Financial Heterogeneity and the Investment Channel of Monetary Policy

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Motivation

- Aggregate investment central to monetary transmission

- Individual firms' investment shaped by financial frictions
  - Rich heterogeneity in financial positions

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- Aggregate investment central to monetary transmission
- Individual firms' investment shaped by financial frictions
  - Rich heterogeneity in financial positions
- What is the role of financial heterogeneity in monetary transmission?

Our Contributions

1. Descriptive empirical evidence
    - Combine high-frequency shocks with quarterly Compustat
    - Firms with low leverage are more responsive to shocks
        - 50% least leveraged account for nearly all aggregated response

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1. Descriptive empirical evidence
    - Combine high-frequency shocks with quarterly Compustat
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        - 50% least leveraged account for nearly all aggregated response

2. Heterogeneous firm New Keynesian model
    - Financial frictions $\rightarrow$ consistent with micro evidence
    - Two implications for aggregate transmission
        - Stimulates investment mostly through unconstrained firms
        - Aggregate effect depends on distribution of net worth

Related Literature

1. Heterogeneity and Monetary Policy
   Doepke and Schneider (2006); Coibon et al (2012); Auclert (2015); Werning (2015); McKay, Nakamura, Steinsson (2016); Wong (2016); Kaplan, Moll, and Violante (2016); Gilchrist, Schoenle, Sim, and Zakrajsek (2016)

2. Financial Frictions and Monetary Transmission
   Bernanke and Gertler (1995); Bernanke, Gertler, and Gilchrist (1999); Gertler, and Gilchrist (1994); Kashyap, Lamont, and Stein (1994); Kashyap and Stein (1995)

3. The Investment Channel of Monetary Policy
   Leeper, Sims and Zha (1996); Fisher (1997); Christiano, Eichenbaum, and Evans (2005)

Descriptive Empirical Evidence

Data Sources

1. Monetary policy shocks $\varepsilon_t^{\mathrm{m}}$: high-frequency identification
    - Compare FFR future before vs. after FOMC announcement
        - Assume nothing else affects FFR in window
    - Time aggregate to quarterly frequency

▸ Summary Statistics

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2. Firm-level outcomes: quarterly Compustat
    - Investment $\Delta \log k_{it+1}$: capital stock from perpetual inventory
    - Leverage x_{it}: debt divided by total assets (standardized over whole sample) Details Summary Statistics Figure Leverage Regressions

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Merge 1990q1 - 2007q2

Regression Specification

$$\Delta \log k_{it+1} = \beta x_{it-1} \varepsilon_t^{\mathrm{m}} + \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it-1} + \varepsilon_{it}$$

- Coefficient β is slope of investment semi-elasticity w.r.t. leverage
- Want to isolate differences due to leverage
  - α_{st}: compare within a sector-quarter
  - Z_{it-1}: conditional on leverage, sales growth, current assets, size, fiscal quarter
- Standard errors clustered two-way by firm + quarter

High-Leverage Firms Less Responsive to Monetary Shocks

	(1)	(2)	(3)	(4)
leverage × ffr shock	-0.93***	-0.73**		
	(0.34)	(0.29)		
ffr shock				
Observations	233232	233232		
R^2	0.107	0.119		
Firm controls	no	yes		
Time sector FE	yes	yes		
Time clustering	yes	yes		

$$\Delta \log k_{it+1} = \beta x_{it-1}\varepsilon_t^{\mathrm{m}} + \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it-1} + \varepsilon_{it}$$

▸ Extensive Margin ▸ Expansionary vs. Contractionary Shocks ▸ Path vs. Target ▸ Dynamics

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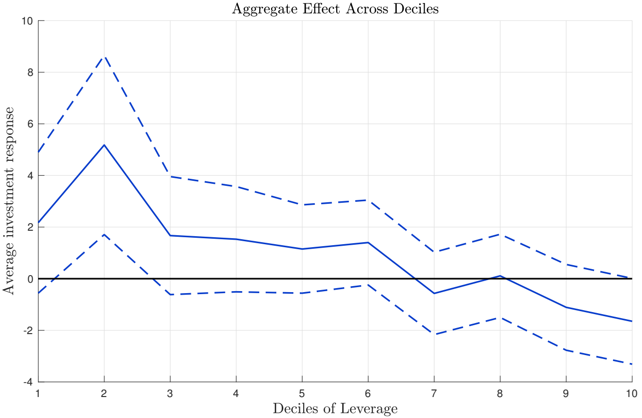
	(0.34)	(0.29)	(0.31)	(0.20)
ffr shock			1.38	1.38***
			(0.99)	(0.20)
Observations	233232	233232	233232	233232
R^2	0.107	0.119	0.104	0.104
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

$$\Delta \log k_{it+1} = \gamma \varepsilon_t^{\mathrm{m}} + \beta x_{it-1} \varepsilon_t^{\mathrm{m}} + \alpha_i + \mathbf{\Gamma}_0{}' Y_t + \mathbf{\Gamma}' Z_{it-1} + \varepsilon_{it}$$

Extensive Margin · Expansionary vs. Contractionary Shocks · Path vs. Target · Dynamics

Heterogeneity Matters for Aggregate Effect



- Aggregated by leverage decile $\Delta \log K_{jt} = \mathbf{\Gamma}_0{}' Y_t + \beta_j \varepsilon_t^{\mathrm{m}} + \varepsilon_{jt}$
- Bottom 60% account for all of aggregate response

Supporting Evidence From Daily Stock Prices

Dependent variable: $\frac{\Delta p_{it}}{p_{it-1}}$

	(1)	(2)	(3)	(4)
leverage × ffr shock	-0.87***	-0.82**	-0.61	-0.61***
	(0.29)	(0.35)	(0.41)	(0.16)
ffr shock			2.49**	2.49***
			(1.13)	(0.18)
Observations	39232	36915	36915	36915
R^2	0.114	0.112	0.029	0.029
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

$$\frac{\Delta p_{it}}{p_{it-1}} = \beta x_{it-1}\varepsilon_t^{\mathrm{m}} + \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it-1} + \varepsilon_{it}$$

Robustness of Main Result

1. Monetary shocks
    - Interaction with other cyclical variables ▸ Details
    - Instrument real rate with high-frequency shocks ▸ Details
    - Same results post 1994 ▸ Details
    - Alternative time aggregation ▸ Details

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▸ Other Robustness

Heterogeneous Firm New Keynesian Model

Model Overview

1. Heterogeneous production firms
    - Produce and invest subject to financial frictions
    - Financial intermediary lends resources from household to firms

2. New Keynesian block
    - Retailers differentiate production firms' output + Calvo sticky prices
    - Final good producer combines retailers goods into final output
    - Monetary authority follows Taylor rule

3. Representative household
    - Owns firms + labor-leisure choice + complete markets

Production Firms

Enter period with state variables z_{jt}, k_{jt}, and b_{jt}

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2. Production: $y_{jt} = z_{jt} k_{jt}^{\theta} n_{jt}^{\nu}, \theta + \nu < 1$ at price p_t
   - $\log z_{jt+1} = \rho_z \log z_{jt} + \varepsilon_{jt+1}^{z}, \varepsilon_{jt+1}^{z} \sim N(0, \sigma_z^2)$

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3. Exogeneous exit: w/ i.i.d. prob π_d, forced to exit

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3. Exogeneous exit: w/ i.i.d. prob π_d, forced to exit
4. Investment: choose $k_{jt+1} = (1-\delta)k_{jt} + i_{jt}$ and financing b_{jt+1}, d_{jt}
   - Debt finance at price $\mathcal{Q}_t(z, k', b')$
   - Equity finance subject to $d_{jt} \geq 0$

Production Firms

$$v_t^0(z,k,b) = \max\{0, \pi_d v_t^{\text{exit}}(z,k,b) + (1-\pi_d) v_t^{\text{cont}}(z,k,b)\}$$

