Financial Constraints and Price Rigidities

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Slides available at yangliu-95.github.io

Research Question

- Vast evidence that financial constraints affect prices since Chevalier and Scharfstein (1996)
  - While prices are important, price rigidities are at least equally important to the New Keynesian framework
- This paper: Financial constraints weaken price rigidities both in theory and in the data

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  - Constrained firms move closer to the flexible-price path despite nominal rigidities
- The channel only requires financial frictions and nominal rigidities
- Significant empirical evidence + Quantitative importance
  - Product-level input/output prices + firm-level balance sheet from India
  - Large magnitude for financially constrained firms: 30-50% amplification

Nonlinear NKPC (not today)

- Embed financial constraints into a textbook New Keynesian model
- Occasionally binding financial constraints generate non-linearity in the NKPC:
  - Large negative shocks squeeze profit margins and tighten financial constraints
  - More firms behave like flexible-price firms
  - Steeper NKPC and amplified inflation responses
- Higher price flexibility during large shocks is likely destabilizing (Bhattarai et al., 2018)

Literature

- **Finance-pricing:** New evidence focusing on cost-price relationships using granular data
  - Chevalier and Scharfstein, 1996, Strasser, 2013, Montero and Urtasun, 2014, Gilchrist et al., 2017, Lenzu et al., 2021, Kim, 2021, Balduzzi et al., 2024, Renkin and Züllig, 2024 ...
- **Nonlinear NKPC:** New theory on the nonlinear effects of financial constraints
  - Blanco et al., 2024, Gagliardone et al., 2024, Harding et al., 2023, Forbes et al., 2022, Ball et al., 2022, Benigno and Eggertsson, 2023, Schmitt-Grohé and Uribe, 2022 ...
- **Pass-through estimation:** New heterogeneity along the financial dimension
  - Amiti et al., 2019, Gagliardone et al., 2023 ...

- Introduction
- Theory
- Empirical Analysis
- Nonlinear Phillips Curve (Appendix)

Firm's Problem

- Firm *i* faces (i) nominal rigidities and (ii) financial constraints

Firm's Problem

- Firm i faces (i) nominal rigidities and (ii) financial constraints
- **Production side:**
  - Standard production function: $Y_{i,t} = A_{i,t} L_{i,t}^{1-\gamma} - \omega$,
  - subject to idiosyncratic productivity shocks.
  - Internal cash flows/EBITDA defined as: $\text{EBITDA}_{i,t} = P_{i,t} Y_{i,t} - W_t L_{i,t}$.
- **Rotemberg adj. cost:** $\mathcal{C}_{i,t} = \frac{\tau_p}{2} \pi_{i,t}^2 P_t Y_t$, where $\pi_{i,t} = \ln P_{i,t} / P_{i,t-1}$
  - $\mathcal{C}_{i,t}$ is not an accounting expense (non-monetary)
  - Why? (i) More realistic, e.g., customers dislike price volatility. (ii) Ensures equivalence with Calvo pricing (in progress)

Financial Frictions

- **Profits and dividends:** Some accounting definitions

$$\text{Profit}_{i,t} = \text{EBITDA}_{i,t} - \text{Interest}_{i,t}; \tag{1}$$
$$\text{Div}_{i,t} = \text{Profit}_{i,t} + (D_{i,t} - D_{i,t-1}). \tag{2}$$

- **Earnings-based borrowing constraint:** One-period debt $D_{i,t}$ subject to:

$$D_{i,t} \leq \phi_i \max(\text{EBITDA}_{i,t},\ 0). \tag{3}$$

- **Liquidity constraint:** Penalty term $\mathcal{E}_{i,t}$ is also non-monetary (e.g., raising equity takes time)

$$\mathcal{E}_{i,t} = -\tau_e \min(0, \text{Div}_{i,t}). \tag{4}$$

Objective Function

- Recall that the Rotemberg cost and negative dividend penalty are non-monetary and do not enter $\text{Div}_{i,t}$:

