The Interest Rate Elasticity of Investment: Micro Estimates and Macro Implications

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How does corporate investment respond to changes in interest rates?

Theoretically:

- Can be powerful amplifier of monetary policy
- Amplification force depends on how firms respond to changes in **cost of capital**
- Macroeconomic models (w/o frictions) imply very strong responses

Why is capital so responsive to changing rates?

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- With fluctuating interest rates, incentive to accelerate purchases to periods when r is low

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Hard to interpret: Macro evidence combines both PE & GE effects

- Cost of capital? Demand shifts? Fed information effect?
- Distinguishing is important for getting the transmission mechanism right

What Do We Know Empirically?

Recent literature in macro uses **micro** consumption estimates (MPC) to discipline models

- MPC cannot tell you overall effect of fiscal stimulus, monetary policy, housing wealth changes
- Can help discriminate b/w models and generate realistic quantitative magnitudes.
- Literature much less well-developed on **investment** side

Importance of Parameter Extends Beyond Monetary Policy

Trump economist outlines case for business tax cuts as GOP weighs bill

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June 16, 2025

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- Lower taxes raise investment, but higher deficits lead to crowd out
- Need to know how investment responds w/o information effects or aggregate demand
- "Portable Statistic" (Nakamura & Steinsson, 2018)

This Project

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Strategy:

- Use fact that **durability** is characteristic that makes capital responsive to interest rates
- Compare investment response among firms with **more vs. less durable capital goods**
- Isolates PE **cost of capital** channel from other GE forces that affect investment

Preview of Results

- Significant investment effects: 1 p.p. interest rate cut $\rightarrow$ 3-4% increase in capital over two years
- But, smaller than comparable estimates of investment response to corporate tax changes
- Puzzle for investment models: both identification strategies estimate **exact same parameter**
  - Cost of capital elasticity

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Second Half: Use quantitative model to reconcile results using model with financial frictions

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- Calibrate models to new empirical estimate of investment response to monetary policy.

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Two Main Findings:

1. Matching empirical estimates requires **very strong frictions**
2. Only **financial frictions** generate significant differences b/w tax rate and monetary elasticities

Mechanism

Adj. costs do not break result that tax elasticities $\approx$ monetary elasticities

- Tax cuts generate free cash flow for firms: tax bill is lower today
  - **Frictionless & Adj. Costs models**: irrelevant, can borrow to fund investment
  - **Financial Frictions**: use free cash flow to buy capital, amplifies investment response

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Results provide evidence for models where cash flows inside firm particularly valuable

- New “portable moment” can be used to adjudicate between competing models

Related Literature

- **Investment Function**: Hall and Jorgenson (1967); Hayashi (1982); Auerbach (1983); Shapiro, Blanchard, and Lovell (1986); Caballero (1994); Caballero, Engel and Haltiwanger (1995); Chirinko, Fazzari, and Meyer (1999); Cummins et al. (1994); Hassett and Glenn Hubbard (2002); House and Shapiro (2008); **Zwick and Mahon (2017)**
  - New quasi-experimental estimate of investment elasticity **from a monetary shock**
- **Monetary Policy and Investment**: Gertler and Gilchrist (1994); Ottonello and Winberry (2020); Bahaj et al. (2020); Cloyne et al. (2020); Jeenas (2019); Dottling and Ratnovski (2020); Gürkaynak, Karasoy-Can and Lee (2021); Jeenas and Lagos (2021), Koby and Wolf (2020), Gormsen and Huber (2024), Fukui et al. (2024), Krussell et al. (2023), Cao et al. (2024), Modi (2024)
  - Direct estimate of investment elasticity
  - New strategy to test for importance of financial constraints
- **Monetary Transmission**: Christiano, Eichenbaum, and Evans (2005); Smets and Wouters (2007); Auclert, Rognlie, Straub (2020); Kaplan, Moll and Violante (2018)
  - Evidence on the monetary transmission mechanism

Roadmap

1. Identification
2. Investment & Financing Results
3. Quantitative Model (Short)
4. Conclusion

Identification

Standard Firm Problem

Firms Choose Capital Each Period to Maximize a Discounted Stream of Dividends:

$$\max_{k_t} \sum_t (\Pi_{s=1}(1+R_s+\Theta))^{-1}(z_t K_{t-1}^{\alpha} - I_t - \psi(K_{t-1}, K))$$

- R_s: one-period, real interest rate
- Θ: discount rate wedge
- $\psi(K_{t-1}, K)$: differentiable adjustment cost function

Investment Euler Equation

Optimal Investment Characterized by Single FOC:

$$\underbrace{1 + \psi_{K_t}(K_{t-1}, K_t)}_{\text{Marginal Cost of Additional Capital}} = \frac{1}{1 + R_{t+1} + \Theta} \underbrace{\left(\alpha z_{t+1} K_t^{\alpha-1} + (1 - \delta_f) - \psi_{K_{t-1}}(K_t, K_{t+1})\right)}_{\text{Marginal Benefit of Additional Capital}} \quad (1)$$

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Assume No Adjustment Costs:

$$\alpha z_{t+1}K_t^{\alpha-1} = \underbrace{R_{t+1}+\delta_f+\Theta=\mu_{f,t}}_{\text{User Cost of Capital}} \tag{2}$$

Deriving the Estimator Alt. Derivation

Partial Equilibrium Interest Rate Semi-Elasticity Given By:

$$\frac{\partial K_t / K_t}{\partial R_{t+1}} = \frac{\Psi}{\delta_f + R_{t+1} + \Theta}$$

Where $\Psi = \frac{1}{\alpha - 1}$ is the curvature of the revenue function

- Demand elasticity
- Decreasing returns to scale
- User cost elasticity

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Differences Across Low-Depreciation (l) and High-Depreciation (h) Industries Identifies Ψ

$$\Delta \log(k_{l,t}) - \Delta \log(k_{h,t}) = \Psi \{ \Delta \log(\mu_{l,t}) - \Delta \log(\mu_{h,t}) \} + \epsilon_t$$

Summarizing

This Project: Two sources of variation

- Changes in interest rates from Fed policy (high-frequency shocks)
- Compare investment response for firms that use more vs. less durable types of capital goods

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Industry-level variation: sector x quarter FEs to narrow control group and dummy out GE factors