Production Firms

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$$v_t^{\text{exit}}(z,k,b) = \max_n p_t z k^\theta n^\nu - w_t n + (1-\delta)k - b - \xi$$

$$\begin{aligned} v_t^{\text{cont}}(z,k,b) = & \max_{n,k',b'} p_t z k^\theta n^\nu - w_t n + (1-\delta)k - b - \xi - k' \\ & + \mathcal{Q}_t(z,k',b')b' + \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} v_{t+1}^0(z',k',b') \right] \\ & \text{such that } d \geq 0 \end{aligned}$$

Financial Intermediary and New Entrants

- Financial intermediary lends from households to firms
  - If firm defaults, can recover up to αk_{jt+1}, $\alpha =$ recovery rate

$$\mathcal{Q}_t(z, k', b') = \beta \mathbb{E}_t[\frac{\lambda_{t+1}}{\lambda_t}(1 - \text{Prob}(v^0_{t+1}(z', k', b') = 0) \times (1 - \min\{1, \alpha \frac{k'}{b'}\}))]$$

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- Each period, constant mass π_e of new entrants
  1. Draw productivity $z_{j,t}$ from ergodic distribution
  2. Endowed with k_0 and b_0

$\implies v^0_t(z_{j,t}, k_0, b_0)$

Retailers and Final Good Producer

- Monopolistically competitive retailers
  - Technology: $\tilde{y}_{it} = y_{it} \implies$ real marginal cost $= p_t$
  - Can reset price $\tilde{p}_{it}$ w/ i.i.d. probability $1 - \varphi$

- Perfectly competitive final good producer

$$Y_t = \left(\int \tilde{y}_{it}^{\frac{\gamma-1}{\gamma}} di \right)^{\frac{\gamma}{\gamma-1}} \implies P_t = \left(\int \tilde{p}_{it}^{1-\gamma} di \right)^{\frac{1}{1-\gamma}} = \text{ numeraire}$$

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- Implies New Keynesian Phillips Curve

$$\pi_t \approx \kappa Y_t p_t + \beta \varphi \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1} \right]$$

Monetary Authority and Household

- Monetary authority follows Taylor rule

$$\log R_t^{\text{nom}} = \log \frac{1}{\beta} + \varphi_\pi \log(1 + \pi_t) + \varepsilon_t^{\text{m}}$$

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$$\log R_t^{\text{nom}} = \log \frac{1}{\beta} + \varphi_\pi \log(1 + \pi_t) + \varepsilon_t^{\text{m}}$$

- Representative household with preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\log C_t - \Psi N_t \right)$$

  - Labor-leisure choice $\implies w_t C_t^{-1} = \Psi$
  - Complete markets $\implies \lambda_t = C_t^{-1}$

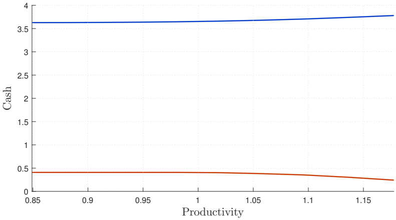
Equilibrium

An equilibrium of this model satisfies

1. Production firms choose investment $k'_t(z, k, b)$, financing $b'_t(z, k, b)$, and default decision
2. Financial intermediaries price default risk $\mathcal{Q}_t(z, k', b')$
3. Retailers and final good producers generate NK Phillips Curve
4. Monetary authority follows Taylor rule
   $\log R_t^{\text{nom}} = \log \frac{1}{\beta} + \varphi_\pi \log(1 + \pi_t) + \varepsilon_t^{\text{m}}$
5. Household chooses labor supply N_t and generates SDF w/ λ_t

Channels of Investment Response to Monetary Policy

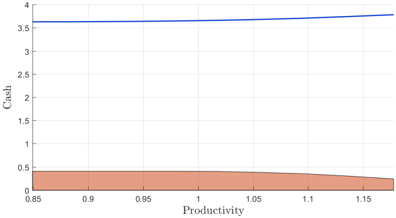
Individual Firm Decisions



- Collapse individual state variables (k, b) into cash-on-hand

$$x = \max_{n} p_t z k^{\theta} n^{\nu} - w_t n + (1 - \delta)k - b - \xi$$

Individual Firm Decisions

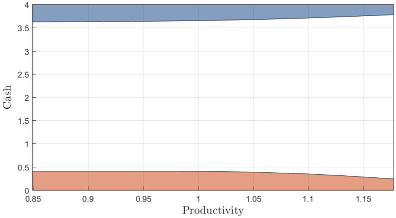


- Default if no feasible choice (k', b') such that

$$d = x - k' + \mathcal{Q}_t(z, k', b')b' \geq 0$$

- Default if $x < \underline{x}_t(z)$

Individual Firm Decisions

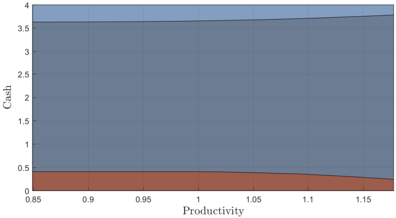


- Unconstrained if can follow $k_t^*(z)$ for all $t \geq 0$ without default risk

$$k' = k_t^*(z) \qquad b' \text{ and } d \text{ indeterminate}$$

- Unconstrained if $x > \overline{x}_t(z)$

Individual Firm Decisions



- For $x \in [\underline{x}_t(z), \overline{x}_t(z)]$, firms are constrained

$$k' = x + \mathcal{Q}_t(z, k', b')b'$$

Debt Price Schedule

Policy Rules

Unconstrained Firms' Response to Monetary Policy

$$k' = \left(\frac{p_{t+1}^{\frac{1}{1-\nu}} w_{t+1}^{-\frac{\nu}{1-\nu}} \mathbb{E}\left[(z')^{\frac{1}{1-\nu}} | z \right]}{R_t - (1-\delta)} \right)^{\frac{1}{1-\theta}}$$

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Investment responds purely through intertemporal channel

$$\frac{\mathrm{d}\log k'}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} = \underbrace{-\frac{1}{1-\theta}\frac{R_t}{R_t-(1-\delta)}\frac{\mathrm{d}\log R_t}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}}_{\text{direct intertemporal substitution}}$$
$$+ \underbrace{\frac{1}{(1-\theta)(1-\nu)}\left(\frac{\mathrm{d}\log p_{t+1}}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} - \nu\frac{\mathrm{d}\log w_{t+1}}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}\right)}_{\text{indirect general equilibrium effects}}$$

Constrained Firms' Response to Monetary Policy

$$k' = x + \mathcal{Q}_t(z, k', b')b'$$

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1. Investment responds through mix of cash flow and borrowing channels

$$\frac{\mathrm{d}\log k'}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} = \underbrace{\frac{\mathrm{d}\log x}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}\frac{x}{k'}}_{\text{cash flow}} + \underbrace{\frac{\mathrm{d}\log \mathcal{Q}_t(z, k', b')b'}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}\frac{q_t(z, k', b')b'}{k'}}_{\text{borrowing}}$$

2. Portfolio choice (k', b') endogenous

Characterizing Constrained Firms' Investment Response

Simplifying assumptions:

1. Labor coefficient $\nu = 0 \implies$ no labor (just to simplify expressions)
2. Recovery rate $\alpha \to -\infty \implies$ all debt is risk-free
3. Firms borrow up to limit $b' = \frac{1}{R_t}\left[p_{t+1}\underline{z}(k')^{\theta} + (1-\delta)k' - \xi\right]$

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$$\frac{d\log k'}{d\varepsilon_t^m} = \frac{1}{u_t(k')k'}\left(\underbrace{p_t z k^{\theta}\frac{d\log p_t}{d\varepsilon_t^m}}_{\text{cash flow}} - \underbrace{\frac{d\log R_t}{d\varepsilon_t^m}\frac{b'}{R_t} + \frac{1}{R_t}\left[p_{t+1}\underline{z}(k')^{\theta}\frac{d\log p_{t+1}}{d\varepsilon_t^m} + \frac{d\log M_{t+1}}{d\varepsilon_t^m}\right]}_{\text{borrowing}}\right)$$

where $u_t(k') \equiv 1 - \frac{1}{R_t}\left(p_{t+1}z'\theta(k')^{\theta-1} + (1-\delta)\right)$

