Micro Data for Macro Models

Topic 3: Financial Frictions and Investment

Thomas Winberry

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Plan for Topic 3

- Two responses to failure of neoclassical investment model:
    1. Adjustment costs feature nonconvexities
    2. Financial frictions influence investment behavior

- Topic 2 discussed how we think about micro- and macro-level implications of nonconvexities

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- Topic 3 studies financial frictions
  1. Overview of mechanisms and empirical literature
  2. Evidence on heterogeneous responses to macro shocks
  3. Aggregate implications for:
     - Monetary shocks (Ottonello and Winberry 2018)
     - Financial shocks (Khan and Thomas 2013)

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Simple Frictionless Model

In period $t = 0$**: continuum of firms** $i \in [0, 1]$

- Initial endowment x_{i0} units of numeraire good
- Invest in capital k_{i1} to produce in $t = 1$
  - Equity finance: pay out of current equity
  - Debt finance: borrow $\frac{1}{R} \times b_{i1}$ from lenders

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In period $t = 1$, produce and choose whether to repay debt

- Produce using capital: $z_{i1} \times k_{i1}^{\alpha}$
  - Productivity z_{i1} stochastic w/ support $[\underline{z}, \overline{z}]$ and CDF $G(z)$
  - Capital fully depreciates after producing
- Repay debt b_{i1}

Firm's Problem

Profit maximization problem:

$$\max_{k_{i1}, b_{i1}} d_{i0} + \frac{1}{R}\mathbb{E}\left[d_{i1}\right]$$

$$\begin{aligned} d_{i0} &= x_{i0} + \frac{1}{R}b_{i1} - k_{i1} \\ d_{i1} &= z_{i1}k_{i1}^{\alpha} - b_{i1} \end{aligned}$$

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Solution illustrates Modigliani-Miller theorem:

$$k_{i1} = \left(\frac{\alpha \mathbb{E}[z_{i1}]}{R}\right)^{\frac{1}{1-\alpha}}$$

any finite b_{i1} and d_{i0} optimal

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→ Frictionless model makes no prediction about financial variables

Financial Frictions

1. Frictions to equity finance:
   - Cannot raise new equity: $d_{i0} \geq 0$
   - Costly to raise new equity: pay some cost κ if $d_{i0} < 0$
   - Incentive to smooth dividends: $-\frac{\phi}{2}\left(d_{i0} - d^*\right)^2$

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   - Limited commitment: firms can default in period 1 $\rightarrow$ lenders charge risk premium

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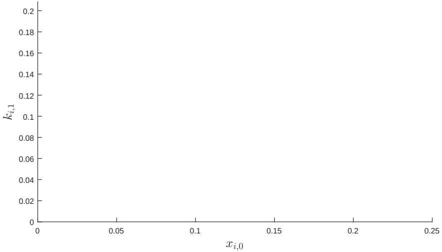
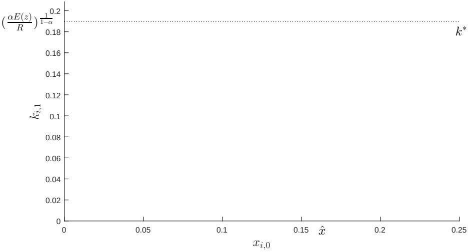
Need both types of frictions for financial variables to matter for investment

Example: $d_{i0} \geq 0$ and $b_{i0} \leq \underline{z}k_{i1}^{\alpha}$



Example: $d_{i0} \geq 0$ and $b_{i0} \leq \underline{z}k_{i1}^{\alpha}$



Unconstrained investment: $k^* = \left(\frac{\alpha \mathbb{E}[z_{i1}]}{R}\right)^{\frac{1}{1-\alpha}}$

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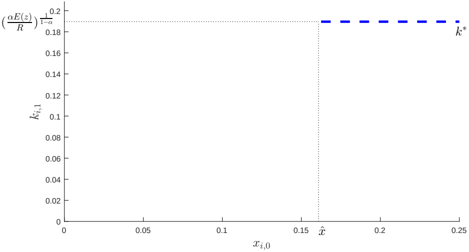

If $x_{i0} \geq \widehat{x} = k^* - \underline{z}(k^*)^{\alpha}$, firm is unconstrained:

$$k_{i1} = k^*$$

any b_{i1} and d_{i0} such that $b_{i1} \leq \underline{z}(k^*)^{\alpha}$ optimal

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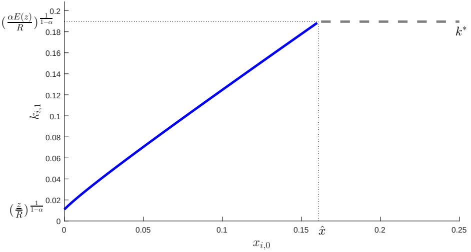
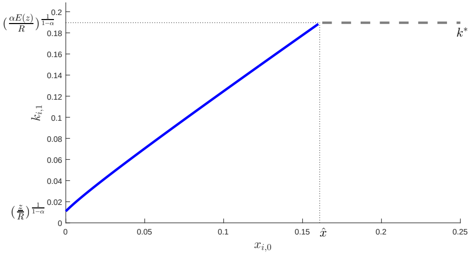


If $x_{i0} < \widehat{x}$, firm is constrained:

$$k_{i1} = x_{i0} + \frac{1}{R}\underline{z}k_{i1}^{\alpha}$$

$$d_{i0} = 0, b_{i1} = \underline{z}k_{i1}^{\alpha}$$

Example: $d_{i0} \geq 0$ and $b_{i0} \leq \underline{z}k_{i1}^{\alpha}$



Slope of investment rule for constrained firms is

$$\text{slope of } k_{i1} = 1 + \frac{\alpha \frac{\underline{z}}{R} k_{i1}^{\alpha-1}}{1 - \alpha \frac{\underline{z}}{R} k_{i1}^{\alpha-1}} > 1$$

Overview of the Empirical Literature

Wave 1

- Investment-cash flow sensitivity regressions: Fazarri, Hubbard, and Petersen (1988)

$$\frac{i_{it}}{k_{it}} = \alpha + \alpha_{\text{cost}} \text{cost}_{it} + \alpha_{\text{cash}} \frac{\text{cash}_{it}}{k_{it}} + \varepsilon_{it}$$

- Interpret α_{cash} as evidence of financial frictions

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Wave 2

- Cash flow correlated with serially correlated productivity $\Longrightarrow$ carefully specified mapping from cash flows to financial frictions
- Kaplan and Zingales (1997), Erickson and Whited (2000)

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Wave 2

- Cash flow correlated with serially correlated productivity $\implies$ carefully specified mapping from cash flows to financial frictions
- Kaplan and Zingales (1997), Erickson and Whited (2000)

Wave 3

- Credibly identified reduced-form studies: Rauh (2006)
- Estimated structural models: Hennesy and Whited (2007)

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2. **Evidence on heterogeneous responses to macro shocks**

3. Aggregate implications for:
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Gertler and Gilchrist (1994)

- Do financial constraints amplify aggregate response to monetary policy?
  - Financial accelerator: indirect effect through net worth x
  - Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1994)

- Test using cross-sectional implication: constrained firms more responsive
  - Proxy for financial constraints with size

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- **Main finding**: sales + inventory investment decline more for small firms following monetary tightening

Data

- Data derived from Quarterly Financial Reports for Manufacturing Corporations (QFR)
  - Survey of manufacturing firms, 1958 - present
  - Records real + financial information

- Collapse into 8 aggregated time series by nominal assets
  1. Not firm-level data
  2. Inflation creates drift in share of firms in each bin

- **Small firms** = bottom 30th percentile of real sales in quarter t
  1. Adjust weighting of asset classes
  2. Adjust for inflation

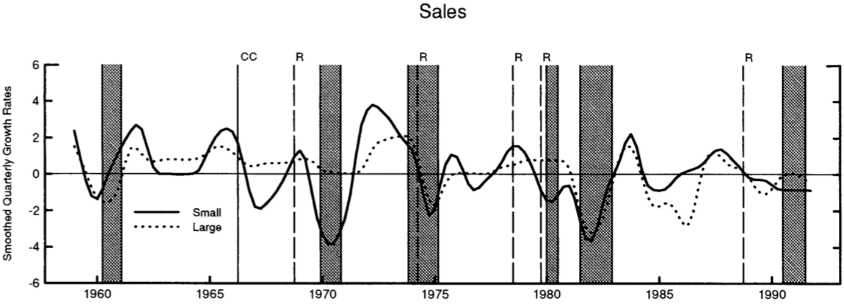
Are Small Firms More Constrained?