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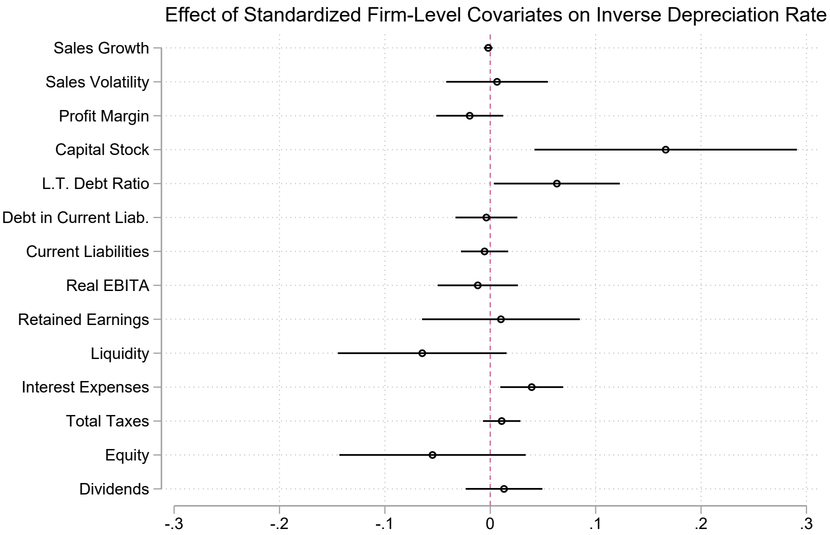
- Factors that change **investment after monetary shocks** not correlated with depreciation rates
- Difference b/w truck & rail investment after shock due to heterogeneous cost of capital
  - Not due to increased demand for one industry, differential responses to news about economy, ...
- Similar argument to **Zwick & Mahon (2017)**: directly comparable to previous estimates

Covariate Balance



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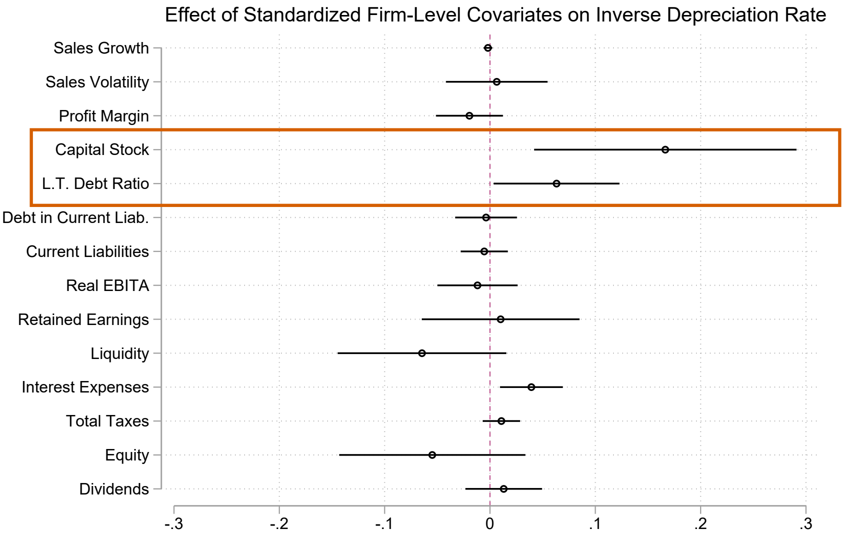


Investment and Financing Results

Data

- **Industry-Level Depreciation Rates**: BEA Data on Fixed Capital Stock Residualized Depreciation Rates
- **Firm-Level Investment & Financing**: Compustat Summary Stats
  - Dependent Variable: Property, Plant, and Equipment
  - Robust to using other variables
- **Monetary Policy Shocks**: Gürkaynak, Karasoy-Can and Lee (2021) Time Series
- **Investment Network**: vohm Lehn and Winberry (2021)
- **Capital Prices and Quantities**: BEA Summary Stats

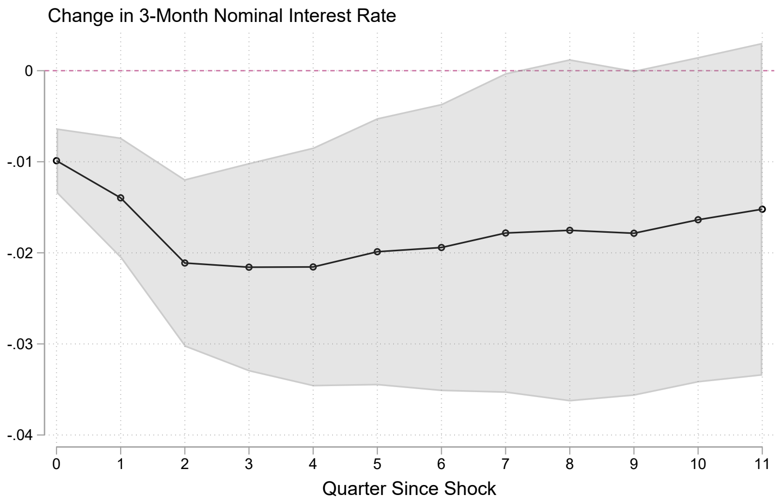
Empirical Strategy

Strategy: Jordà (2005) local projections.

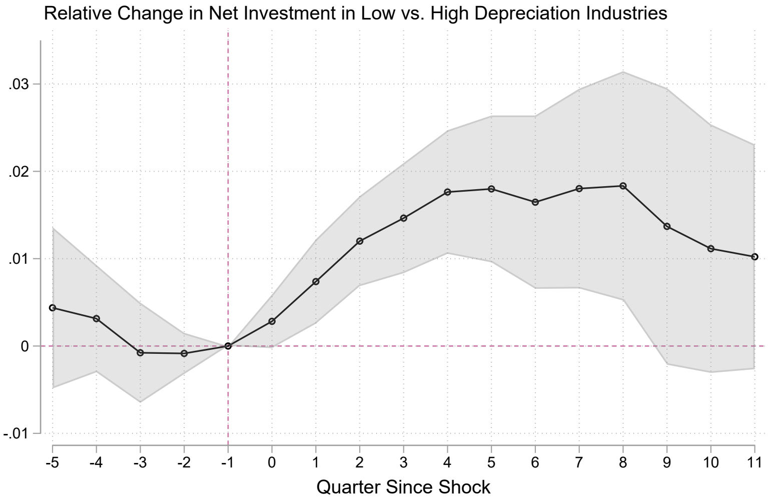
$$\log k_{f,t+h} - \log k_{f,t-1} = \beta_h \epsilon_t \delta_i + \boldsymbol{\alpha}_{\boldsymbol{f,h}} + \boldsymbol{\alpha}_{\boldsymbol{s \times t,h}} + \Gamma' Z + e_{f,t,h}$$