Heterogeneity in Investment Semi-Elasticities

1. Low-leverage firms more likely to be unconstrained
   - More responsive if intertemporal channel dominates

2. Exposure to cash flow and borrowing channels varies with capital
   - Firms with more capital are more exposed to cash flow channel
   - Firms with more debt are exposed to borrowing channel

3. Constrained firms can also use resources to pay down debt

Quantitative Analysis

Fixed Parameters

Parameter	Description	Value
Household		
β	Discount rate	0.99
Firms		
θ	Labor coefficient	0.64
ν	Capital coefficient	0.21
δ	Depreciation	0.03
b_0	Initial debt	0
New Keynesian Block		
γ	Demand elasticity	10
φ_π	Taylor rule coefficient	1.25
φ	Prob keep price	0.25

Parameters to be Computed

Parameter	Description	Value
Productivity process		
ρ_z	Persistence	
σ_z	SD of innovations	
Financial frictions		
ξ	Operating cost	
α	Loan recovery rate	
Firm lifecycle		
k_0	Initial capital	
π_d	Exogeneous exit rate	

Choose labor disutility Ψ to ensure steady state employment = 0.6

Choose entry rate π_e to ensure steady state mass of firms = 1

Empirical Targets

- Investment: balanced panel from LRD (Cooper and Haltiwanger 2006)

Moment	Description	Data	Model
$\mathbb{E}\left[\frac{i}{k}\right]$	Mean investment rate (annual)	12.2%	
$\sigma\left(\frac{i}{k}\right)$	SD investment rate (annual)	33.7%	

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- Financial: aggregate data (Bernanke, Gertler, and Gilchrist 1999)

Moment	Description	Data	Model
$\mathbb{E}$ [default rate]	Mean default rate (annual)	3%	
$\frac{B}{K}$	Agg debt to capital ratio	50%	

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- Entry and exit: business dynamics statistics (Khan, Senga, and Thomas 2016)

Moment	Description	Data	Model
$\mathbb{E}$ [exit rate]	Mean exit rate (annual)	10%	
$k_0/\mathbb{E}[k-b]$	Avg size of new entrants	28.5%	

Empirical Targets

- Investment: balanced panel from LRD (Cooper and Haltiwanger 2006)

Moment	Description	Data	Model
$\mathbb{E}\left[\frac{i}{k}\right]$	Mean investment rate (annual)	12.2%	9.8%
$\sigma\left(\frac{i}{k}\right)$	SD investment rate (annual)	33.7%	32.0%

- Financial: aggregate data (Bernanke, Gertler, and Gilchrist 1999)

Moment	Description	Data	Model
$\mathbb{E}$ [default rate]	Mean default rate (annual)	3%	3.01%
$\frac{B}{K}$	Agg debt to capital ratio	50%	52%

- Entry and exit: business dynamics statistics (Khan, Senga, and Thomas 2016)

Moment	Description	Data	Model
$\mathbb{E}$ [exit rate]	Mean exit rate (annual)	10%	10.1%
$k_0/\mathbb{E}[k-b]$	Avg size of new entrants	28.5%	20.7%

Parameters to be Computed

Parameter	Description	Value
Productivity process		
ρ_z	Persistence	0.9
σ_z	SD of innovations	0.0285
Financial frictions		
ξ	Operating cost	0.0748
α	Loan recovery rate	0.16
Firm lifecycle		
k_0	Initial capital	0.412
π_d	Exogeneous exit rate	0.0215

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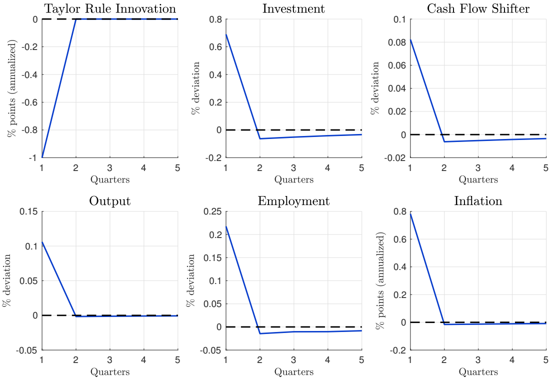
Choose entry rate π_e to ensure steady state mass of firms = 1

Lesson 1: Unconstrained Firms Drive Aggregate Response



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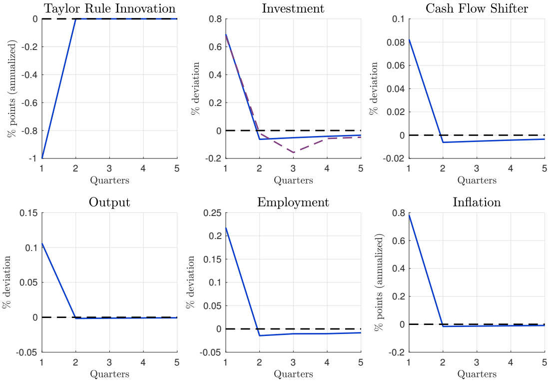

- Unconstrained firms accounts for almost all aggregate response

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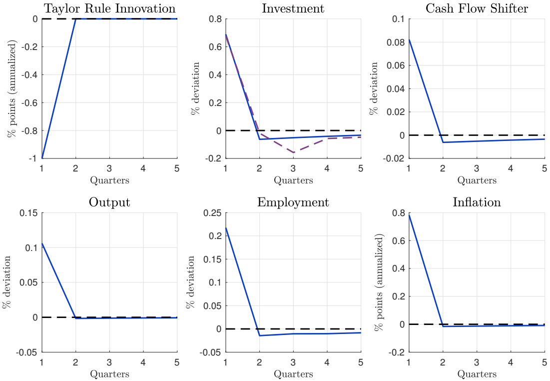
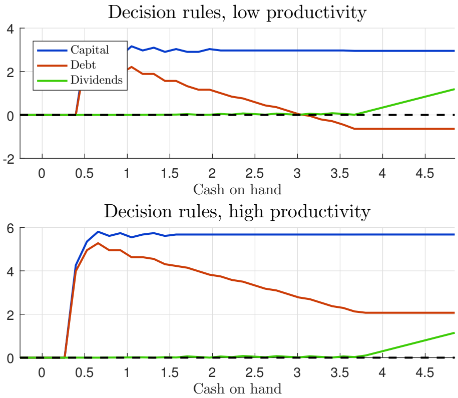
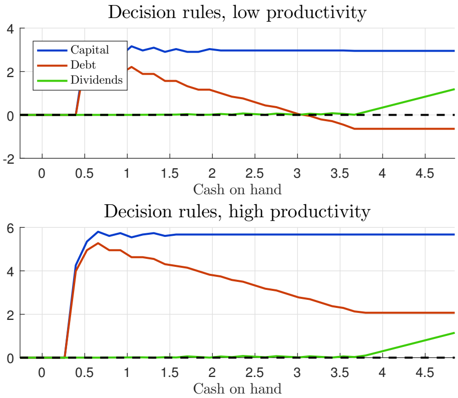


- Unconstrained firms accounts for almost all aggregate response
  1. Low-leverage firms more likely to be unconstrained
  2. In data, low-leverage firms account for all aggregate response