TABLE II
COMPOSITION OF DEBT FINANCE BY ASSET SIZE, 1986:4

Type of debt as percentage of total	Asset size (in millions of dollars)				
	All	<50	50–250	250–1000	>1000
Short-term debt	0.16	0.29	0.18	0.14	0.13
Bank loans	0.08	0.25	0.15	0.09	0.04
Comm. paper	0.05	0.00	0.00	0.03	0.07
Other	0.02	0.04	0.02	0.02	0.02
Long-term debt	0.84	0.71	0.82	0.86	0.87
Bank loans	0.22	0.43	0.40	0.31	0.14
Other	0.62	0.28	0.42	0.56	0.73
% of bank loans	0.30	0.68	0.55	0.40	0.17

- Small firms more bank dependent
- Large firms have more long term debt + commercial paper

Small vs. Large Firms Over the Cycle



- CC = credit crunch
- R = Romer date for monetary tightening

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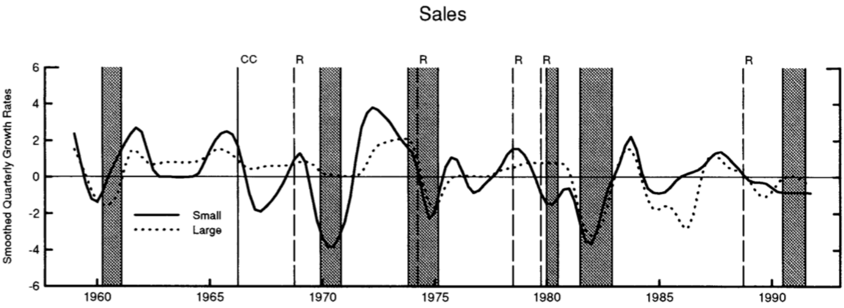

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- Sales of small firms declines by more in most episodes

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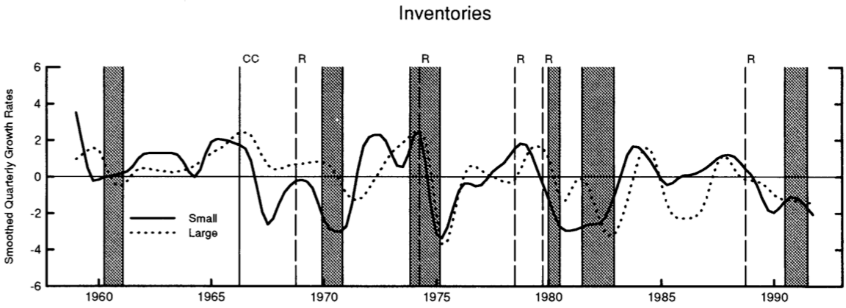
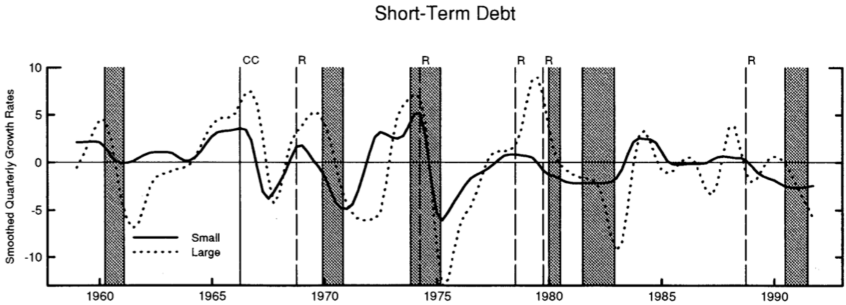


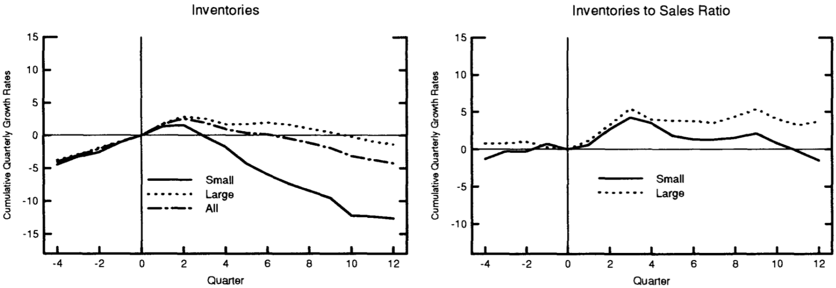
- Similar pattern for inventories, but less pronounced

Small vs. Large Firms Over the Cycle



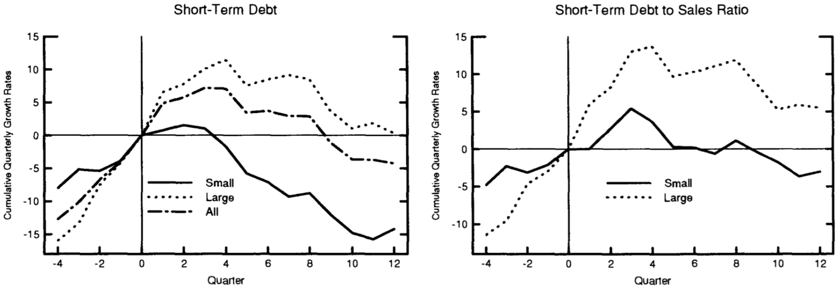
- Less clear pattern for short-term debt

Small Firms Contract More Following Romer Dates



- Average time series following Romer dates

Small Firms Contract More Following Romer Dates



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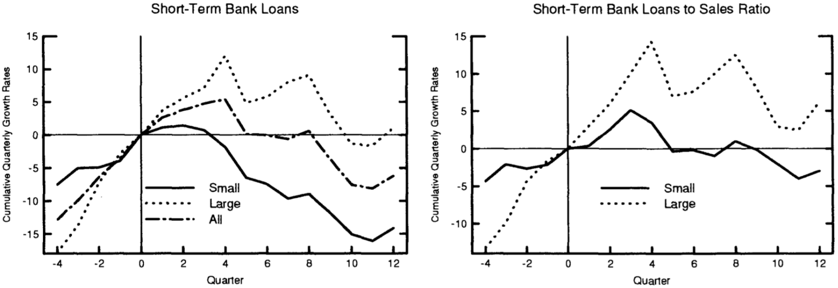


Crouzet and Mehrotra (2017)

- Gertler and Gilchrist (1994) based on aggregated QFR series
- Crouzet and Mehrotra (2017) reassess their findings using micro-data underlying QFR
  - Focus on cyclical sensitivity rather than monetary shocks
- **Main findings**:
  1. Some evidence small firms more sensitive
  2. Does not matter for explaining aggregate fluctuations
  3. Cyclical sensitivity not driven by financial variables

Data

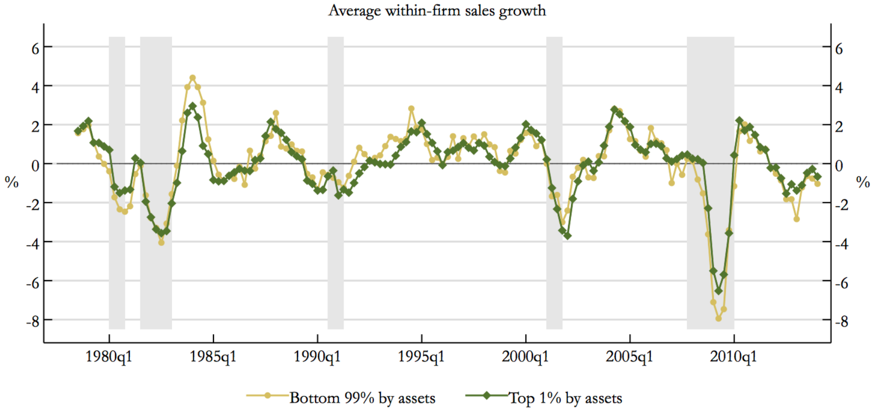
- Data derived from IRS corporate tax returns + survey, 1977 - present
  - Rotating panel of small firms (assets $250k - $250m)
  - Universe of large firms (assets > $250m)
  - Firm time used by researchers, so a lot of work!
- Advantages:
  1. Representative sample of manufacturing firms
  2. High-quality balance sheet information
  3. Quarterly frequency
- Disadvantages:
  1. Only manufacturing firms (so far)
  2. Short panel of small firms