- t is time, f(firms) $\subset$ i(industries) $\subset$ s(sectors)
- δ_i: Standardized, industry-level depreciation rate (BEA Data)
- ϵ_t: High-frequency monetary shock (Nakamura & Steinsson, 2018)
- $\boldsymbol{\alpha}_{\boldsymbol{s \times t,h}}$: sector x quarter FEs

The Effect of Monetary Shocks on Short-Term Interest Rates



Monetary Policy Shocks Increase Net Investment



Further Results

- Driven by changes in short rates
  - Rates
- No increase in L.T. Debt
  - L.T. Debt
- Results hold in a separate dataset of capital goods purchases
  - BEA Data
- Additional results on firm financing
  - Other Results
- Extensive robustness checks
  - Robustness
- Macro counterfactual
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Identifying Interest-Rate Elasticities Using Tax-Policy Changes

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With corporate tax code (Hall and Jorgenson, 1967):

$$\mu_{f,t} = (\delta_f + R_{t+1} + \Theta)\frac{1-\tau z}{1-\tau} \quad \Rightarrow \quad \frac{\partial K_t / K_t}{\partial T / T} = \Psi$$

where $T = \frac{1-\tau z}{1-\tau}$ is the effect of taxes on the cost of capital

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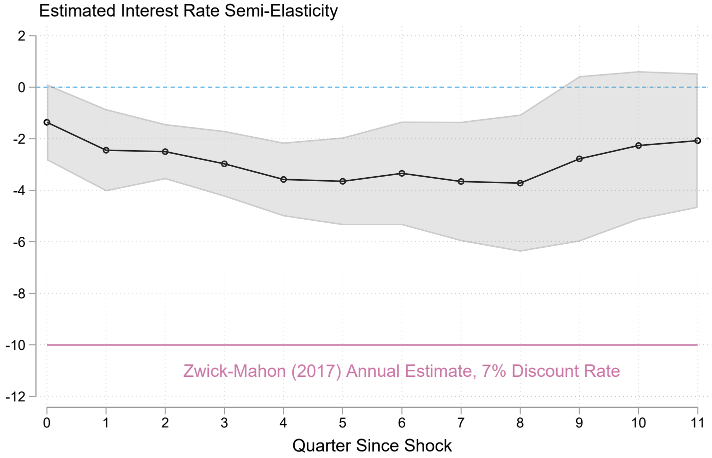
- Tax & monetary policy both affect investment by changing cost of capital
- Quasi-experimental estimates from tax policy informative about interest-rate elasticities

Interest Rate Elasticities Are Smaller Than Tax Elasticities



Magnitude: Fed lowers rates by 1 p.p. $\Longrightarrow$ capital demand increases by 4% after 8 quarters

Recap

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- However, tax elasticities are 3x larger than monetary elasticities
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What type of model can jointly rationalize both results?

Model

Model Set-Up Equilibrium Parameters

Model of corporate investment with **heterogeneous firms** and a **corporate tax system**:

$$
\begin{aligned}
V_t(k,z,\delta) = \max_{k',n}\ & p_t f(k,z,n_{f,t}) - w_t n_{f,t} - q_t(k' - (1-\delta) * k) - \\
& \psi(k',k,I_{f,t}) - T(\pi_{f,t},\tau_t,\theta_t) + \mathbb{E}_t[\frac{1}{1+r_t} V_{t+1}(k',z',\delta)]
\end{aligned}
\tag{3}
$$

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- Laboratory to study the effects of both monetary and fiscal policy
- **Mimic Estimator**: study effect of policy holding fixed other prices
- **Appendix**: close model with standard RA New Keynesian model
- Two moments to match: **interest rate (targeted)** and **tax policy (untargeted)** elasticities

Two Competing Models to Slow Investment Response

Adjustment Costs:

$$\psi(k', k, I_{f,t}) = \frac{\eta}{2}\left(\frac{k' - k}{k}\right)^2 k + \zeta \mathbb{1}\{I_{f,t} \neq 0\} w_t$$

- Costly to install capital; matches lumpy investment

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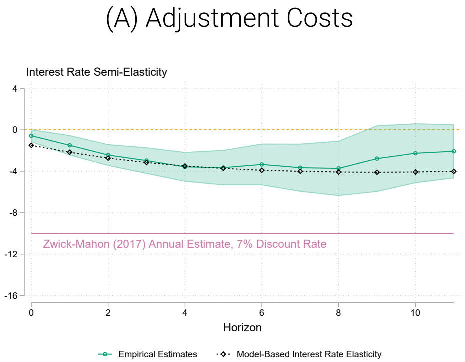
Financial Frictions:

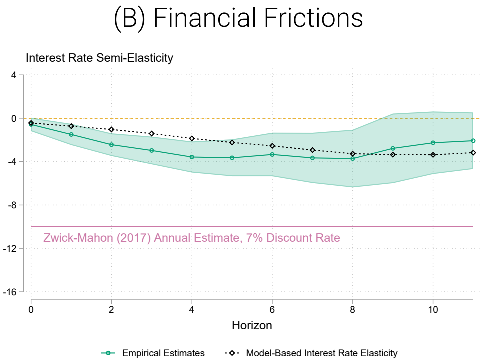
$$D_{f,t} \geq \omega \pi_{f,t}$$

- Frictions to financing investment; investment constrained by EBITA

Targeted Elasticities In Competing Models

Adjustment Costs   Financial Frictions





Untargeted Moment: Bonus Depreciation Estimator

Table: Untargeted Moment: Implied Interest Rate Elasticity from Tax Rate Shock

	Data	Adjustment Costs Model	Financial Frictions Model
Tax Rate Elasticity	-10.00	-1.55	-8.05

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Mechanisms

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- **Frictionless model**: monetary and fiscal policy affect investment by changing **cost of capital**
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  - Cannot generate big differences between monetary & tax elasticities

Mechanisms Qualitative Evidence

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- **Need models where cash inside firm more valuable than cash outside firm**
  - Financial friction that endogenously generates high discount rates (Gormsen & Huber, 2024)

