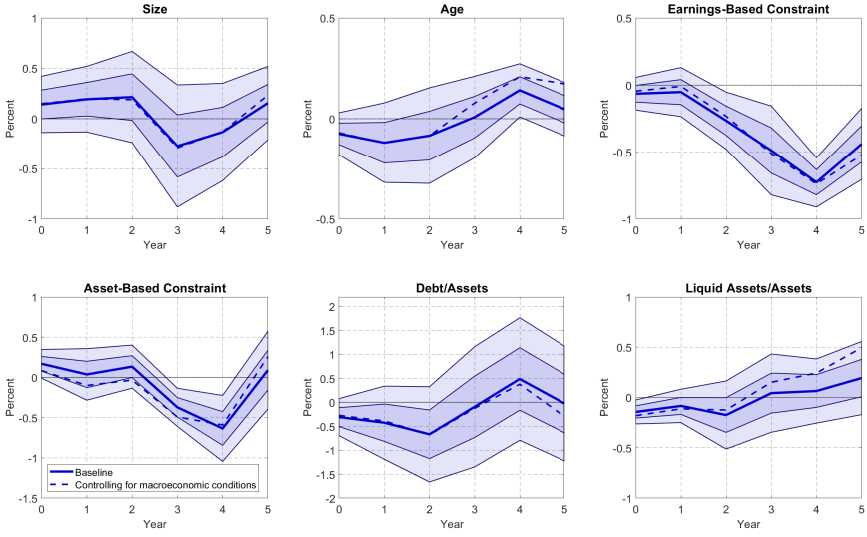

68 & 95% confidence bands

Robustness: Age/Dividend Controls (Cloyne et al.)

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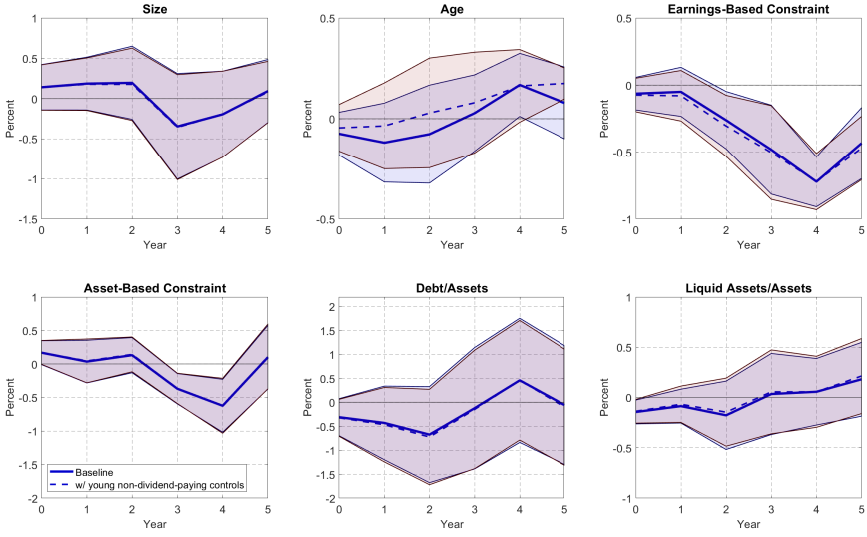

68 & 95% confidence bands

Robustness: Controlling for Expected Sales

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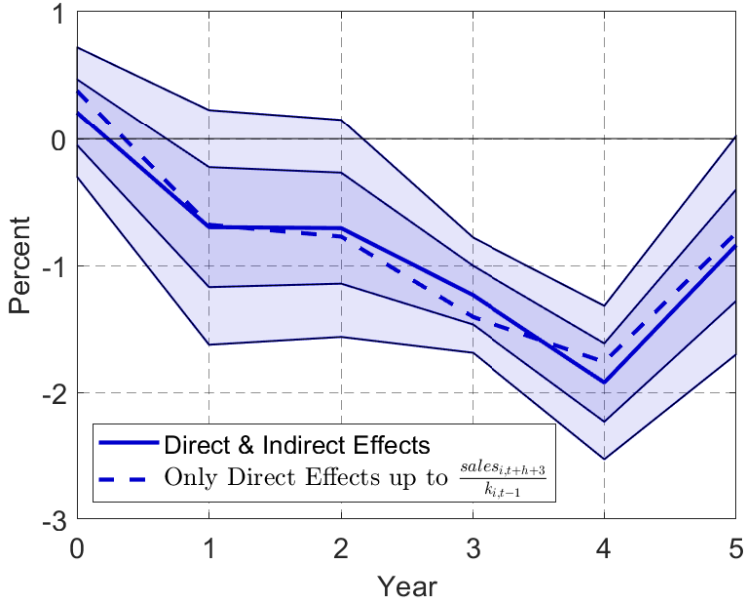
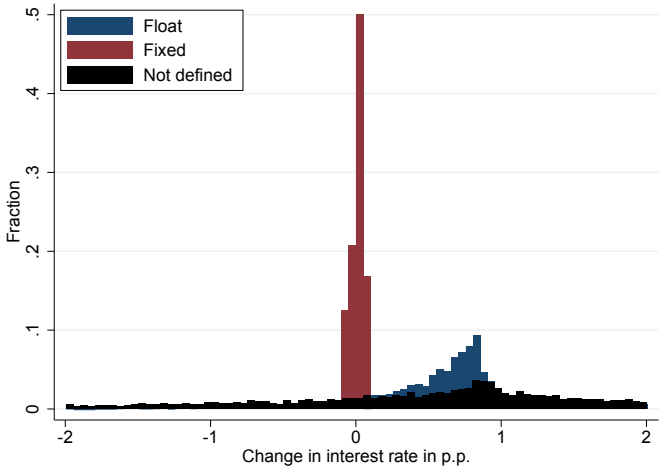