Firms' Balance Sheets by Size

Size group	*0-90th*	*90-99th*	*99-99.5th*	*>99.5th*
Assets				
Financial assets, incl. cash	0.149	0.099	0.074	0.055
Short-term assets				
Receivables	0.284	0.229	0.165	0.124
Inventory	0.218	0.241	0.172	0.130
Other	0.040	0.037	0.042	0.041
Long-term assets				
Net property, plant and equipment	0.269	0.288	0.289	0.287
Other, incl. intangibles	0.050	0.106	0.259	0.362
Liabilities				
Debt				
Due in 1 year or less				
Bank debt	0.083	0.083	0.032	0.016
Non-bank debt	0.035	0.019	0.019	0.028
Due in more than 1 year				
Bank debt	0.107	0.111	0.110	0.072
Non-bank debt	0.123	0.079	0.141	0.179
Trade payables	0.156	0.123	0.085	0.071
Other, incl. capital leases	0.099	0.121	0.187	0.233
Equity	0.393	0.463	0.426	0.416

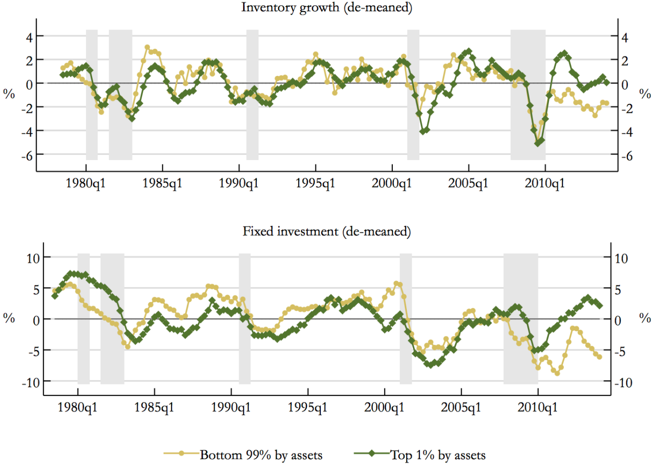
- Small firms more bank dependent and have more short term debt
- Small firms also have more short-term assets

Small vs. Large Firms Over the Cycle



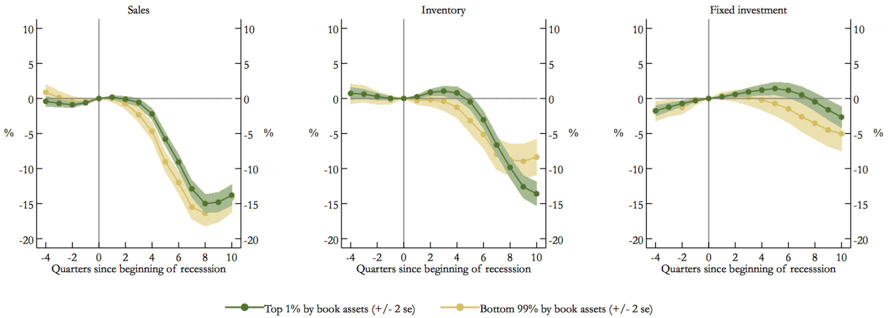
- Small firm sales fall more during 1981 and 2008 recession

Small vs. Large Firms Over the Cycle



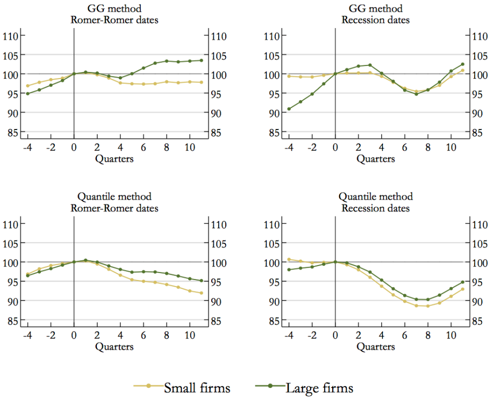
- Less clear picture for inventories and capital investment

Small vs. Large Firms Over the Cycle



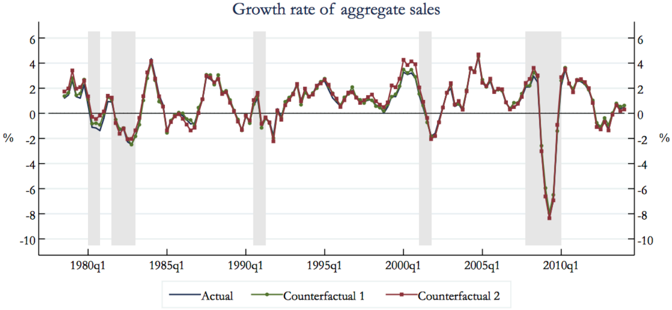
- Results driven by 1981 and 2008 recessions

How to Reconcile with Gertler and Gilchrist?



- Different cyclical responsiveness for monetary shocks vs. recessions

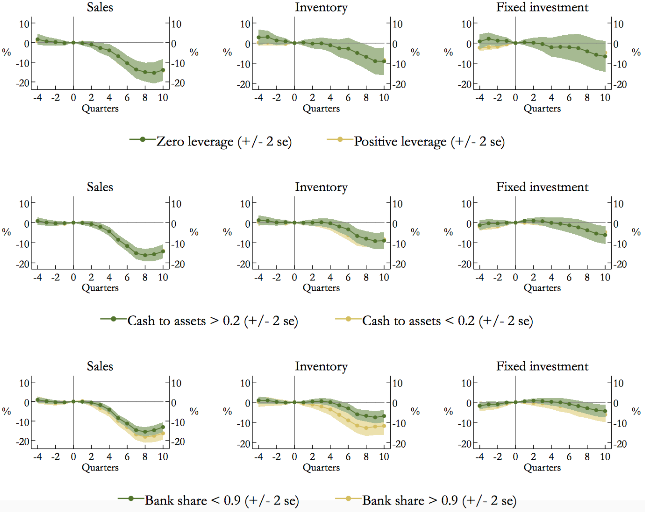
Differences Unimportant for Aggregate Dynamics



- Aggregate decomposition
  $$G_t = g_t^{\text{large}} + s_{t-4}\left(g_t^{\text{small}} - g_t^{\text{large}}\right) + \text{cov}_t$$
- Counterfactual 1 = $G_t - s_{t-4}\left(g_t^{\text{small}} - g_t^{\text{large}}\right)$
- Counterfactual 2 = g_t^{large}

Why No Agg. Differences? High Concentration

Direct Test: Differences by Financial Characteristics?



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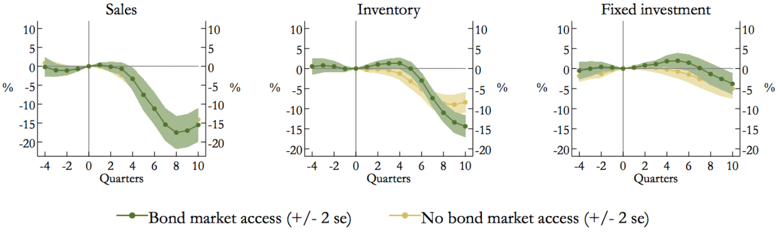

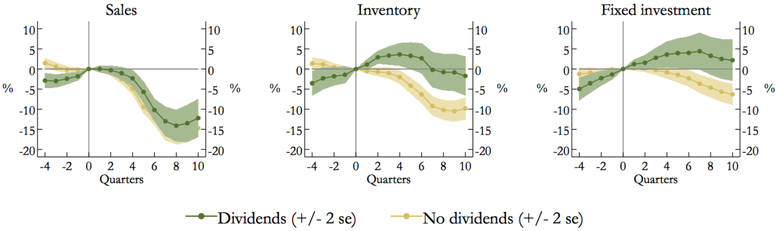

Wrapping Up Gerter-Gilchrist and Crouzet-Mehrotra

- Do financial frictions amplify response to shocks?