Conclusion

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- New method to estimate interest rate investment elasticity
- Results imply 1 p.p. drop in interest rates increases capital demand by $\approx 3 - 4\%$
- Substantial effects, but smaller than naive extrapolation from tax elasticities
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Policy Implications:

- Tax policy more stimulative than monetary policy
  - True in both PE (investment more responsive) and GE (less crowd out)
  - OBBB: crowd out from higher deficits **1.3% (Zwick-Mahon) vs. 0.6% (CBO) vs. 0.4% (this paper)**
- Cash flow mediates responsiveness of investment (recessions vs. expansions)
  - Interactions b/w monetary policy (changes cost of capital) and tax policy (generates cash for firms)

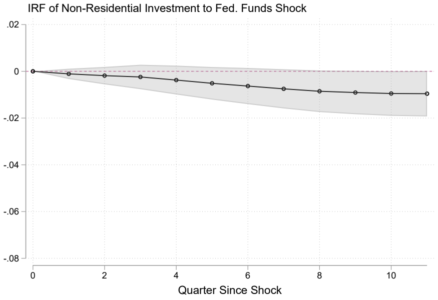
Thank You!

Appendix

Estimates of a Contractionary Fed. Funds Shock on Investment

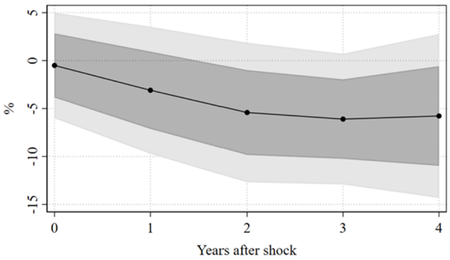
Back

VAR Fed. Funds Shock



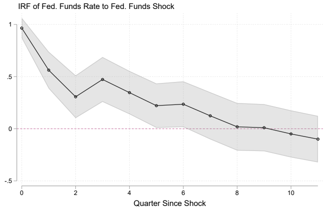
Krussell et al. (2023) Monetary Shock

Figure 2. Average capital response.

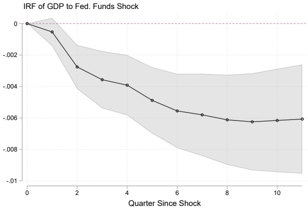


VAR Estimates Back

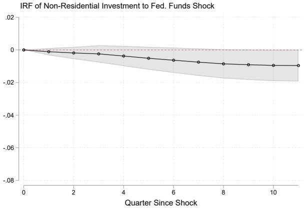
Fed. Funds Rate



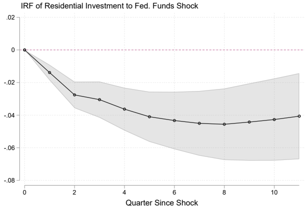
GDP



Non-Residential Investment

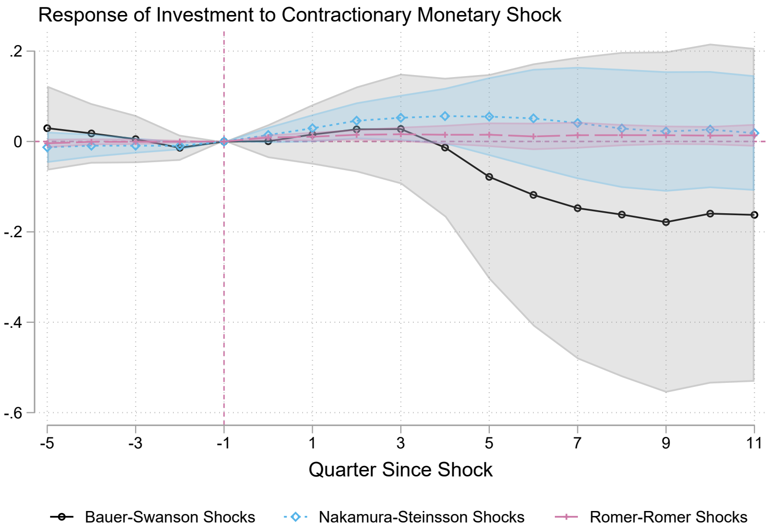


Residential Investment



The Effect of a Contractionary Shock on Non-Res. Investment

Back



Alternative Derivation

Back

Firms maximize:

$$\max_{I_t} \sum_t (\Pi_{s=1}(1 + R_s + \Theta))^{-1}(K_t^{\alpha} - I_t * (\frac{I_t}{I^*})^{\frac{1}{\xi}})$$

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Assuming capital is sufficiently long-lived and shock is temporary (House & Shapiro, 2008):

$$\alpha K^{*\alpha - 1} \approx -\frac{(\xi + 1)\frac{I_t}{I^*}^{\frac{1}{\xi}}}{\xi}(\delta_f + R_t + \Theta)$$

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Implying:

$$\Delta \log(I_{l,t}) - \Delta \log(I_{h,t}) \approx \xi\{\Delta \log(\mu_{l,t}) - \Delta \log(\mu_{h,t})\} + \epsilon_{f,t}$$

Residualized Depreciation Rates

Data Slide

Industry	Residualized Depreciation
Funds, Trusts, Oth. Finance	-6.0%
Rail Transportation	-3.5%
Education Services	-3.4%
Primary Metal Manufacturing	-3.4%
Utilities	-3.3%
Broadcasting	-3.2%
Petrol. and Coal Manufacturing	3.7%
Performing Arts	3.7%
Misc. Professional Services	5.3%
Car Manufacturing	6.8%
Computer Systems Design	7.0%
Truck Transportation	8.8%