Constrained Firms Use Additional Cash to Pay Down Debt

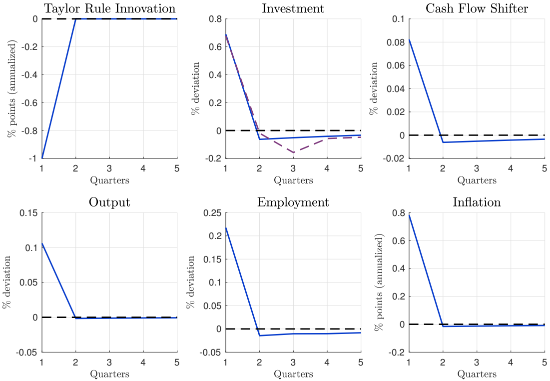


Constrained Firms Use Additional Cash to Pay Down Debt



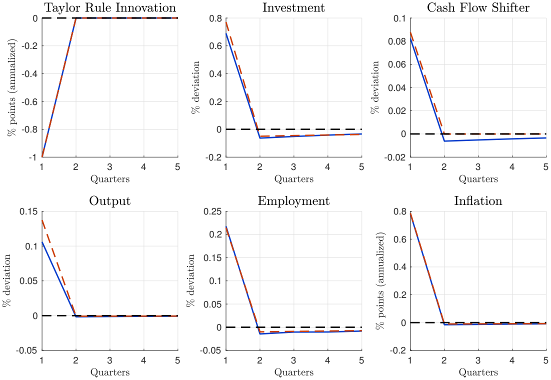
- Some empirical support ▸ Empirical Evidence
  - High-leverage firms decrease debt after monetary shock

Lesson 1: Unconstrained Firms Drive Aggregate Response



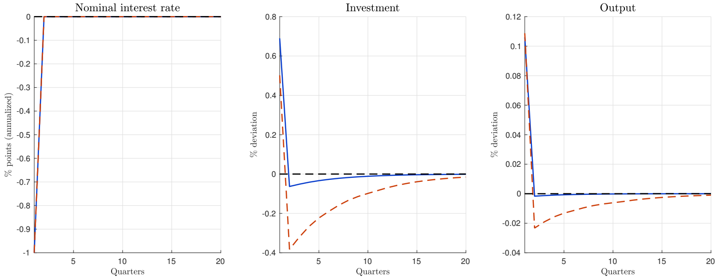
- Unconstrained firms accounts for almost all aggregate response
  1. Low-leverage firms more likely to be unconstrained
  2. In data, low-leverage firms account for all aggregate response

Lesson 1: Unconstrained Firms Drive Aggregate Response



- Aggregates quantitative similar to rep firm model

Lesson 2: Aggregate Effects Depends on Initial Distribution



- Effect after $\varepsilon^{m}_{-1} = -0.0075$ vs. steady state

  $\rightarrow$ Keep your powder dry until you need it

Conclusion

Financial Heterogeneity and Monetary Policy

1. Descriptive empirical evidence
   - Firms with low leverage are more responsive to shocks

2. Heterogeneous firm New Keynesian model
   - Stimulates through mostly through unconstrained firms
   - Aggregate effect depends on distribution of net worth

Appendix

Data Appendix: Descriptive Statistics

Monetary Shocks ▸ Back

	high frequency	smoothed	sum
mean	-0.0209	-0.0481	-0.0477
median	0	-0.0124	-0.00536
std	0.0906	0.111	0.132
min	-0.463	-0.480	-0.479
max	0.152	0.235	0.261
num	183	79	80

Pass-Through to Interest Rates ▸ Back

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ffr shock	2.22***	2.03***	2.18***	1.99***	2.14***	1.64***	1.63***	1.29***
	(0.31)	(0.31)	(0.35)	(0.28)	(0.35)	(0.37)	(0.32)	(0.32)
GDP Growth		3.27*				2.92		3.02*
		(1.94)				(1.78)		(1.61)
CPI Inflation			-1.46			1.08		-1.72
			(3.47)			(3.75)		(3.59)
VIX				-0.02***		-0.03***		-0.01***
				(0.01)		(0.01)		(0.01)
Unemployment Rate					-7.41*	-12.79***		-2.99
					(3.87)	(4.24)		(4.16)
L.ΔR_t							0.53***	0.45***
							(0.10)	(0.11)
Constant	0.03	-0.07	0.07	0.43***	0.43*	1.12***	0.03	0.41
	(0.04)	(0.08)	(0.10)	(0.13)	(0.22)	(0.33)	(0.03)	(0.29)
Observations	71	71	71	71	71	71	70	70
R^2	0.378	0.398	0.379	0.453	0.404	0.536	0.615	0.662

Summary Statistics

▸ Data ▸ Intro

Statistic	$\Delta \log K$	$\mathbb{I}\{\frac{i_{j,s,t}}{k_{j,s,t}} > \iota\}$	$\texttt{leverage}_{jt}$
Average	0.004	0.732	0.267
Median	-0.004	1.000	0.204
Std	0.093	0.443	0.364
Bottom 5%	-0.089	0.000	0.000
Top 5%	0.130	1.000	0.726

Summary Statistics: Balance-Sheet Components

	mean
Current Assets	53.2
Capital	40.6
Other Assets	6.29
Liabilities	57.1
Short Term Debt	7.42
Long Term Debt	19
Other Liabilities ST	22.9
Other Liabilities LT	7.78
Equity	42.9

Note: in percent of total assets.

Summary Statistics: Financial Heterogeneity and Balance Sheet Components

	Low Leverage	High Leverage	All
Current Assets	61.6	44.8	53.2
Capital	33.3	47.8	40.6
Other Assets	5.18	7.4	6.29
Liabilities	36.6	77.6	57.1
Short Term Debt	2.16	12.7	7.42
Long Term Debt	4.24	33.7	19
Other Liabilities ST	22.7	23.1	22.9
Other Liabilities LT	7.46	8.11	7.78
Equity	63.4	22.4	42.9

Note: in percent of total assets.

Summary Statistics: Financial Heterogeneity and Investment

	Low Leverage	High Leverage	All
$\Delta logK$	.937	.0074	.43
$\mathbb{I}\left\{\frac{i_{jt}}{k_{jt}} > \iota\right\}$	.74	.725	.732

Summary Statistics: Financial Heterogeneity and Other Firm Characteristics

	Low Leverage	High Leverage	All
Sales Growth	1.34	.725	1.03
Total Assets	1388	2469	1928

Data Appendix: Figures

Firm Heterogeneity: Leverage

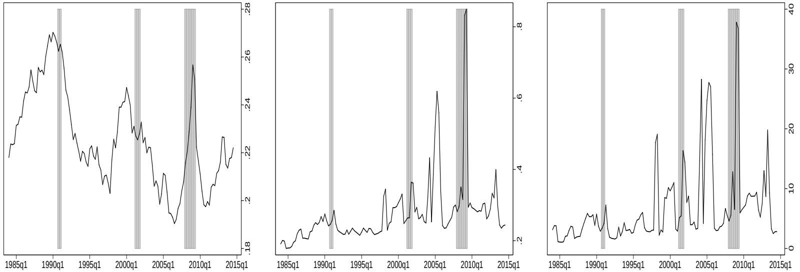


Figure: Mean, SD, Skewness

Back

Firm Heterogeneity: Net Leverage

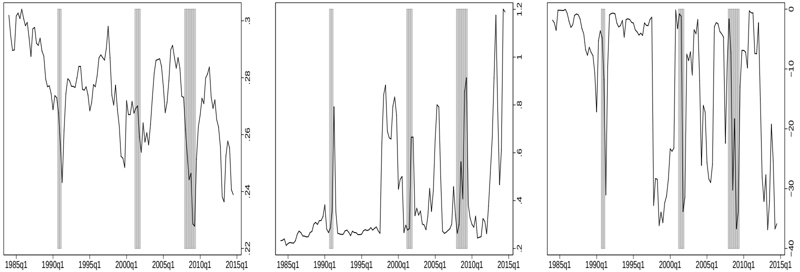


Figure: Mean, SD, Skewness

Firm Heterogeneity: Investment

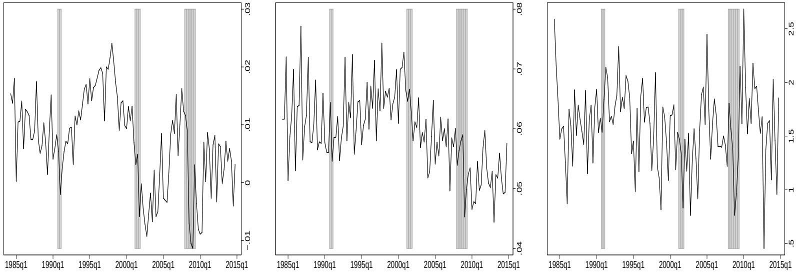


Figure: Mean, SD, Skewness

Seasonally adjusted at industry level.