- Mixed evidence in cross-sectional data
    - Depends on weighting of firms
    - Depends on shock

Plan for Topic 3

1. Overview of mechanisms and empirical literature

2. Evidence on heterogeneous responses to macro shocks

3. **Aggregate implications for**:
    - **Monetary shocks (Ottonello and Winberry 2018)**
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Motivation

- Want to understand the role of financial frictions in shaping the investment channel of monetary policy

- Which firms respond the most to monetary policy?

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- Want to understand the role of financial frictions in shaping the investment channel of monetary policy
- Which firms respond the most to monetary policy?
- Firms more affected by financial frictions:
  - Have steeper marginal cost of investment $\implies$ dampen
  - More sensitive to cash flows + collateral values $\implies$ amplify (financial accelerator across firms)
- We revisit this question with
  1. New **cross-sectional evidence**
  2. **Heterogeneous firm New Keynesian** model

Our Contributions

Descriptive evidence on heterogeneous responses
using high-frequency shocks and quarterly Compustat

1. Firms with low leverage, good ratings, and large "distance to default" are more responsive
2. Heterogeneity primarily driven by distance to default

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Heterogeneous firm New Keynesian model
with financial frictions arising from default risk

1. Model consistent with heterogeneous responses
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   - Driven by low-risk firms, which is time-varying

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$\Longrightarrow$ **Default risk dampens response to monetary policy**

Related Literature

1. **Household Heterogeneity and Monetary Policy**
   Doepke and Schneider (2006); Auclert (2015); Werning (2015); Wong (2016); Gornermann, Kuester, Nakajima (2016); Kaplan, Moll, and Violante (2018)

2. **Financial Heterogeneity and Investment**
   Khan and Thomas (2013); Gilchrist, Sim and Zakrajsek (2014); Khan, Senga and Thomas (2016)

3. **Financial Frictions and Monetary Transmission**
   - Gertler, and Gilchrist (1994); Kashyap, Lamont, and Stein (1994); Kashyap and Stein (1995); Jeenas (2018)
   - Bernanke, Gertler, and Gilchrist (1999)

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 net investment
   - Leverage ℓ_{it}: debt divided by total assets
   - Credit rating cr_{jt}: S&P rating of firm's long-term debt
   - Distance to default dd_{jt}: constructed following Gilchrist and Zakrasjek (2012) ▸ Sample Construction ▸ Compustat vs. NIPA

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Merge 1990q1 - 2007q2

Summary Statistics of Firm-Level Variables

(a) Marginal Distributions

Statistic	$\Delta \log k_{jt+1}$	ℓ_{jt}	$\mathbb{1}\{cr_{jt} \geq A\}$	dd_{jt}
Mean	0.005	0.267	0.024	5.744
Median	-0.004	0.204	0.000	4.704
S.D.	0.093	0.361	0.154	5.032
95th Percentile	0.132	0.725	0.000	14.952

(b) Correlation Matrix (raw variables)

	ℓ_{jt}	$\mathbb{1}\{cr_{jt} \geq A\}$	dd_{jt}
ℓ_{jt}	1.00		
(p-value)			
$\mathbb{1}\{cr_{jt} \geq A\}$	-0.02	1.00	
	(0.00)		
dd_{jt}	-0.46	0.21	1.00
	(0.00)	(0.00)	

(c) Correlation matrix (residualized)

	ℓ_{jt}	$\mathbb{1}\{cr_{jt} \geq A\}$	dd_{jt}
ℓ_{jt}	1.00		
(p-value)			
$\mathbb{1}\{cr_{jt} \geq A\}$	-0.02	1.00	
	(0.00)		
dd_{jt}	-0.38	0.05	1.00
	(0.00)	(0.00)	

Baseline Empirical Specification

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

- Coefficient of interest β: how semi-elasticity of investment w.r.t. monetary policy depends on leverage
- Want to isolate differences due to leverage
    - α_{st}: compare within a sector-quarter
    - Z_{it-1}: conditional on financial position y_{it-1}, sales growth, log total assets, current assets share, fiscal quarter dummy
- Standard errors clustered two-way by firm and quarter

Low-Risk Firms More Responsive

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
leverage × shock	-0.66**	-0.52**					
	(0.27)	(0.25)					
$\mathbb{1}\{\text{cr}_{jt} \geq A\}$			2.69**				
			(1.16)				
dd × shock				1.06**			
				(0.45)			
ffr shock							
Observations	239259	239259	239259	151433			
R^2	0.108	0.119	0.116	0.137			
Firm controls	no	yes	yes	yes			
Time sector FE	yes	yes	yes	yes			
Time clustering	yes	yes	yes	yes			

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

- Monetary expansion has positive sign ($-\varepsilon_t^{\text{m}}$)
- Standardize leverage and distance to default over all firms and quarters

Low-Risk Firms More Responsive

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
leverage × shock	-0.66**	-0.52**			-0.50*	-0.47	
	(0.27)	(0.25)			(0.25)	(0.39)	
$\mathbb{1}\{cr_{jt} \geq A\}$			2.69**		2.41**		
			(1.16)		(1.19)		
dd × shock				1.06**		0.70	
				(0.45)		(0.44)	
ffr shock							
Observations	239259	239259	239259	151433	239259	151433	
R^2	0.108	0.119	0.116	0.137	0.119	0.139	
Firm controls	no	yes	yes	yes	yes	yes	
Time sector FE	yes	yes	yes	yes	yes	yes	
Time clustering	yes	yes	yes	yes	yes	yes	

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

- Monetary expansion has positive sign ($-\varepsilon_t^{m}$)
- Standardize leverage and distance to default over all firms and quarters

Low-Risk Firms More Responsive

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
leverage × shock	-0.66**	-0.52**			-0.50*	-0.47	-0.24
	(0.27)	(0.25)			(0.25)	(0.39)	(0.38)
$\mathbb{1}\{\text{cr}_{jt} \geq A\}$			2.69**		2.41**		
			(1.16)		(1.19)		
dd × shock				1.06**		0.70	1.07**
				(0.45)		(0.44)	(0.52)
ffr shock							1.63**
							(0.72)
Observations	239259	239259	239259	151433	239259	151433	151433
R^2	0.108	0.119	0.116	0.137	0.119	0.139	0.126
Firm controls	no	yes	yes	yes	yes	yes	yes
Time sector FE	yes	yes	yes	yes	yes	yes	no
Time clustering	yes	yes	yes	yes	yes	yes	yes

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

- Monetary expansion has positive sign ($-\varepsilon_t^{\mathrm{m}}$)
- Standardize leverage and distance to default over all firms and quarters

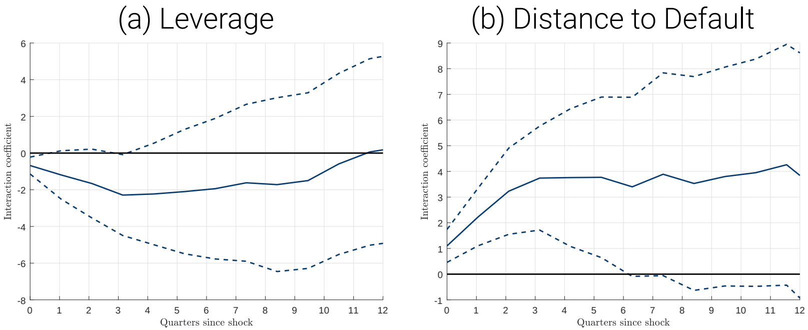
Results Hold Using Only Within-Firm Variation