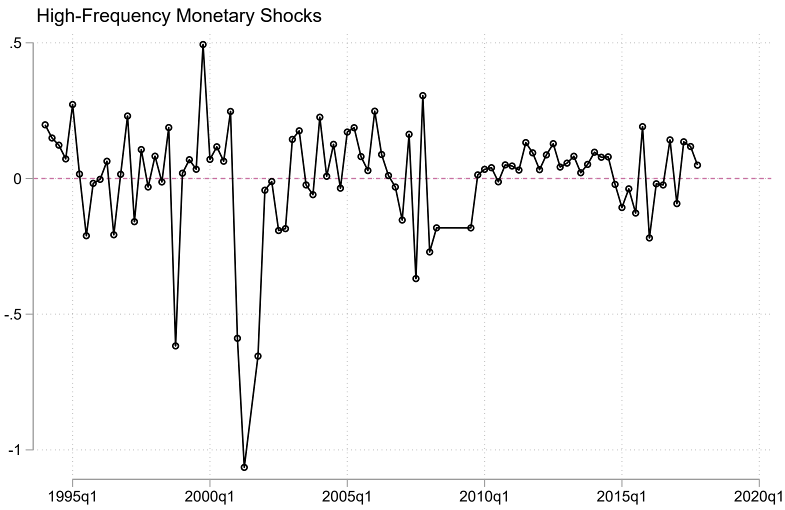
Compustat Summary Statistics

Data Slide

	N	Mean	Median	SD	P10	P90
D.Log Capital	263,450	0.00	-0.00	0.08	-0.06	0.07
1-Year D.Log Capital	244,256	0.03	-0.00	0.33	-0.25	0.38
2-Year D.Log Capital	225,724	0.06	0.02	0.50	-0.41	0.62
1-Year Cumulative Capex / L.Capital	242,961	0.36	0.24	0.40	0.06	0.78
2-Year Cumulative Capex / L.Capital	221,938	0.66	0.43	0.77	0.11	1.40
D.Log Cash and Short-Term Assets	259,926	0.02	0.00	0.67	-0.61	0.66
Real Sales Growth	263,554	0.01	0.01	0.22	-0.21	0.23
Real Assets (USD Millions)	263,554	5.36	5.37	2.33	2.34	8.37
Share Current Assets in Total Assets	263,554	-0.03	0.00	1.01	-1.47	1.32

Time Series of Monetary Shocks

Data Slide



BEA Summary Statistics

Data Slide

	N	Mean	Median	SD	P10	P90
Gross Investment (s.a., ann., USD Mill.)	3,456	28,123.51	18,378.50	29,476.59	4,048.00	73,119.00
Capital Price Index	3,456	0.95	0.86	0.80	0.58	1.02
1-Year D.Log Investment	3,312	0.04	0.05	0.22	-0.19	0.26
1-Year D.Log Prices	3,312	0.01	0.02	0.05	-0.02	0.05

Which Interest Rates Matter?

Frictionless Model: Only short-term rate matters

- With frictions, the whole path of short rates matters
- Outside model, L.T. rates may matter: firm financing, risk & term premia
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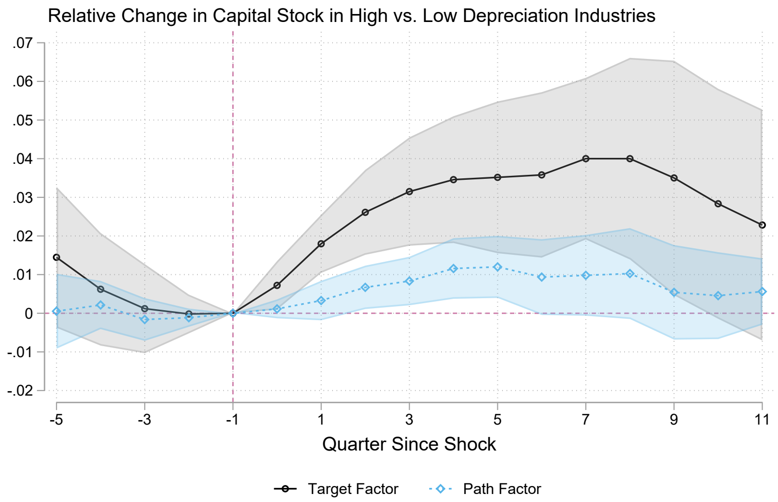
Strategy: Look separately at Target and Path monetary shocks (GSS, 2005)

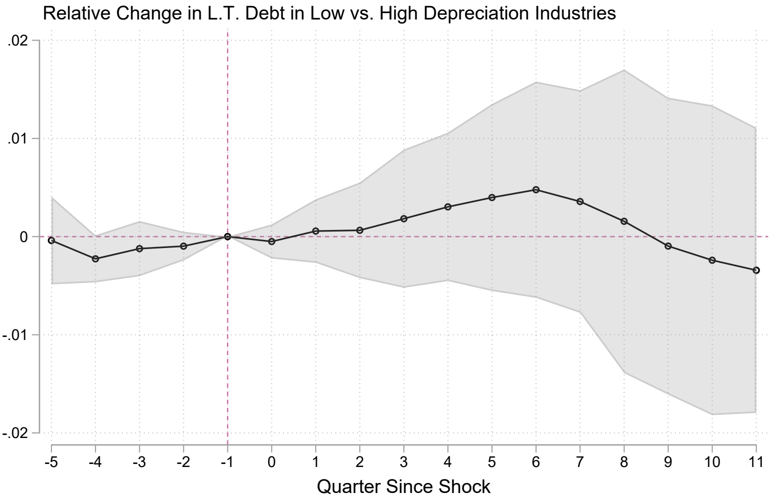
- Target Factor: related to changes in immediate Fed. Funds futures
- Path Factor: Info about future path of policy, but orthogonal to change in target
  - GSS (2005) show path factor responsible for movements on 5- and 10-year yields

Results Driven by Target Factor

Back



But No Increase in Long-Term Debt Back



Replication in BEA Data

Replication Excercise: Run regression at **capital good** level

- Dataset representative of aggregate U.S. economy
- Can investigate effects on capital prices
- Apples to apples comparison of effects of tax and monetary policy

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Regression Specification:

$$\log(I_{i,t}) = \beta \epsilon_t \delta_i + \alpha_i + \alpha_{c,t} + \eta \frac{1 - \tau z_{i,t}}{1 - \tau} + e_{i,t} \tag{4}$$

Effect in BEA Data

Back

	Gross Investment					Cumulative Investment	
	t=-4	*t*=-2	*t*=0	*t*=2	*t*=4	*t*=4	*t*=8
Exposure x Shock	-0.016	0.014	0.039*	0.048**	0.080***	0.056***	0.043**
	(0.025)	(0.021)	(0.020)	(0.022)	(0.027)	(0.020)	(0.020)
Tax Rate UCE	-4.46***	-4.35***	-4.25***	-4.17***	-4.03***	-4.10***	-3.91***
	(0.44)	(0.47)	(0.42)	(0.42)	(0.39)	(0.38)	(0.35)
N	3132	3204	3276	3204	3132	3276	3276
R^2	0.92	0.92	0.92	0.92	0.92	0.93	0.93
Capital FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date-Class FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interest Rate UCE	0.38	-0.34	-0.93	-1.15	-1.92	-1.35	-1.04