Back

Firm Heterogeneity:
Investment – Extensive Margin

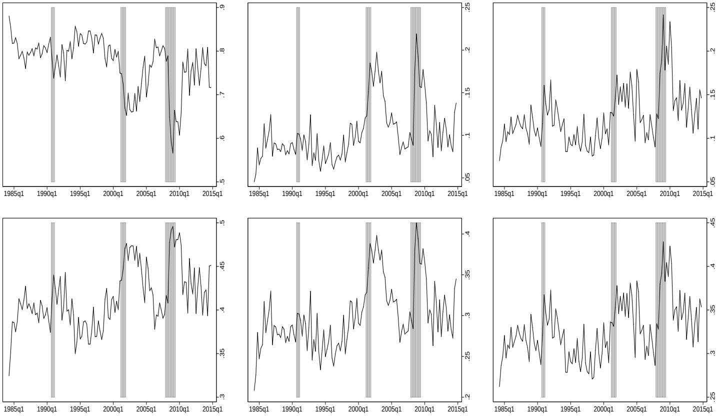


Figure: Mean Positive, Negative, Inaction

Cross-sectional Moments
Real Sales Growth

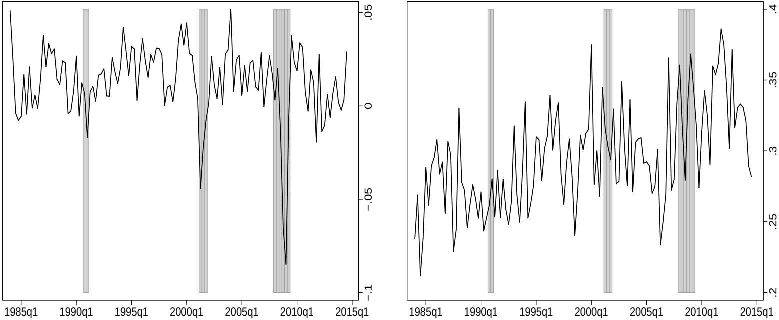


Figure: Mean, SD

Seasonally adjusted at industry level.

Cross-sectional Moments
Size

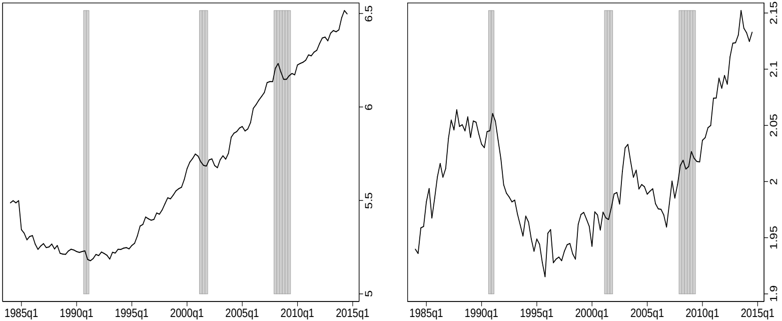


Figure: Mean, SD

Cross-sectional Moments
Real Sales Growth

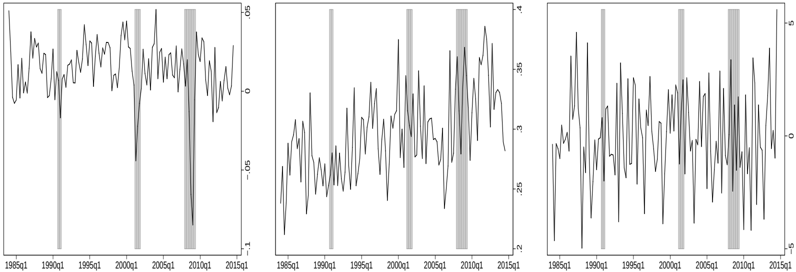


Figure: Mean, SD, Skewness

Seasonally adjusted at industry level.

Cross-sectional Moments
Size

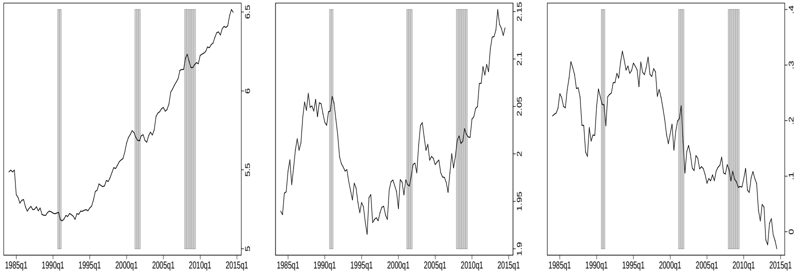


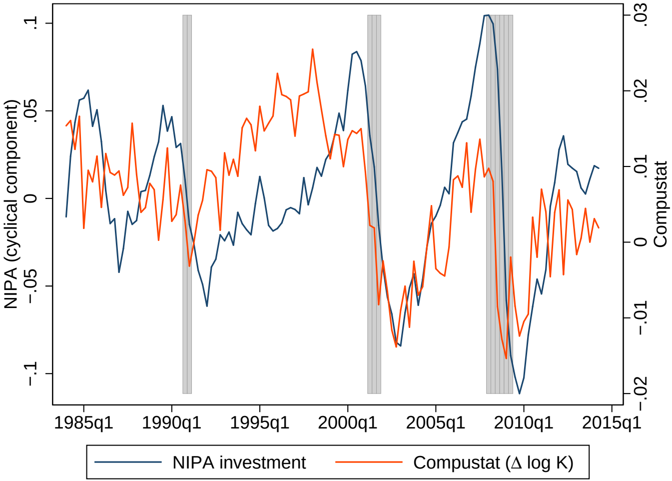
Figure: Mean, SD, Skewness

Constructing Investment

1. Start with firms' reported level of plant, property, and equipment (`ppegtq`) as firms' initial value of capital
2. Compute differences of net plant, property, and equipment (`ppentq`) to get net investment
3. Interpolate missing values when missing a single quarter in the data
4. Compute capital using perpetual inventory method
5. Compute gross investment using depreciation rates of Fixed Asset tables from NIPA at the industry level
6. Trim the data: extreme values and short spells

▸ Data

Investment: Compustat and NIPA



Back

Sectoral Controls

Sectors considered:

1. Agriculture, Forestry, And Fishing: $\texttt{sic} < 10$
2. Mining: $\texttt{sic} \in [10, 14]$
3. Construction: $\texttt{sic} \in [15, 17]$
4. Manufacturing: $\texttt{sic} \in [20, 39]$
5. Transportation, Communications, Electric, Gas, And Sanitary Services: $\texttt{sic} \in [40, 49]$
6. Wholesale Trade: $\texttt{sic} \in [50, 51]$
7. Retail Trade: $\texttt{sic} \in [52, 59]$
8. Services: $\texttt{sic} \in [70, 89]$

Sectors not considered:

1. Finance, Insurance, and Real Estate: $\texttt{sic} \in [60, 67]$
2. Public Administration: $\texttt{sic} \in [91, 97]$

Back

Firm-Level Heterogeneity Variables

1. Leverage: Ratio of total debt (`dlcq`+`dlttq`) to total assets (`atq`).
2. Net leverage: Subtract current assets (`actq`) net of other current liabilities (`lctq`) from debt liabilities to total assets .
    - Current assets consists of cash and other assets expected to be realized in cash within the next 12 months.
    - Current liabilities are those due within one year.