	(1)	(2)	(3)	(4)	(5)
leverage × ffr shock	-0.81**	-0.68**		-0.33	-0.21
	(0.31)	(0.28)		(0.37)	(0.38)
dd × ffr shock			1.10***	0.89**	1.12**
			(0.39)	(0.38)	(0.47)
ffr shock					1.64**
					(0.77)
Observations	219702	219702	151433	151433	151433
R^2	0.113	0.124	0.137	0.139	0.126
Firm controls	no	yes	yes	yes	yes
Time sector FE	yes	yes	yes	yes	no
Time clustering	yes	yes	yes	yes	yes

$$\Delta \log k_{it+1} = \beta(y_{it-1} - \mathbb{E}_i[y_{it}])\varepsilon_t^{m} + \alpha_i + \alpha_{st} + \Gamma_1' Z_{it-1} + \Gamma_2(y_{it-1} - \mathbb{E}_i[y_{it}])Y_{t-1} + \varepsilon_{it}$$

- Monetary expansion has positive sign ($-\varepsilon_t^{m}$)
- Standardize demeaned leverage and distance to default over all firms and quarters

Dynamics of Differences Across Firms



$$\log k_{it+h+1} - \log k_{it} = \beta_h (y_{it-1} - \mathbb{E}_i[y_{it}])\varepsilon_t^{\mathrm{m}} + \alpha_{ih}\alpha_{sth} + \\ + \Gamma'_{1h} Z_{it-1} + \Gamma_{2h}(y_{it-1} - \mathbb{E}_i[y_{it}]) Y_{t-1} + \varepsilon_{ith}$$

Heterogeneous Firm New Keynesian Model

Model Overview

1. **Investment block**
    - Heterogeneous firms invest s.t. default risk
    - Intermediary lends resources from household to firms

2. **New Keynesian block**
    - Retailers differentiate output s.t. sticky prices
    - Final good producer combines goods into final output
    - Monetary authority follows Taylor rule (monetary shock)
    - Capital good producer with adjustment costs

3. **Representative household**
    - Owns firms + labor-leisure choice

Heterogeneous Firms

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

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

1. **Exogenous exit**: w/ i.i.d. prob π_d, forced to exit at end of period

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

1. **Exogenous exit**: w/ i.i.d. prob π_d, forced to exit at end of period
2. **Default decision**
    - If default, value = 0
    - If continue, repay debt b_{jt} and pay operating cost ξ

Heterogeneous Firms

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

1. **Exogenous exit**: w/ i.i.d. prob π_d, forced to exit at end of period
2. **Default decision**
   - If default, value = 0
   - If continue, repay debt b_{jt} and pay operating cost ξ
3. **Production**: $y_{jt} = z_{jt}(\omega_{jt}k_{jt})^{\theta}n_{jt}^{\nu}$, $\theta + \nu < 1$ at price p_t
   - $\log z_{jt+1} = \rho \log z_{jt} + \varepsilon_{jt+1}^{z}$, $\varepsilon_{jt+1}^{z} \sim N(0, \sigma^2)$
   - $\log \omega_{jt} \sim N(-\sigma_{\omega}^2/2, \sigma_{\omega}^2)$ i.i.d.
     - Undepreciated captial $(1-\delta)\omega_{jt}k_{jt}$

Heterogeneous Firms

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

1. **Exogenous exit**: w/ i.i.d. prob π_d, forced to exit at end of period
2. **Default decision**
    - If default, value = 0
    - If continue, repay debt b_{jt} and pay operating cost ξ
3. **Production**: $y_{jt} = z_{jt}(\omega_{jt}k_{jt})^{\theta}n_{jt}^{\nu}$, $\theta + \nu < 1$ at price p_t
    - $\log z_{jt+1} = \rho \log z_{jt} + \varepsilon^z_{jt+1}$, $\varepsilon^z_{jt+1} \sim N(0, \sigma^2)$
    - $\log \omega_{jt} \sim N(-\sigma^2_{\omega}/2, \sigma^2_{\omega})$ i.i.d.
        - Undepreciated captial $(1-\delta)\omega_{jt}k_{jt}$
4. **Investment**: choose $q_t k_{jt+1}$ and financing b_{jt+1}, d_{jt}
    - External finance b_{jt+1} at price $\mathcal{Q}_t(z_{jt}, k_{jt+1}, b_{jt+1})$
    - Internal finance subject to $d_{jt} \geq 0$

Financial Intermediary

- **Financial intermediary** lends from households to firms
  - No default: get $1/\Pi_{t+1}$ (nominal debt)
  - Default: get up to $\alpha q_{t+1}\omega_{jt+1}k_{jt+1}$ per unit of debt

Financial Intermediary

- **Financial intermediary** lends from households to firms
  - No default: get $1/\Pi_{t+1}$ (nominal debt)
  - Default: get up to $\alpha q_{t+1}\omega_{jt+1}k_{jt+1}$ per unit of debt

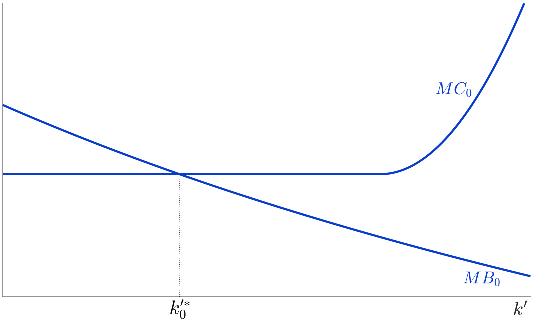
$$\mathcal{Q}_t(z,k',b') = \mathbb{E}_t[\Lambda_{t+1}((1-\mathbb{1}\{\text{default}_{t+1}(z',\omega',\zeta',k',b')\})\times\frac{1}{\Pi_{t+1}})$$
$$+\mathbb{1}\{\text{default}_{t+1}(z',\omega',\zeta',k',b')\}\times\min\{1,\alpha\frac{q_{t+1}\omega'k'}{b'/\Pi_{t+1}}\})]$$

An Equilibrium of this Model Satisfies

1. **Heterogeneous firms** choose investment $k'_t(z, \omega, k, b)$, financing $b'_t(z, \omega, k, b)$, and default decision
2. **Financial intermediaries** price default risk $\mathcal{Q}_t(z, k', b')$
3. **Firm entry** with shifted initial distribution ▸ Details
4. **Retailers and final good producer** generate Phillips Curve ▸ Details
5. **Monetary authority** follows Taylor rule ▸ Details
6. **Capital good producer** generates capital price q_t ▸ Details
7. **Household** supplies labor N_t and generates SDF w/ Λ_{t+1} ▸ Details

Channels of Investment Response to Monetary Policy

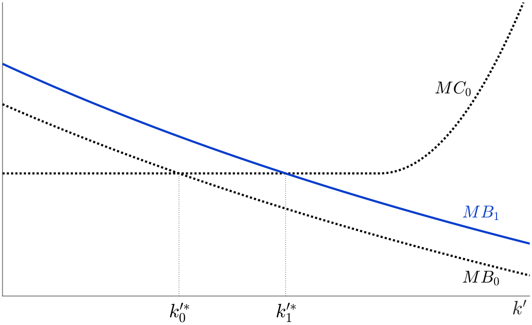
Risk-Free Firms' Response



$$q_t = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b'))]}\right)$$

$$\text{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1}z'(\omega'k')^{\theta}(n')^{\nu} - w_{t+1}n' + q_{t+1}(1-\delta)\omega'k'\right)$$

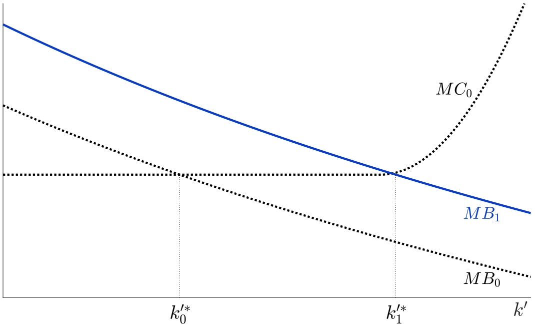
Risk-Free Firms' Response: Discount Rate Falls



$$q_t = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b')]}\right)$$

$$\text{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1}z'(\omega'k')^{\theta}(n')^{\nu} - w_{t+1}n' + q_{t+1}(1-\delta)\omega'k'\right)$$