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Effect on Capital Prices

Back

	L4. Ln(P)	L2.Ln(P)	Ln(P)	F1. Ln(P)	F2. Ln(P)	F4. Ln(P)	F8. Ln(P)
Exposure x Shock	-0.086	-0.065	-0.028	-0.024	-0.015	-0.015	-0.022
	(0.075)	(0.073)	(0.076)	(0.075)	(0.075)	(0.073)	(0.065)
N	3132	3204	3276	3240	3204	3132	2988
R^2	0.75	0.74	0.73	0.73	0.73	0.74	0.74
Capital FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date-Class FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

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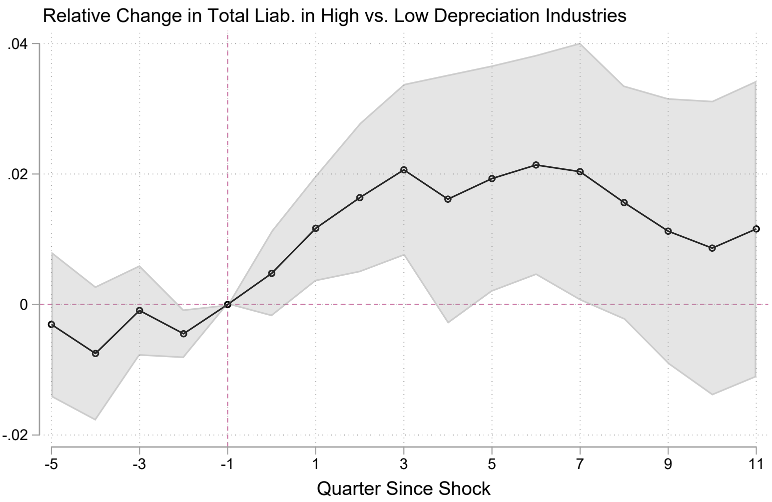
Other Results Back

- Increase in liabilities
  - Liabilities
- Rapid increase, then decrease in cash holdings
  - Cash and S.T. Assets
- No change in inflation or capital goods prices
  - Inflation

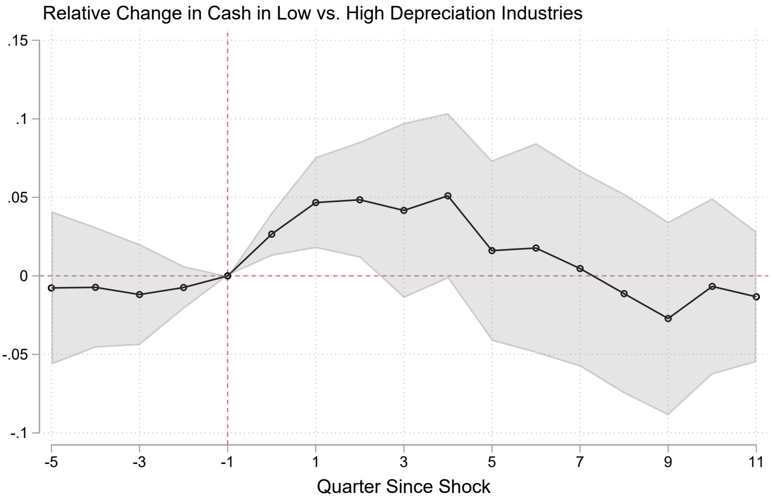
Increase on Liabilities Side of Balance Sheet

Back



The Effect of Monetary Shocks on Cash and Short-Term Assets

Other Results



Effect on Inflation

Other Results

	CPI	F1. CPI	F2. CPI	F3.CPI	F4.CPI	F5.CPI
Monetary Shock	-0.0013	-0.0012	-0.0035	-0.0036	0.0014	-0.0019
	(0.0026)	(0.0023)	(0.0031)	(0.0034)	(0.0033)	(0.0040)
N	91	90	89	88	87	86
R^2	0.0026	0.0025	0.013	0.014	0.0021	0.0039

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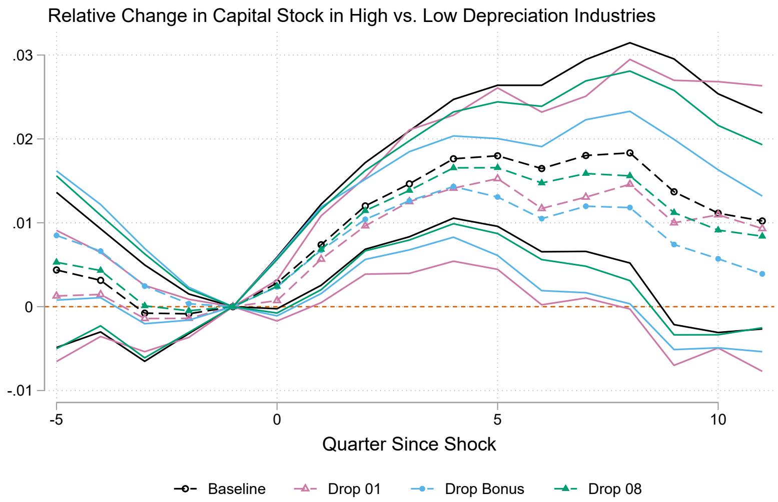
Robustness Checks Back

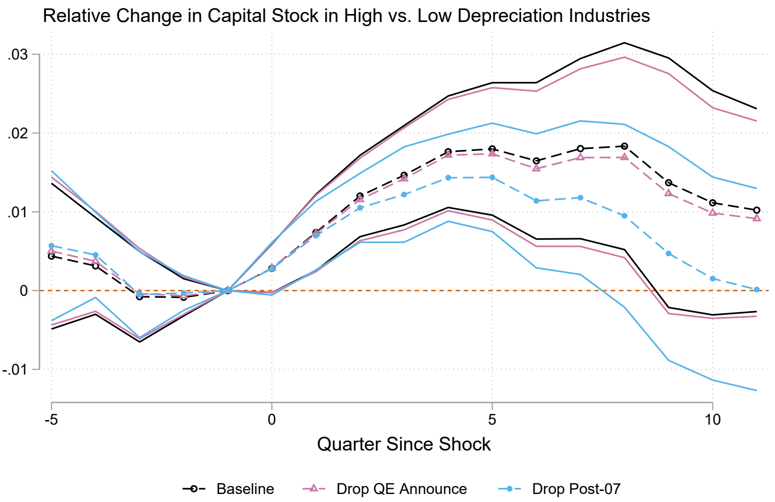
- Not confounded by QE policies or Bonus Depreciation
  - Bonus Dep. QE
- Not sensitive to set of controls
  - Varying Set of Controls Interacted Controls
- Controlling for recovery rate & size interacted with shocks
  - Size & Irreversability
- Using Capex instead of PPE
  - Capex
- Heterogeneity by Firm Size
  - Firm Size Heterogeneity