▸ Data

Firm-Level Heterogeneity Variables

1. Real Sales Growth: log-differences in sales (`saleq`) deflated using CPI.
2. Size: Log of total assets.

▸ Data

Data Appendix: Regressions

Leverage and Firm Level Characteristics ▸ Back

	(1)	(2)	(3)	(4)
leverage $(t-1)$	1.01***	1.01***	1.01***	1.01***
	(0.06)	(0.07)	(0.06)	(0.07)
sales growth $(t-1)$	-0.01**	-0.02***	-0.01*	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
size $(t-1)$	-0.01*	-0.01**	-0.01*	-0.01**
	(0.01)	(0.00)	(0.01)	(0.00)
share current assets $(t-1)$	0.00	0.00	0.00	0.00
	(0.04)	(0.04)	(0.04)	(0.04)
investment $(t-1)$	0.00	0.01	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
sales growth (t)		-0.04**		-0.04**
		(0.02)		(0.02)
investment (t)			-0.03*	-0.02*
			(0.02)	(0.01)
Observations	290854	289961	290854	289961
R^2	0.504	0.512	0.504	0.512
Firm controls	yes	yes	yes	yes
Time sector FE	yes	yes	yes	yes
Time clustering	yes	yes	yes	yes

Leverage and Firm Level Characteristics

Back

	(1)	(2)	(3)	(4)
sales growth $(t-1)$	-0.01*	-0.02***	-0.01*	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
size $(t-1)$	-0.01*	-0.01	-0.01*	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
share current assets $(t-1)$	-0.00	-0.00	-0.00	0.00
	(0.01)	(0.01)	(0.02)	(0.02)
investment $(t-1)$	0.00	0.01	0.00	0.01
	(0.00)	(0.00)	(0.00)	(0.01)
sales growth (t)		-0.04**		-0.04**
		(0.02)		(0.02)
investment (t)			-0.03	-0.02
			(0.02)	(0.02)
Observations	290854	289961	290854	289961
R^2	0.061	0.063	0.061	0.063
Firm controls	yes	yes	yes	yes
Time sector FE	yes	yes	yes	yes
Time clustering	yes	yes	yes	yes

Extensive Margin Measure of Investment

Back

Dependent variable: $\mathbb{1}\{\frac{i_{it}}{k_{it}} \geq 1\%\}$				
	(1)	(2)	(3)	(4)
leverage × ffr shock	-5.22***	-4.80***	-4.59***	-4.59***
	(1.25)	(1.11)	(1.19)	(0.87)
ffr shock			4.01	4.01***
			(4.41)	(0.87)
Observations	233232	233232	233232	233232
R^2	0.213	0.217	0.204	0.204
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

$$\mathbb{1}\{\frac{i_{it}}{k_{it}} \geq 1\%\} = \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it-1} + \beta x_{it-1}\varepsilon_t^m + \varepsilon_{it}$$

Expansionary vs. Contractionary Shocks Back

Dependent variable: $\Delta \log k_{it+1}$	(1)	(2)
leverage × ffr shock	-0.73**	
	(0.29)	
leverage × pos ffr shock		-0.90**
		(0.37)
leverage × neg ffr shock		0.05
		(0.75)
Observations	233232	233232
R^2	0.119	0.119
Firm controls	yes	yes

Expansionary vs. Contractionary Shocks ▸ Back

Dependent variable: $\mathbb{1}\{\frac{i_{it}}{k_{it}} > 1\%\}$		
	(1)	(2)
leverage × ffr shock	-4.80***	
	(1.11)	
leverage × pos ffr shock		-5.48***
		(1.36)
leverage × neg ffr shock		-1.86
		(3.28)
Observations	233232	233232
R^2	0.217	0.217
Firm controls	yes	yes

Target vs. Path Decomposition ▸ Back

Dependent variable: $\Delta \log k_{it+1}$	(1)	(2)
leverage × ffr shock	-0.73**	
	(0.29)	
leverage × target shock		-1.01***
		(0.37)
leverage × path shock		1.35
		(1.20)
Observations	233232	227652
R^2	0.119	0.121

$$\Delta \log k_{it+1} = \alpha_i + \alpha_{s,t} + \mathbf{\Gamma}' Z_{it-1} + \beta_1 x_{it-1} \varepsilon_t^{m,\text{target}} + \beta_2 x_{it-1} \varepsilon_t^{m,\text{path}} + \varepsilon_{it}$$

$\varepsilon_t^{m,\text{target}}$ and $\varepsilon_t^{m,\text{path}}$ following Gurkanyak, Sack, and Swanson (2005)

▸ Post-1994 ▸ Expansionary vs. Contractionary Shocks

Decomposition by Leverage ▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)	(3)	(4)
ST debt × ffr shock	-0.54**		-0.58**	
	(0.25)		(0.25)	
LT debt × ffr shock		-0.38	-0.43	
		(0.27)	(0.28)	
leverage × ffr shock				-0.70**
				(0.29)
other liab × ffr shock				-1.39
				(1.04)
Observations	233232	233232	233232	233211
R^2	0.118	0.117	0.119	0.119
Firm controls	yes	yes	yes	yes

▸ Decomposition with Extensive Margin investment

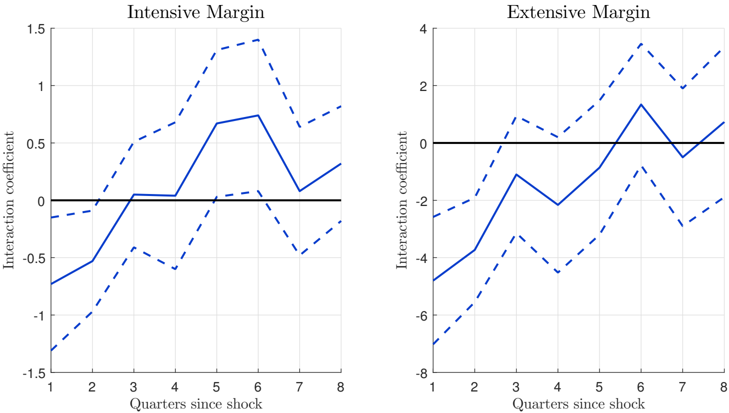
Net Leverage ▸ Back

	(1)	(2)	(3)	(4)
net leverage × ffr shock	-0.89**	-0.68**	-0.61*	-0.61***
	(0.40)	(0.33)	(0.33)	(0.19)
ffr shock			1.37	1.37***
			(0.99)	(0.20)
Observations	233232	233232	233232	233232
R^2	0.112	0.119	0.104	0.104
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

$$\Delta \log k_{it+1} = \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it-1} + \beta x_{it-1} \varepsilon_t^m + \varepsilon_{it}$$

Dynamics of Differences Short-Lived

Back



$$\Delta \log k_{it+j} = \alpha_i^j + \alpha_{st}^j + \Gamma^{j\prime} Z_{it-1} + \beta_j x_{it-1} \varepsilon_t^m + \varepsilon_{it}$$

Pass-Through to Other Rates

Back

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ffr shock	2.22***	2.03***	2.18***	1.99***	2.14***	1.64***	1.63***	1.29***
	(0.31)	(0.31)	(0.35)	(0.28)	(0.35)	(0.37)	(0.32)	(0.32)
GDP Growth		3.27*				2.92		3.02*
		(1.94)				(1.78)		(1.61)
CPI Inflation			-1.46			1.08		-1.72
			(3.47)			(3.75)		(3.59)
VIX				-0.02***		-0.03***		-0.01***
				(0.01)		(0.01)		(0.01)
Unemployment Rate					-7.41*	-12.79***		-2.99
					(3.87)	(4.24)		(4.16)
L.ΔR_t							0.53***	0.45***
							(0.10)	(0.11)
Constant	0.03	-0.07	0.07	0.43***	0.43*	1.12***	0.03	0.41
	(0.04)	(0.08)	(0.10)	(0.13)	(0.22)	(0.33)	(0.03)	(0.29)
Observations	71	71	71	71	71	71	70	70
R^2	0.378	0.398	0.379	0.453	0.404	0.536	0.615	0.662