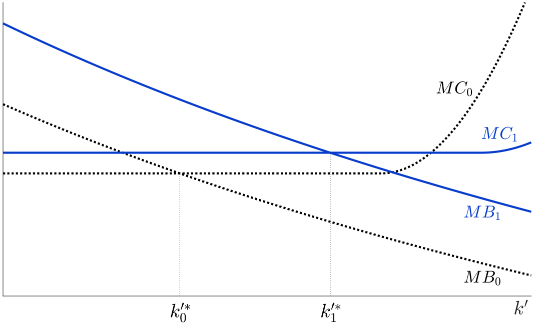
Risk-Free Firms' Response: Future Revenue Rises



$$q_t = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b')]}\right)$$

$$\text{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1} z'(\omega' k')^{\theta}(n')^{\nu} - w_{t+1}n' + q_{t+1}(1-\delta)\omega' k'\right)$$

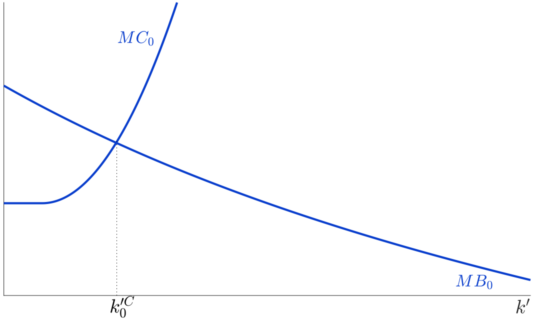
Risk-Free Firms' Response: Price of Capital Rises



$$q_t = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b')]}\right)$$

$$\text{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1}z'(\omega'k')^{\theta}(n')^{\nu} - w_{t+1}n' + q_{t+1}(1-\delta)\omega'k'\right)$$

Risky Firms' Response

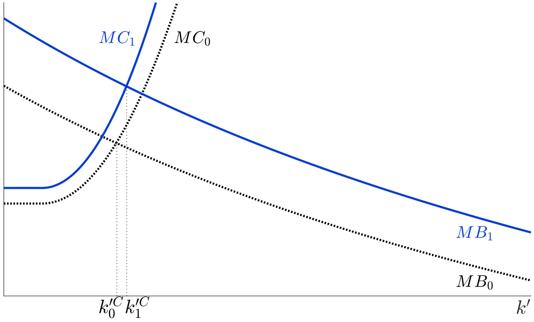


$$\left(q_t - \varepsilon_{R,k'}\frac{b'}{k'}\right)\frac{R_t^{\text{sp}}(z,k',b')}{1-\varepsilon_{R,b'}} = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b')]}\right)$$

$$d = 0 \implies \quad q_t k' = \max_n p_t z(\omega k)^\theta n^\nu - w_t n - b - \xi + q_t(1-\delta)\omega k + \frac{1}{R_t(z,k',b')}b'$$

$$\text{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1} z'(\omega' k')^\theta (n')^\nu - w_{t+1}n' + q_{t+1}(1-\delta)\omega' k'\right)$$

Risky Firms' Response: Previous Channels

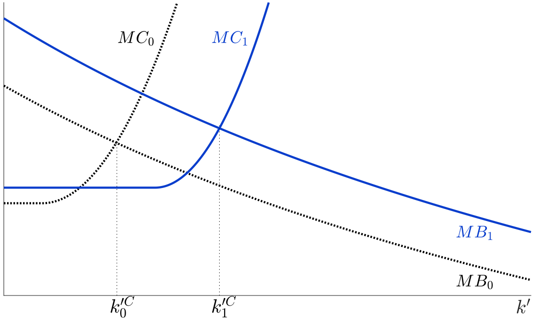


$$\left(q_t - \varepsilon_{R,k'}\frac{b'}{k'}\right)\frac{R_t^{sp}(z,k',b')}{1-\varepsilon_{R,b'}} = \frac{1}{R_t}\left(\mathbb{E}_t\left[\mathrm{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\mathrm{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b')]}\right)$$

$$d = 0 \implies \quad q_t k' = \max_n p_t z(\omega k)^\theta n^\nu - w_t n - b - \xi + q_t(1-\delta)\omega k + \frac{1}{R_t(z,k',b')}b'$$

$$\mathrm{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1} z'(\omega' k')^\theta (n')^\nu - w_{t+1} n' + q_{t+1}(1-\delta)\omega' k'\right)$$

Risky Firms' Response: Cash Flow Rises

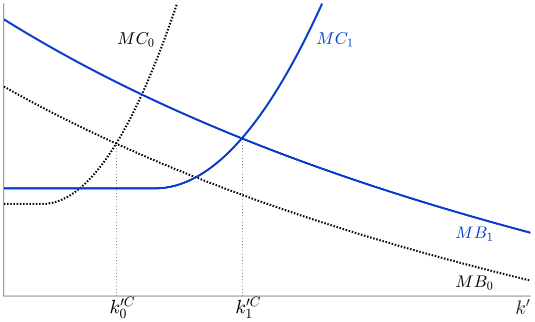


$$\left(q_t - \varepsilon_{R,k'}\frac{b'}{k'}\right)\frac{R_t^{sp}(z,k',b')}{1-\varepsilon_{R,b'}} = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'),1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b')]}\right)$$

$$d = 0 \implies \quad q_t k' = \max_n p_t z(\omega k)^\theta n^\nu - w_t n - b - \xi + q_t(1-\delta)\omega k + \frac{1}{R_t(z,k',b')}b'$$

$$\text{MRPK}_{t+1}(z',k') = \frac{\partial}{\partial k'}\left(\max_{n'} p_{t+1}z'(\omega' k')^\theta (n')^\nu - w_{t+1}n' + q_{t+1}(1-\delta)\omega' k'\right)$$

Risky Firms' Response: Recovery Value Rises

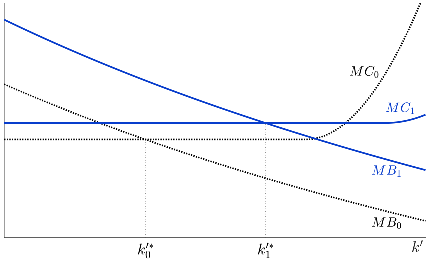


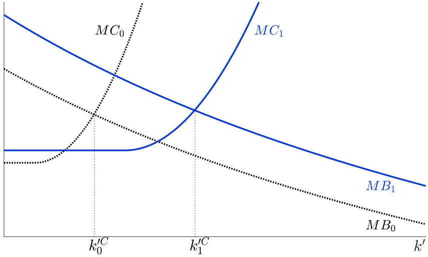
$$\left(q_t - \varepsilon_{R,k'}\frac{b'}{k'}\right)\frac{R_t^{sp}(z,k',b')}{1-\varepsilon_{R,b'}} = \frac{1}{R_t}\left(\mathbb{E}_t\left[\text{MRPK}_{t+1}(z',k')\right] + \frac{\mathbb{C}ov_t(\text{MRPK}_{t+1}(z',k'), 1+\lambda_{t+1}(z',k',b'))}{\mathbb{E}_t[1+\lambda_{t+1}(z',k',b'))]}\right)$$

$$d = 0 \implies \quad q_t k' = \max_n p_t z(\omega k)^\theta n^\nu - w_t n - b - \xi + q_t(1-\delta)\omega k + \frac{1}{R_t(z,k',b')}b'$$

$$R_t^{sp}(z,k',b') = \text{Prob}\left(\text{default}_{t+1}(z',k',b')\right)\left(1 - \min\{1, \alpha\frac{q_{t+1}\omega' k'}{b'/\Pi_{t+1}}\}\right)$$

Which Is More Responsive? Quantitative Question





Calibration

Overview of Calibration

- **Fix** subset of parameters to standard values ▸ Details
- **Choose** parameters governing idiosyncratic shocks, financial frictions, and lifecycle to match empirical targets