Removing Periods Around Bonus Announcements

Robustness

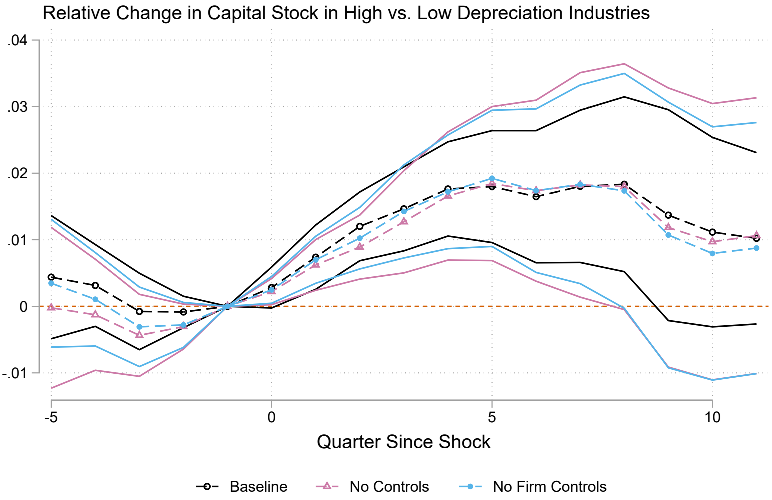


Removing Periods Around QE Announcements Robustness

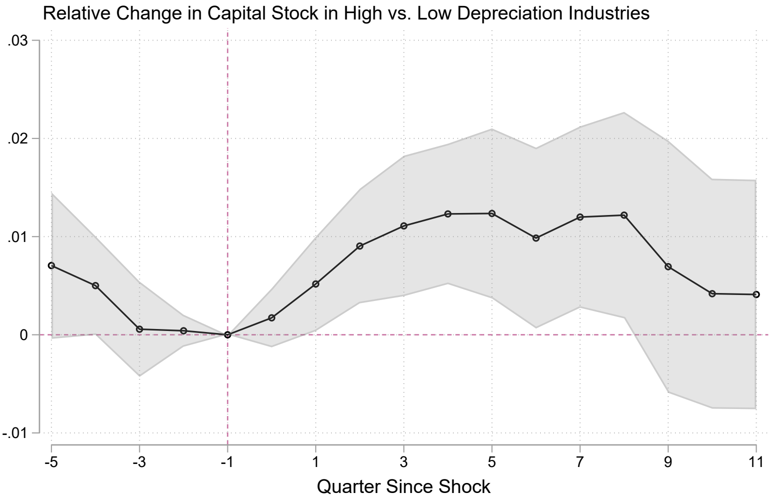


Varying the Set of Controls

Robustness

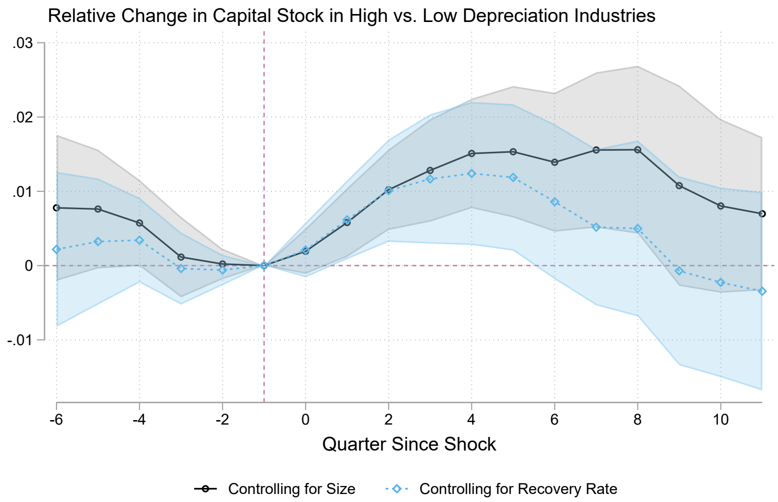


Allowing for my Interactive Controls Robustness

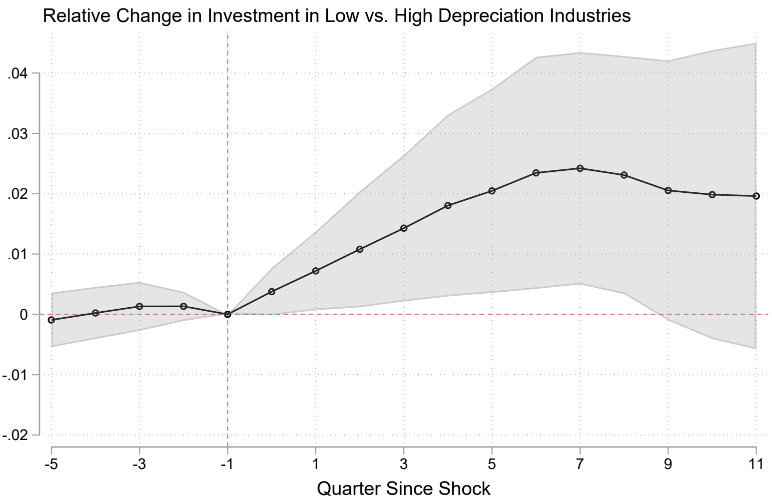


Controlling for Size and Irreversability

Robustness



Using Normalized Capex as Dependent Variable Robustness



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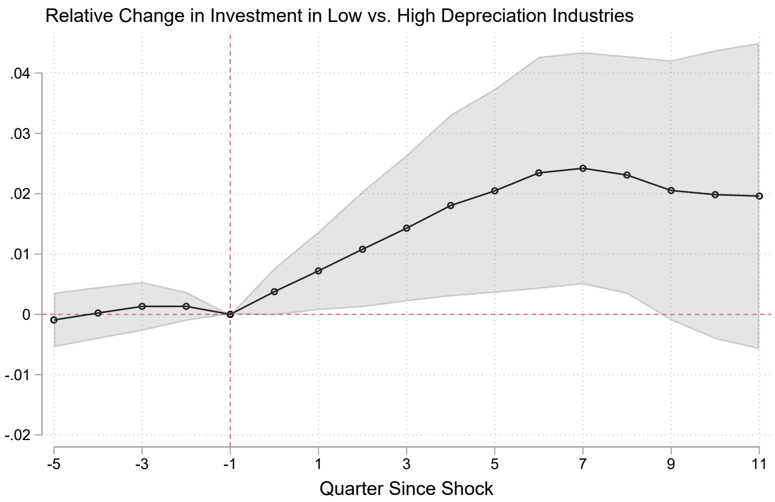