Results Post-1994

Back

Dependent variable: $\Delta \log k_{it+1}$				
	(1)	(2)	(3)	(4)
leverage × ffr shock	-0.52	-0.56	-0.66	-0.66**
	(0.49)	(0.44)	(0.45)	(0.26)
ffr shock			-0.05	-0.05
			(1.54)	(0.29)
Observations	185805	185805	185805	185805
R^2	0.120	0.131	0.116	0.116
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

Results Post-1994 ▸ Back

Dependent variable: $\mathbb{1}\{\frac{i_{it}}{k_{it}} > 1\%\}$

	(1)	(2)	(3)	(4)
leverage × ffr shock	-2.59	-2.51	-2.63	-2.63**
	(1.95)	(1.79)	(1.97)	(1.12)
leverage	-0.02***	-0.02***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
ffr shock			-2.85	-2.85**
			(6.34)	(1.26)
Observations	185805	185805	185805	185805
R^2	0.229	0.234	0.219	0.219
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

Robustness: Interaction with Cyclical Variables

Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)	(3)	(4)	(5)
leverage × ffr shock	-0.81***	-0.72**	-0.73**	-0.87***	-0.95***
	(0.29)	(0.28)	(0.29)	(0.29)	(0.30)
leverage × dlog gdp	-0.05				-0.06
	(0.08)				(0.07)
leverage × dlog cpi		-0.07			-0.07
		(0.09)			(0.09)
leverage × ur			0.00		0.00
			(0.00)		(0.00)
leverage × vix				0.00*	0.00*
				(0.00)	(0.00)
Observations	233232	233232	233232	233232	233232
R^2	0.119	0.119	0.119	0.119	0.119
Firm controls	yes	yes	yes	yes	yes

Robustness: Interaction with Cyclical Variables ‣ Back

Dependent variable: $\mathbb{1}\{\frac{i_{it}}{k_{it}} > \iota\}$

	(1)	(2)	(3)	(4)	(5)
leverage × ffr shock	-4.86***	-4.73***	-4.77***	-5.26***	-5.17***
	(1.19)	(1.08)	(1.11)	(1.10)	(1.15)
leverage × dlog gdp	-0.04				-0.11
	(0.29)				(0.28)
leverage × dlog cpi		-0.54			-0.56
		(0.41)			(0.43)
leverage × ur			-0.00		-0.00
			(0.00)		(0.00)
leverage × vix				0.00	0.00
				(0.00)	(0.00)
Observations	233232	233232	233232	233232	233232
R^2	0.217	0.217	0.217	0.217	0.217
Firm controls	yes	yes	yes	yes	yes

Robustness: Interaction with Firm-Level Variables

▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)	(3)	(4)	(5)
leverage × ffr shock	-0.73**		-0.73**		-0.72**
	(0.29)		(0.28)		(0.29)
sales growth × ffr shock		-0.06	-0.07		
		(0.26)	(0.26)		
size × ffr shock				0.35	0.38
				(0.27)	(0.26)
Observations	233232	233232	233232	233232	233232
R^2	0.119	0.117	0.119	0.117	0.119
Firm controls	yes	yes	yes	yes	yes
Time sector FE	yes	yes	yes	yes	yes
Time clustering	yes	yes	yes	yes	yes

$$\Delta \log k_{it+1} = \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it} + \beta y_{it-1} \varepsilon_t^m + \varepsilon_{it}$$

Robustness: Instrument Leverage

Back

	(1)	(2)
leverage × ffr shock	-0.66**	-2.31**
	(0.32)	(0.94)
Observations	225753	216928
R^2		
Firm controls, Time-Sector FE	yes	yes
Instrument	4q lag	8q lag

Robustness: Instrument Leverage ▸ Back

First Stage

	(1)	(2)
L4 leverage × ffr shock	3.05***	
	(0.54)	
L8 leverage × ffr shock		0.84**
		(0.35)
Observations	225687	216845
R^2	0.516	0.245
Firm controls, Time-Sector FE	yes	yes
Instrument	4q lag	8q lag

Robustness: Instrument Real Rate ▸ Back

	(1)	(2)
leverage × ffr	-0.33***	-0.26***
	(0.07)	(0.07)
Observations	233232	233232
R^2		
Firm controls	no	yes

Robustness: Alternative Time Aggregation ▸ Back

	(1)	(2)	(3)	(4)
leverage × ffr shock (sum)	-0.89***	-0.79***	-0.79***	-0.79***
	(0.33)	(0.28)	(0.29)	(0.17)
ffr shock (sum)			1.02	1.02***
			(0.82)	(0.18)
Observations	236296	236296	236296	236296
R^2	0.106	0.118	0.103	0.103
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

$$\Delta \log k_{it+1} = \alpha_i + \alpha_{st} + \mathbf{\Gamma}' Z_{it-1} + \beta x_{it-1} \varepsilon_t^{\text{m}} + \varepsilon_{it}$$

Path vs. Target Decomposition After 1994 ▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)	(3)
leverage × ffr shock	-0.56		
	(0.44)		
leverage × target shock		-1.01	-1.00*
		(0.61)	(0.54)
leverage × path shock		1.58	1.67
		(1.47)	(1.29)
Observations	185805	180225	180225
R^2	0.131	0.123	0.134
Firm controls	yes	no	yes

Path vs. Target Decomposition After 1994 ▸ Back

Dependent variable: $\mathbb{1}\{\frac{i_{i,t}}{k_{i,t}} > 1\%\}$

	(1)	(2)	(3)
leverage × ffr shock	-2.51		
	(1.79)		
leverage × target shock		-4.99*	-4.72*
		(2.55)	(2.38)
leverage × path shock		3.61	3.36
		(5.28)	(4.95)
Observations	185805	180225	180225
R^2	0.234	0.231	0.236
Firm controls	yes	no	yes

Path vs. Target Decomposition for Expansionary and Contractionary Shocks ▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)	(3)	(4)
leverage × ffr shock	-0.73**			
	(0.29)			
leverage × pos ffr shock		-0.90**		
		(0.37)		
leverage × neg ffr shock		0.05		
		(0.75)		
leverage × target shock			-1.01***	
			(0.37)	
leverage × path shock			1.35	
			(1.20)	
leverage × pos target shock				-1.10*
				(0.57)
leverage × pos path shock				2.21
				(2.04)
leverage × neg target shock				-0.93
				(0.95)
leverage × neg path shock				0.21
				(2.50)
Observations	233232	233232	227652	227652
R^2	0.119	0.119	0.121	0.121
Firm controls	yes	yes	yes	yes

Romer and Romer Shocks ▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)	(3)
leverage × ffr shock	0.73^{**}		
	(0.29)		
leverage × RR shock		0.00	-0.08
		(0.11)	(0.12)
Observations	233232	297094	213955
R^2	0.119	0.108	0.125
Firm controls	yes	yes	yes
Sum rr shocks			-0.74
p-value			0.00

Romer and Romer Shocks ▸ Back

Dependent variable: $\mathbb{I}\{\frac{i_{it}}{k_{it}} > \iota\}$			
	(1)	(2)	(3)
leverage × ffr shock	4.80***		
	(1.11)		
leverage × RR shock		-0.08	-0.37
		(0.42)	(0.51)
Observations	233232	297094	213955
R^2	0.217	0.200	0.228
Firm controls	yes	yes	yes
Sum rr shocks			-2.39
p-value			0.00