Parameters to be Computed

Parameter	Description	Value
Idiosyncratic shock processes		
ρ	Persistence of TFP	
σ	SD of innovations to TFP	
σ_ω	SD of capital quality	
Financial frictions		
ξ	Operating cost	
α	Loan recovery rate	
Firm lifecycle		
m	Mean shift of entrants' prod.	
s	SD shift of entrants' prod.	
k_0	Initial capital	
π_d	Exogeneous exit rate	

Choose labor disutility Ψ to ensure steady state employment = 0.6

Empirical Targets

Moment	**Description**	**Data**	**Model**
Investment behavior (annual)			
$\sigma\left(\frac{i}{k}\right)$	SD investment rate	33.7%	
Financial behavior (annual)			
$\mathbb{E}\left[\text{default rate}\right]$	Mean default rate	3.00%	
$\mathbb{E}\left[\text{credit spread}\right]$	Mean credit spread	2.35%	
$\mathbb{E}\left[b/k\right]$	Mean gross leverage ratio	34.4%	
Firm Growth (annual)			
$\mathbb{E}[n_1]/\mathbb{E}[n]$	Rel. size of age 1 firms	28%	
$\mathbb{E}[n_2]/\mathbb{E}[n]$	Rel. size of age 2 firms	36%	
Firm Exit (annual)			
$\mathbb{E}\left[\text{exit rate}\right]$	Mean exit rate	8.7%	
$\mathbb{E}\left[M_1\right]/\mathbb{E}\left[M\right]$	Share of firms at age 1	10.5%	
$\mathbb{E}\left[M_2\right]/\mathbb{E}\left[M\right]$	Share of firms at age 2	8.1%	

Empirical Targets

Moment	Description	Data	Model
Investment behavior (annual)			
$\sigma\left(\frac{i}{k}\right)$	SD investment rate	33.7%	31.8%
Financial behavior (annual)			
$\mathbb{E}$ [default rate]	Mean default rate	3.00%	2.01%
$\mathbb{E}$ [credit spread]	Mean credit spread	2.35%	2.54%
$\mathbb{E}[b/k]$	Mean gross leverage ratio	34.4%	33.6%
Firm Growth (annual)			
$\mathbb{E}[n_1]/\mathbb{E}[n]$	Rel. size of age 1 firms	28%	42%
$\mathbb{E}[n_2]/\mathbb{E}[n]$	Rel. size of age 2 firms	36%	66%
Firm Exit (annual)			
$\mathbb{E}$ [exit rate]	Mean exit rate	8.7%	7.88%
$\mathbb{E}[M_1]/\mathbb{E}[M]$	Share of firms at age 1	10.5%	7.4%
$\mathbb{E}[M_2]/\mathbb{E}[M]$	Share of firms at age 2	8.1%	6.1%

Parameters to be Computed

Parameter	Description	Value
Idiosyncratic shock processes		
ρ	Persistence of TFP	0.86
σ	SD of innovations to TFP	0.03
σ_ω	SD of capital quality	0.04
Financial frictions		
ξ	Operating cost	0.02
α	Loan recovery rate	0.91
Firm lifecycle		
m	Mean shift of entrants' prod.	2.92
s	SD shift of entrants' prod	1.11
k_0	Initial capital	0.46
π_d	Exogeneous exit rate	0.02

Choose labor disutility Ψ to ensure steady state employment = 0.6

Overview of Calibration

- **Fix** subset of parameters to standard values ▸ Details

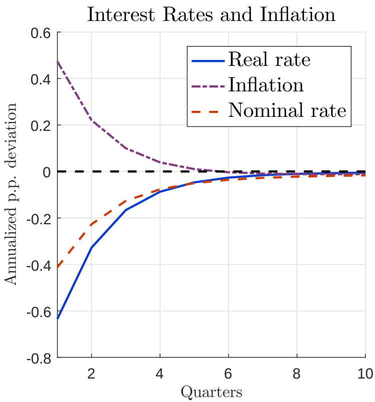
- **Choose** parameters governing idiosyncratic shocks, financial frictions, and lifecycle to match empirical targets

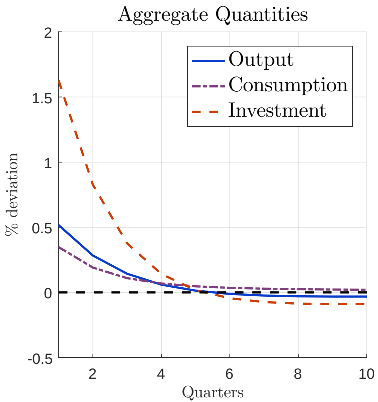
Overview of Calibration

- **Fix** subset of parameters to standard values ▸ Details
- **Choose** parameters governing idiosyncratic shocks, financial frictions, and lifecycle to match empirical targets
- **Analyze** sources of financial heterogeneity ▸ Details
  1. Lifecycle dynamics
  2. Productivity shocks
- **Verify** model (roughly) matches untargetted statistics
  1. Lifecycle dynamics ▸ Details
  2. Distribution of investment and leverage ▸ Details
  3. Investment-cash flow sensitivity ▸ Details

Quantitative Analysis of Monetary Transmission Mechanism

Aggregate Monetary Transmission Mechanism





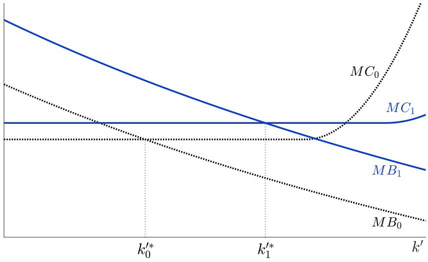
- Peak responses in line with VARs (CEE 2005)
- Not designed to generate hump-shaped responses

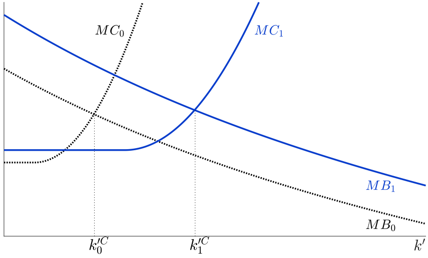
Heterogeneous Responses Consistent with Data

	Model		Data	
	(1)	(2)	(1)	(2)
leverage × ffr shock	-1.193	-0.955	-0.94^{***}	-0.73^{***}
			(0.33)	(0.29)
R^2	0.151	0.216	0.107	0.119
Time FE	yes	yes	yes	yes
Firm controls	no	yes	no	yes

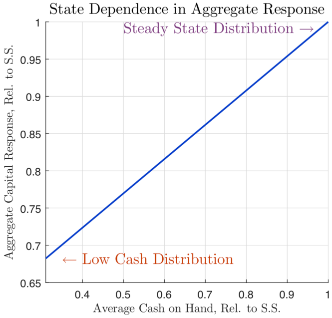
$$\Delta \log k_{it+1} = \beta \ell_{it-1} \varepsilon_t^{m} + \alpha_i + \alpha_{st} + \Gamma' Z_{it-1} + \varepsilon_{it}$$

Heterogeneous Responses Consistent with Data





Aggregate Effect Depends on Distribution of Risk



Back of the envelope calculation:

- Fix investment response across state space
- Vary initial distribution of cash on hand:

$$\mu(z,x) = \omega \underbrace{\mu_{\text{normal}}(z,x)}_{\text{s.s.}} + (1-\omega) \underbrace{\mu_{\text{bad}}(z,x)}_{\text{s.s., low prod.}}$$

Conclusion

Financial Heterogeneity and Investment Channel

Default risk dampens response of investment to monetary policy

Financial Heterogeneity and Investment Channel

Default risk dampens response of investment to monetary policy

1. **Which firms respond the most?**
   - Firms with low leverage and high credit ratings
   - Indicates default risk is key to micro response

2. **Implications for aggregate transmission?**
   - Low-risk firms drive aggregate response
   - Suggests that aggregate effect depends on distribution of default risk