Heterogeneous Responses to Interest Rate Shocks by Firm Size

Robustness

	1-Year Effect			2-Year Effect		
	All Firms	Small Firms	Big Firms	All Firms	Small Firms	Big Firms
Main Coefficient	0.015***	0.011*	0.015**	0.018**	0.009	0.023*
	(0.003)	(0.005)	(0.005)	(0.006)	(0.004)	(0.009)
Observations	199960	107096	92121	184608	99358	84573
R^2	0.221	0.213	0.248	0.314	0.298	0.355

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Equilibrium Model

Equilibrium is:

- Take prices $\{p_t, w_t, q_t\}$, policy parameters $\{r_t, \tau_t, \theta_t\}$, and $\mu_0(k, z, \delta)$ as given
- Value functions $V_t(k, z, \delta)$, policy functions $k_t(z, k, \delta)$, size dist. $\mu(k, z, \delta)$ s.t.
- All firms optimize, and firm-size distribution is consistent with decision rules
- Study MIT shocks to interest rates and expensing parameter

Fixed Parameters

Model

Parameter	Description	Value	Source
β	Discount Factor	0.994	Data
v	Labor Coefficient	0.57	Capital Share
α	Capital Coefficient	0.28	Capital Share
ρ	Persistence of TFP	0.9	Ottonello & Winberry (2020)
σ_j	S.D. of TFP Innovations	0.053	Ottonello & Winberry (2020)
τ	Baseline Corp. Tax Rate	0.04	U.S. Corp. Tax Distortion
θ	Baseline Expensing Parameter	0	U.S. Corp. Tax Distortion

Adjustment Costs Calibration Back

Parameter	Description	Value	Source
η	Convex Cost	2.950	Estimated
$\bar{\zeta}$	Upper Bound on Fixed Cost	0.703	Winberry (2021)

Earnings-Based Borrowing Constraints Calibration

Back

Parameter	Description	Value	Source
η	Convex Cost	0.0	Restricted
$\bar{\zeta}$	Upper Bound on Fixed Cost	0.0	Restricted
ω	Lower Bound on Dividends	0.10	Estimated

Mechanisms Back

> *"We are living within our cash flow, meaning that we want to be able to fund our CapEx and our dividend from our cash flow. And so* ***that is the constraint****, and so, because we have a limited amount of capital, that is why we have the hurdle rate set at 15 percent IRR for projects." –* ***Kim Dang, Kinder Morgan CFO***

(Gormsen & Huber, 2024)

Macro Counterfactual

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Sahm et al. (2012) and Orchard et al. (2024a,b) construct **macro counterfactuals** to evaluate magnitudes and assess plausibility of micro results

- Show that estimated MPCs imply implausibly large aggregate effects

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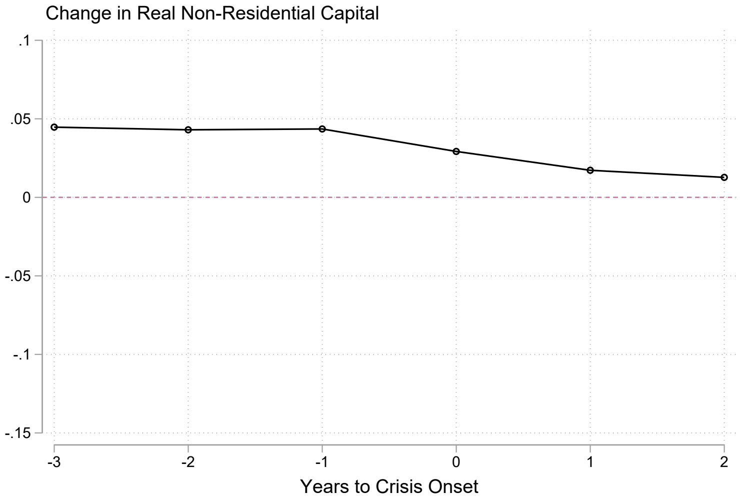
Apply estimates to historical episode: 2001 Fed Interest Rate Cuts

- Surprise loosening in first half of 2001
  - Interest rate surprises and forward rates suggest 1.5 - 1.7 p.p. interest rate cut
- Apply estimates and those from Zwick & Mahon (2017) to construct counterfactual investment series **if Fed had not cut interest rates**

Net Investment During the 2001 Recession



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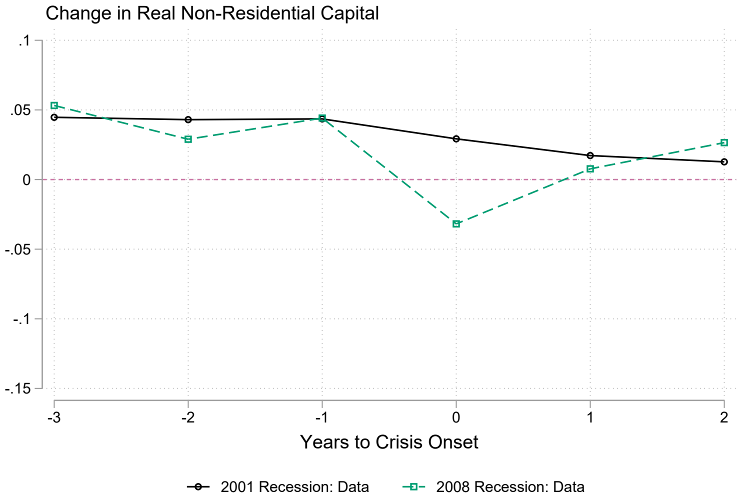

Net Investment During the 2001 Recession

Net Investment During the 2001 Recession Results