$$\max_{\{P_{i,t},D_{i,t}\}} \mathrm{E}_t \sum_{h=0}^{\infty} \Lambda_{t,t+h} \frac{1}{P_{t+h}} \left[\text{Div}_{i,t+h} - (\mathcal{C}_{i,t+h} + \mathcal{E}_{i,t+h})\right], \tag{5}$$

subject to

$$\text{Nominal rigidities:} \quad \mathcal{C}_{i,t} = \frac{\tau_p}{2} \pi_{i,t}^2 P_t Y_t; \tag{6}$$

$$\text{Borrowing constraint:} \quad \phi_i \max(\text{EBITDA}_{i,t},\ 0) - D_{i,t} \geq 0; \tag{7}$$

$$\text{Equity/liquidity constraint:} \quad \mathcal{E}_{i,t} = -\tau_e \min(0, \text{Div}_{i,t}). \tag{8}$$

(9)

Optimal Prices

- Optimal prices are more sensitive to marginal costs when $\xi_{i,t}$ is higher:

$$\pi_{i,t} = \underbrace{\left(1 + \underbrace{\xi^{div}_{i,t} + \xi^{ebc}_{i,t}\phi_i}_{\xi_{i,t}}\right)}\ \underbrace{\frac{\epsilon_{i,t}-1}{\tau_p}\frac{P_{i,t}Y_{i,t}}{P_tY_t}}_{\kappa}\left[\mathcal{M}_{i,t}MC_{i,t}\frac{P_t}{P_{i,t}} - 1\right] + \mathrm{E}_t\,\Lambda_{t,t+1}\frac{Y_{t+1}}{Y_t}\pi_{i,t+1}, \qquad (10)$$

  - $\mathcal{M}_{i,t} = \frac{\epsilon_{i,t}}{\epsilon_{i,t}-1}$, and $MC_{i,t} = \frac{\partial L_{i,t}}{\partial Y_{i,t}}\frac{W_t}{P_t}$ (real marginal cost),
  - $\xi^{div}_{i,t}$ and $\xi^{ebc}_{i,t}$ are the Lagrangian multipliers on the liquidity and borrowing constraints

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- But it's still messy... It is more useful to examine the limiting case.

Nominal Rigidities in the Limiting Case

- Let $P_{i,t}^f$ be the optimal flexible price that satisfies: $P_{i,t} = \mathcal{M}_{i,t} MC_{i,t} P_t$

Nominal Rigidities in the Limiting Case

- Let $P^f_{i,t}$ be the optimal flexible price that satisfies: $P_{i,t} = \mathcal{M}_{i,t} MC_{i,t} P_t$

Proposition (Nominal Rigidities and Financial Frictions)

In the limiting case where (i) $\xi_{i,t} \to \infty$ and (ii) $\forall h, \frac{\xi_{i,t}}{\xi_{i,t+h}} \to \infty$, the optimal sticky price $P^*_{i,t}$ converges to the optimal flexible price $P^f_{i,t}$. Hence, tight financial constraints weaken nominal rigidities.

$$\lim_{\xi_{i,t} \to \infty} P^*_{i,t} = P^f_{i,t}. \tag{11}$$

- In the special case of CES + CRS, the limiting case features complete cost pass-through.

Real Rigidities in the Limiting Case

- Strategic complementarities depend on how $P_{-i,t}$ affects $\mathcal{M}_{i,t}$:
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Proposition (Strategic Complementarities and Financial Frictions)

Holding marginal costs constant:

- *If* $\frac{\partial \epsilon_{i,t}}{\partial p_{-i,t}} > 0$, *strategic complementarities strengthen in the limiting case, i.e., tight financial constraints amplify strategic complementarities.*
- *If (i)* $\frac{\partial \epsilon_{i,t}}{\partial p_{-i,t}} = 0$ *and (ii)* $\frac{\partial \epsilon_{i,t+h}}{\partial p_{-i,t}} > 0$ *for some* $h \geq 1$, *strategic complementarities vanish in the limiting case, i.e., tight financial constraints weaken strategic complementarities.*