Inventory Investment

	(1)	(2)	(3)	(4)
leverage × ffr shock	-1.08	-0.89	-0.76	-0.76
	(1.02)	(0.96)	(0.94)	(0.65)
ffr shock			-1.55	-1.55***
			(1.34)	(0.60)
Observations	193557	193557	193557	193557
R^2	0.059	0.060	0.053	0.053
Firm controls	no	yes	yes	yes
Time sector FE	yes	yes	no	no
Time clustering	yes	yes	yes	no

$$\Delta \log \mathtt{inventories}_{it+1} = \alpha_i + \alpha_{s,t} + \mathbf{\Gamma}' Z_{it} + \beta x_{it-1} \varepsilon_t^m + \varepsilon_{it}$$

Robustness: Nonlinearities ▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)
leverage × ffr shock	-1.51***	-1.16**
	(0.56)	(0.52)
leverage^2 × ffr shock	1.78**	1.30*
	(0.76)	(0.69)
Observations	233232	233232
R^2	0.109	0.120
Firm controls	no	yes

Robustness: Nonlinearities ▸ Back

Dependent variable: $\mathbb{I}\{\frac{i_{it}}{k_{it}} > \iota\}$

	(1)	(2)
leverage × ffr shock	-8.67***	-8.09***
	(2.28)	(2.12)
leverage^2 × ffr shock	9.20***	8.31***
	(3.11)	(2.87)
Observations	233232	233232
R^2	0.214	0.219
Firm controls	no	yes

Debt Levels ▸ Back

Dependent variable: $\Delta \log k_{it+1}$

	(1)	(2)
debt level × ffr shock	-0.04	-0.10
	(0.28)	(0.27)
Observations	230659	230659
R^2	0.103	0.116
Firm controls	no	yes

Dependent variable: $\mathbb{I}\{\frac{i_{it}}{k_{it}} > \iota\}$

	(1)	(2)
debt level × ffr shock	-1.73	-2.10
	(1.42)	(1.42)
Observations	230659	230659
R^2	0.212	0.217
Firm controls	no	yes

Debt Financing ▸ Back

Dependent variable: $\Delta b_{i,t+1}/a_{i,t}$

	(1)	(2)
leverage × ffr shock	-2.66	-1.76
	(4.06)	(4.22)
Observations	230659	230659
R^2	0.040	0.041
Firm controls	no	yes

Dependent variable: $\mathbb{I}\{\Delta b_{i,t+1} > 0\}$

	(1)	(2)
leverage × ffr shock	-2.54	-1.78
	(1.93)	(1.70)
Observations	230659	230659
R^2	0.151	0.156
Firm controls	no	yes

Equity Financing ▸ Back

Dependent variable: $\Delta n_{i,t+1}/a_{i,t}$

	(1)	(2)
leverage $\times$ ffr shock	3.79	2.93
	(2.73)	(2.73)
Observations	233195	233195
R^2	0.037	0.045
Firm controls	no	yes

Dependent variable: $\mathbb{I}\{\Delta n_{i,t+1} > 0\}$

	(1)	(2)
leverage $\times$ ffr shock	3.55^{*}	2.66
	(1.90)	(1.81)
Observations	233195	233195
R^2	0.192	0.202
Firm controls	no	yes

Cash Financing ▸ Back

Dependent variable: $\Delta\mathbf{cash}_{i,t+1}/a_{i,t}$

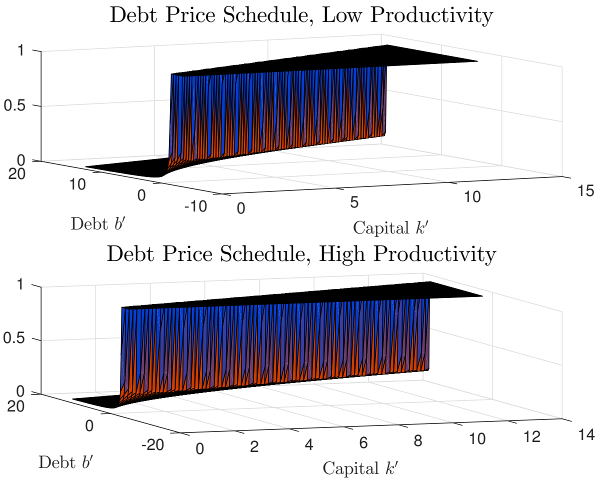
	(1)	(2)
leverage × ffr shock	-0.10	-0.73
	(1.29)	(1.33)
Observations	233196	233196
R^2	0.029	0.041
Firm controls	no	yes

Dependent variable: $\mathbb{I}\{\Delta\mathbf{cash}_{i,t+1} > 0\}$

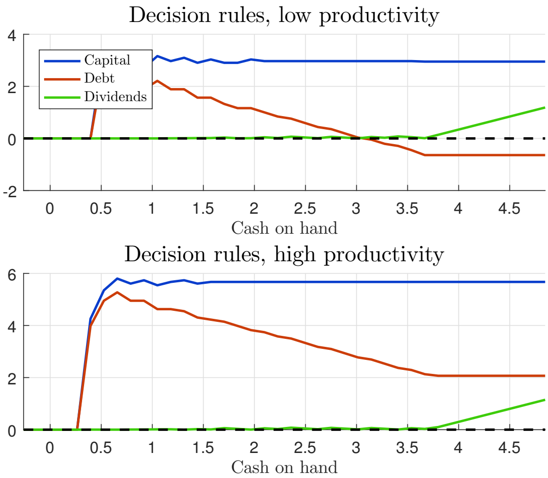
	(1)	(2)
leverage × ffr shock	-0.76	-0.63
	(1.66)	(1.57)
Observations	233196	233196
R^2	0.083	0.096
Firm controls	no	yes

Appendix Quantitative Model

Debt Price Schedule ▸ Back



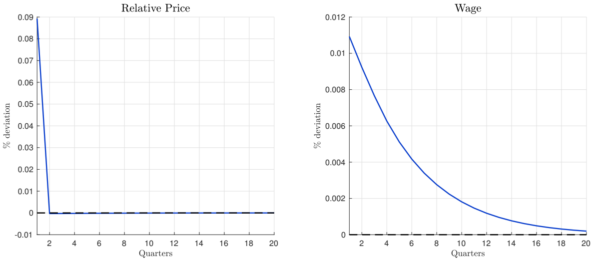
Policy Rules ▸ Back



Why Cash Flow Effect So Strong?

$$\frac{d\log k'}{d\varepsilon_t^m} = \underbrace{\frac{d\log x}{d\varepsilon_t^m}\frac{x}{k'}}_{\text{cash flow }>99\%} + \underbrace{\frac{d\log q_t(z,k',b')b'}{d\varepsilon_t^m}\frac{q_t(z,k',b')b'}{k'}}_{\text{borrowing costs }<1\%}$$

1. Cash-flow effect: $\frac{d\log x}{d\varepsilon_t^m} = \frac{1}{(1-\theta)(1-\nu)}\left(\frac{d\log p_t}{d\varepsilon_t^m} - \nu\frac{d\log w_t}{d\varepsilon_t^m}\right)$



Why Cash Flow Effect So Strong?

$$\frac{\mathrm{d}\log k'}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} = \underbrace{\frac{\mathrm{d}\log x}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}\frac{x}{k'}}_{\text{cash flow } >99\%} + \underbrace{\frac{\mathrm{d}\log q_t(z,k',b')b'}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}\frac{q_t(z,k',b')b'}{k'}}_{\text{borrowing costs } <1\%}$$

1. Cash-flow effect: $\frac{\mathrm{d}\log x}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} = \frac{1}{(1-\theta)(1-\nu)}\left(\frac{\mathrm{d}\log p_t}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} - \nu\frac{\mathrm{d}\log w_t}{\mathrm{d}\varepsilon_t^{\mathrm{m}}}\right)$
2. Borrowing cost effect:
$\frac{\mathrm{d}\log q_t(z,k',b')b'}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} = -\frac{1}{R_t}\frac{\mathrm{d}\log R_t}{\mathrm{d}\varepsilon_t^{\mathrm{m}}} +$ default probs + new borrowing