Appendix

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 gross investment using depreciation rates of Fixed Asset tables from NIPA at the industry level
5. Trim the data: extreme values and short spells

▸ 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: $\texttt{sic} \in [91, 97]$

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

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Firm Entry ▸ Back

- Firms exit due to exit shocks and default

- One new entrant for each exiting firm
  1. Draw productivity z_{jt} from shifted distribution

$$\log z_{jt} \sim N\left(-m\frac{\sigma}{\sqrt{1-\rho^2}}, s^2\frac{\sigma^2}{1-\rho^2}\right)$$

  2. Draw capital quality ω_{jt} from ergodic distribution
  3. Endowed with k_0 units of capital and $b_0 = 0$ units of debt

$\implies$ incumbent w/ initial state $(z_{jt}, \omega_{jt}, k_0, 0)$

Retailers and Final Good Producer ▸ Back

- Monopolistically competitive retailers
  - Technology: $\tilde{y}_{it} = y_{it} \implies$ real marginal cost $= p_t$
  - Set price $\tilde{p}_{it}$ s.t. quadratic cost $-\frac{\varphi}{2}\left(\frac{\tilde{p}_{it}}{\tilde{p}_{it-1}} - 1\right)^2 Y_t$
- Perfectly competitive final good producer
  - Technology: $Y_t = \left(\int \tilde{y}_{it}^{\frac{\gamma-1}{\gamma}} di\right)^{\frac{\gamma}{\gamma-1}} \implies P_t = \left(\int \tilde{p}_{it}^{1-\gamma} di\right)^{\frac{1}{1-\gamma}}$
- Implies New Keynesian Phillips Curve

$$\pi_t = \frac{\gamma - 1}{\varphi} \log \frac{p_t}{p^*} + \beta \mathbb{E}_t \left[\pi_{t+1}\right]$$

The Rest of the Model ▸ Back

- Monetary authority follows Taylor rule

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

- Capital good producer with technology

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta)K_t \implies q_t = 1/\Phi'\left(\frac{I_t}{K_t}\right) = \left(\frac{I_t/K_t}{\delta}\right)^{\frac{1}{\phi}}$$

- Representative household with preferences

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

  - Owns firms $\implies \Lambda_{t+1} = \beta \frac{C_t}{C_{t+1}}$
  - Labor-leisure choice $\implies w_t C_t^{-1} = \Psi$
  - Euler equation for bonds $\implies 1 = \beta R_t^{\text{nom}} \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Pi_{t+1}}\right]$

Model-Implied Investment-Cash Flow Sensitivity

Back

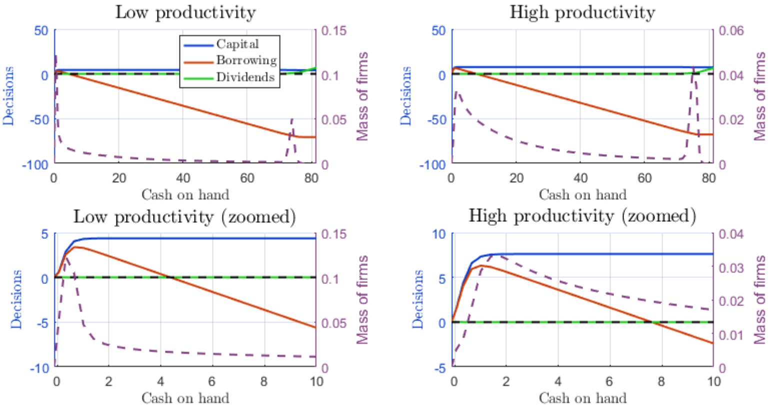
	Model		Data	
cash flow	1.08	0.18	0.021	0.021
Tobin's q		0.15		0.008

$$\frac{i_{it}}{k_{it}} = \alpha_i + \alpha_1 \frac{\pi_{it-1}}{k_{it}} + \alpha_2 q_{it} + \varepsilon_{it}$$

Fixed Parameters ▸ Back

Parameter	Description	Value
Household		
β	Discount factor	0.99
Firms		
ν	Labor coefficient	0.64
θ	Capital coefficient	0.21
δ	Depreciation	0.026
New Keynesian Block		
ϕ	Aggregate capital AC	4
γ	Demand elasticity	10
φ_π	Taylor rule coefficient	1.25
φ	Price adjustment cost	90

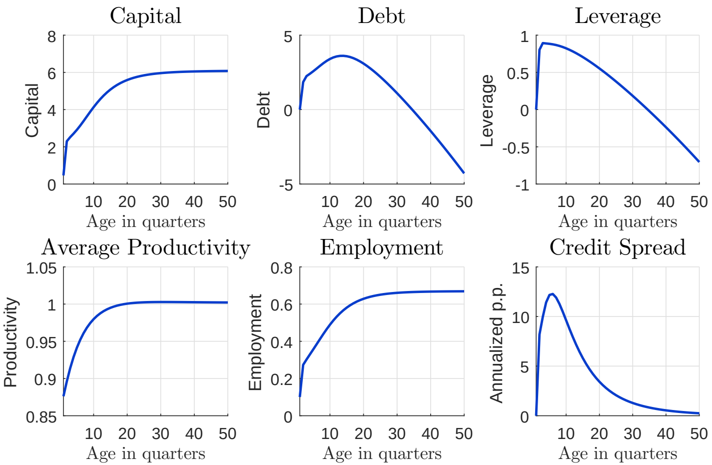
Steady State Decision Rules ▸ Back



Two key sources of **financial heterogeneity**

1. Lifecycle dynamics
2. Productivity shocks

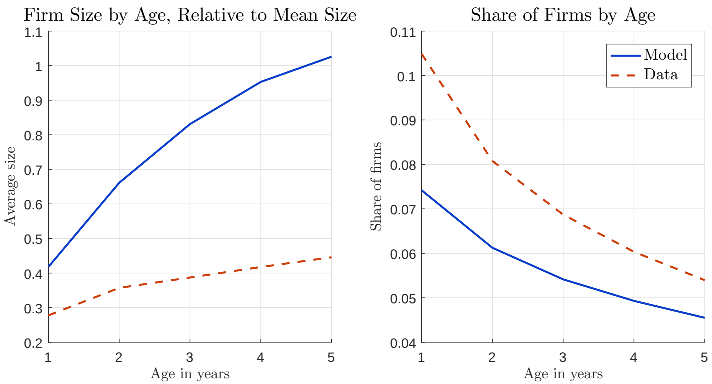
Firm Lifecycle Dynamics ▸ Back



- Young firms riskier than average
- But default risk spread out over large set of firms

Firm Lifecycle Dynamics in the Model and Data

▸ Back



- Firms growth more quickly than in data
  - Data features other sources of lifecycle dynamics
- Age-dependence of exit rates in line with data

Financial Heterogeneity in the Model and Data

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Investment and leverage heterogeneity

Moment	Description	Data	Sel. Model	Full Model
Investment heterogeneity (annual LRD)				
$\mathbb{E}\left[\frac{i}{k}\right]$	Mean investment rate	12.2%	8.83%	20.6%
$\sigma\left(\frac{i}{k}\right)$	SD investment rate (calibrated)	33.7%	31.8%	38.5%
$\rho\left(\frac{i}{k}, \frac{i}{k}_{-1}\right)$	Autocorr investment rate	0.058	-0.26	-0.26
Leverage heterogeneity (quarterly Compustat)				
$\sigma\left(\frac{b}{k}\right)$	SD leverage ratio	36.4%	76.4%	77.0%
$\rho\left(\frac{b}{k}, \frac{b}{k}_{-1}\right)$	Autocorr leverage ratio	0.94	0.92	0.95
Joint investment and leverage (quarterly Compustat)				
$\rho\left(\frac{i}{k}, \frac{b}{k}\right)$	Corr. of leverage and investment	-0.08	-0.16	-0.02

Measured investment-cash flow sensitivity

	Without cash flow		With cash flow	
	Data	*Model*	*Data*	*Model*
Tobin's q	0.01***	0.06	0.01***	0.02
cash flow			0.02***	0.08
R^2	0.097	0.065	0.104	0.086