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Empirical Analysis

- Propositions 1 and 2 are empirically testable predictions.
- More importantly, Are the mechanisms quantitatively important? — How often do we see the limiting case in the data?
- ⇒ Pass-through regressions to examine the two propositions
  - à la Amiti et al. (2019)

Data

- Indian CMIE Prowess database
  - Details: Goldberg et al. (2010a), Goldberg et al. (2010b), De Loecker et al. (2016) ...
  - Data cleaning: Amiti et al. (2019)
- Annual panel of Indian manufacturing firms:
  - Balance sheet data: financial information
  - Product-level prices/quantities for both outputs and material inputs
    - Output prices highly correlated with aggregate PPI PPI
  - 1992-2011: Include both high- and stable-inflation periods
- Ideal to test how finance interacts with cost-price relationships

Baseline Specification

- Double-interaction pass-through regressions: Tight $\xi_{i,t}$ $\times$ Marginal costs

$$\begin{aligned}\Delta p_{i,t} = {} & \beta_0 \Delta mc_{i,t} + \beta_1 \mathbf{1}_{i,t}^{\text{Tight}} \Delta mc_{i,t} && \cdots\cdots \text{Cost pass-through} \\ & + \gamma_0 \Delta p_{-i,t} + \gamma_1 \mathbf{1}_{i,t}^{\text{Tight}} \Delta p_{-i,t} && \cdots\cdots \text{Strategic comp.} \\ & + \zeta\ \mathbf{1}_{i,t}^{\text{Tight}} + \text{Fixed Effects} + \varepsilon_{i,t}. && (12)\end{aligned}$$

- β_1, γ_1, and ζ are the effects of financial constraints on pricing

Baseline Specification (cont.)

- Pre-determined $\mathbf{1}_{i,t}^{\text{Tight}}$: Dummy $= 1$ if below 25^{th}, lagged by 2 years
  - EBITDA-to-sales: Internal cash flows, more comparable across firms
  - ICR: Interest coverage ratio
  - DSCR: Debt service coverage ratio (current portion of debt obligations)

Within-firm variation | Density plot

- $\Delta mc_{i,t}$: Use average variable cost (COGS) to measure MC Amiti et al. (2019), Gagliardone et al. (2023)

$$\Delta mc_{i,t} = \Delta \ln \frac{\text{COGS}_{i,t}}{Y_{i,t}}. \tag{13}$$

Identification Challenges: $\Delta mc_{i,t}$

- By definition: $d\ mc_{i,t} = d$ input price$_{i,t} + d\ \frac{\partial \text{input}_{i,t}}{\partial Y_{i,t}}$
  - Textbook model where firms are price takers: Any input price can be an IV
- Unfortunately we don't live in the textbook model:
  - Financially constrained firms may negotiate harder for lower input prices, which biases β_1

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  - Top 10% 6-digit product codes ranked by the # of unique buyers (> 152 in Prowess)
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  - Top 10% 6-digit product codes ranked by the # of unique buyers (> 152 in Prowess)
  - Price changes are assumed exogenous for various idiosyncratic reasons
- **Main IV:** Price changes of major inputs $\times$ Input cost share $= (x^{\text{mj}} \Delta \rho^{\text{mj}})_{i,t}$
  - Sanity check (β_0): Estimates highly consistent with the literature
  - Sanity check (β_1): Financial constraints not correlated with lower input prices

Example of major inputs

Identification Challenges: $\Delta p_{-i,t}$

- Need idiosyncratic variation in competitors' marginal costs to identify γ's
- **Main IV:** Similar to $\Delta mc_{i,t}$
  - For each competitor j, calculate cost contribution by major inputs: Price changes of major inputs $\times$ Cost share $= (x^{\text{mj}} \Delta \rho^{\text{mj}})_{j,t}$
  - Averaged across competitors, weighted by market share $= (x^{\text{mj}} \Delta \rho^{\text{mj}})_{-i,t}$