Identifying Fixed-Rate Firms, 2006

back



4.9% of firms have fixed-rate contracts, compared with 4.2% in publicly available data

A Model

back

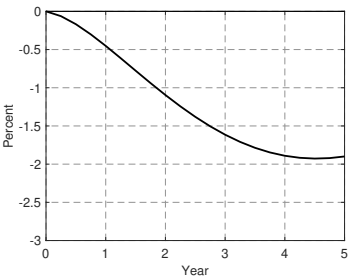
Representative firm, partial equilibrium:

$$\max_{I_t} \sum_{t=0}^{\infty} \left(\prod_{s=0}^{t} \frac{1}{1+r_s} \right) \left(A_t K_t^{\alpha} - I_t \left(1 + S\left(\frac{I_t}{I_{t-1}} \right) \right) \right) \quad \text{s. t.} \quad K_{t+1} = (1-\delta)K_t + I_t$$

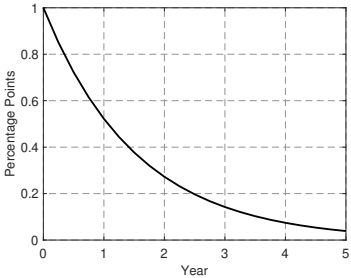
- I is investment, K is capital
- r is the interest rate, A is productivity
- δ is the depreciation rate, α the capital share of output
- $S(\cdot)$ is an investment adjustment function satisfying $S(1) = 0$, $S'(1) = 0$, and $S''(1) = \phi$

Impulse Responses to an Interest Rate Shock

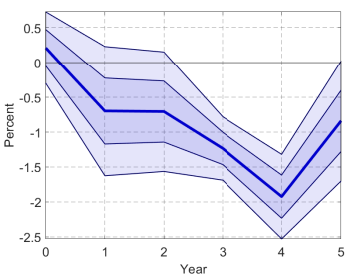
back



(a) Capital



(b) Interest rate



(c) Empirical counterpart

Robustness: Closeness to Consumers

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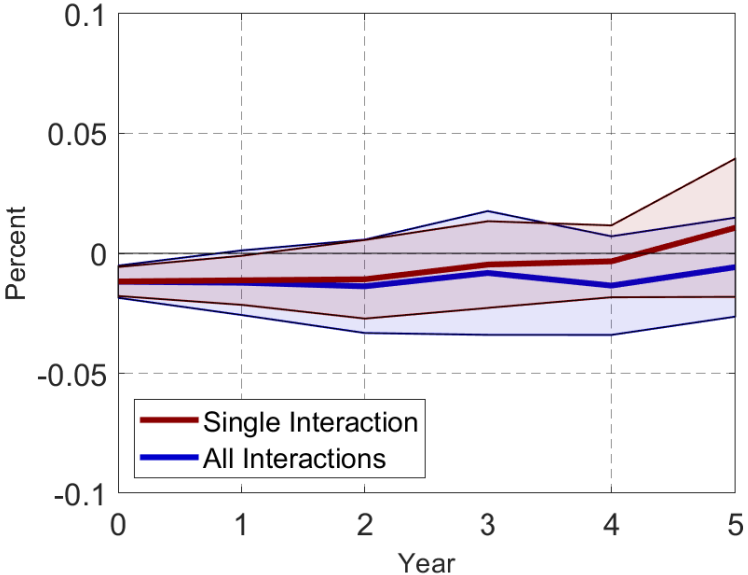
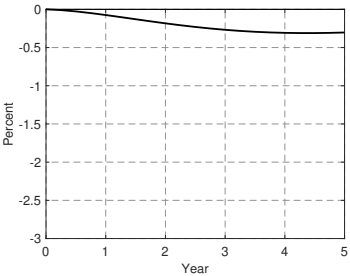
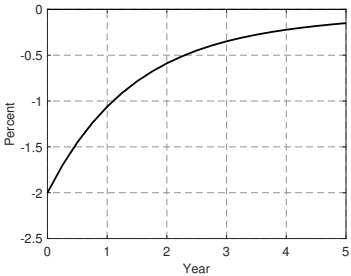


Impulse Responses to a Productivity Shock

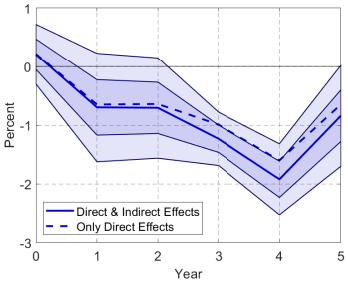
back



(a) Capital



(b) Productivity



(c) Empirical counterpart

Identifying Fixed-Rate Firms

back

1. Use firm-bank account data to estimate the interest rate on each contract:

$$r_{j,t} = \frac{\text{interest payments}_{j,t}}{0.5 \cdot (\text{debt}_{j,t-1} + \text{debt}_{j,t})}$$

2. Compute the median interest rate each year and the change in this median interest rate
3. Define loan contract:
   - **Fixed rate** if $dr < 0.1$ p.p. & median $dr > 0.1$ p.p.
   - **Adjustable rate** if median $dr > 0.1$ p.p. & abs(dr - median dr) < 0.1 p.p.
   - **Unassigned** if neither of the above
4. Restrict attention to firms having only one debt contract.