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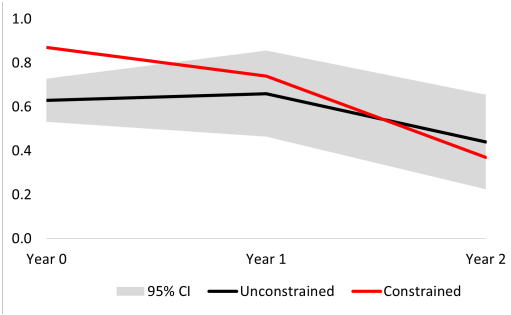
  - Averaged across competitors, weighted by market share $= (x^{mj}\Delta\rho^{mj})_{-i,t}$
- Is there enough idiosyncratic variation?
  - Concern: Firms still source in the same domestic market even if they have different suppliers, especially true for major input markets
  - Strongly pass the underidentification test (Kleibergen-Paap rk LM statistic ≈ 40)
- (All IVs are interacted with the dummy to avoid the "forbidden regression")

Effects of Financial Constraints on Pricing (Tight = Low EBITDA)

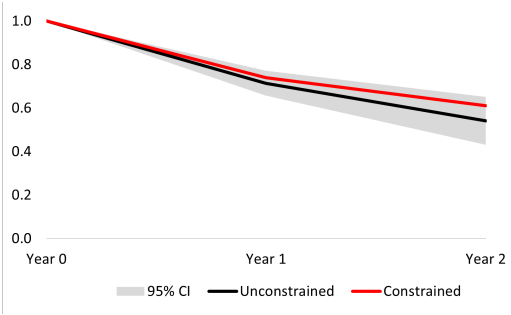
Dep. variable: $\Delta p_{i,t}$	(1)	(2)	(3)	(4)
$\Delta mc_{i,t}$ ($\hat{\beta}_0$)	0.64***	0.64***	0.63***	0.62***
	(0.05)	(0.06)	(0.05)	(0.05)
Tight $\times$ $\Delta mc_{i,t}$ ($\hat{\beta}_1$)	0.23***	0.20**	0.24***	0.27***
	(0.08)	(0.09)	(0.08)	(0.08)
$\Delta p_{-i,t}$ ($\hat{\gamma}_0$)	0.35***	0.35***	0.29***	0.36***
	(0.08)	(0.09)	(0.09)	(0.13)
Tight $\times$ $\Delta p_{-i,t}$ ($\hat{\gamma}_1$)	-0.26**	-0.24**	-0.26**	-0.29***
	(0.10)	(0.11)	(0.10)	(0.11)
Tight	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Firm + Year + Sector FE (Industry FE)	Y	Y		
Firm + Sector-Year FE (Industry-Year FE)			Y	Y
R^2	0.729	0.732	0.688	0.671
N	9,738	9,065	9,738	9,065
Firms	826	797	826	797
Two-digit Sectors (Four-digit Industries)	9	25	9	25
Weak IV F-test (Cragg-Donald)	64.65	59.32	65.63	58.30
Weak IV F-test (Kleibergen-Paap)	15.05	14.11	15.09	10.00
Hansen J-test p-value	0.575	0.654	0.248	0.559
Financial Amplification				
$\hat{\beta}_0 + \hat{\beta}_1$	0.88***	0.85***	0.87***	0.88***
$\hat{\gamma}_0 + \hat{\gamma}_1$	0.09	0.11	0.03	0.07

Notes: Weighted by average PPI-deflated sales. Standard errors are clustered by firm and sector/industry-year.

Dynamic Effects on Pricing



(a) Cumulative Price Change w.r.t. $\Delta mc_{i,t}$



(b) Major Input Price Persistence $(\rho^{mj}_{i,t+h} - \rho^{mj}_{i,t-1})$

Higher Pass-through ⇒ More Stable Margins

(b) **Effects on the EBITDA Margin**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	x = EBITDA				x = ICR				x = DSCR			
$\Delta mc_{i,t}$ ($\hat{\beta}_0$)	-0.20***	-0.20***	-0.18***	-0.18***	-0.22***	-0.21***	-0.19***	-0.20***	-0.22***	-0.23***	-0.19***	-0.21***
	(0.05)	(0.05)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
Tight × $\Delta mc_{i,t}$ ($\hat{\beta}_1$)	0.14	0.17	0.16*	0.14*	0.28*	0.28*	0.21*	0.24*	0.23*	0.27**	0.19*	0.21**
	(0.14)	(0.13)	(0.09)	(0.08)	(0.16)	(0.15)	(0.12)	(0.12)	(0.12)	(0.12)	(0.10)	(0.10)
$\Delta p_{-i,t}$ ($\hat{\gamma}_0$)	0.20**	0.13			0.22***	0.09			0.22**	0.13		
	(0.09)	(0.12)			(0.08)	(0.11)			(0.09)	(0.11)		
Tight × $\Delta p_{-i,t}$ ($\hat{\gamma}_1$)	-0.13	-0.19			-0.28	-0.28			-0.25*	-0.30**		
	(0.18)	(0.16)			(0.20)	(0.19)			(0.14)	(0.13)		
Tight	0.01***	0.01***	0.01	0.01	0.01**	0.01***	0.00	0.00	0.01**	0.01**	0.00	-0.00
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector-Year FE	Y		Y		Y		Y		Y		Y	
Industry-Year FE		Y		Y		Y		Y		Y		Y
R^2	0.021	0.017	0.013	0.018	-0.017	-0.015	-0.004	-0.003	-0.017	-0.024	-0.009	-0.009
N	9,702	9,030	9,702	9,030	9,702	9,030	9,702	9,030	9,702	9,030	9,702	9,030
Firms	826	797	826	797	826	797	826	797	826	797	826	797
Two-digit Sectors	9		9		9		9		9		9	
Four-digit Industries		25		25		25		25		25		25

Additional Results (in the paper)

- Leverage:
  - Constrained firms moderately deleverage; Unconstrained firms unaffected
- Total intermediate goods costs (not just major inputs):
  - Constrained firms do not have higher present/future input costs
- Non-linear effects of $\Delta mc_{i,t}$: Stronger during large cost increases (3.5%)
- Non-binary dummy: One-sided effects of financial constraints
- Output (noisy)
- ...

Summary

- EBITDA, ICR, DSCR give nearly identical results
- Financial constraints weaken both nominal rigidities and real rigidities
  - Proportion 1: $\beta_1 \gg 0$; Cost pass-through $\uparrow$; Nominal rigidities $\downarrow$
  - Proportion 2: $\gamma_1 \ll 0$; Strategic complementarities $\downarrow$; Real rigidities $\downarrow$
- Quantitatively important:
  - On average, $(\hat{\beta}_0 + \hat{\beta}_1) \approx 0.85$ is $> 30\%$ higher than $\hat{\beta}_0 \approx 0.64$
  - $(\hat{\beta}_0 + \hat{\beta}_1) \approx 1$ (50% higher) during large cost shocks ($>$ 70th percentile, or $> 3.5\%$)
  - Recall that the "Tight" dummy covers 25% of observations

Appendix

Appendix

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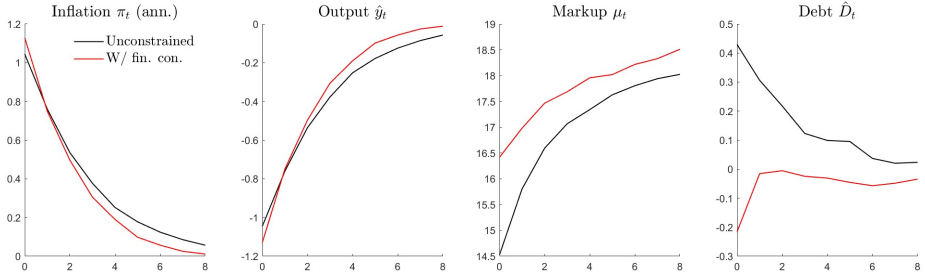
New Keynesian Model

- Adding financial constraints to a textbook NK model
  - Heterogeneous firm block
    - With financial constraints & idio. productivity shocks
    - (No strategic complementarities in the textbook model)
  - Representative households
  - Flexible wages
  - Taylor rule MP

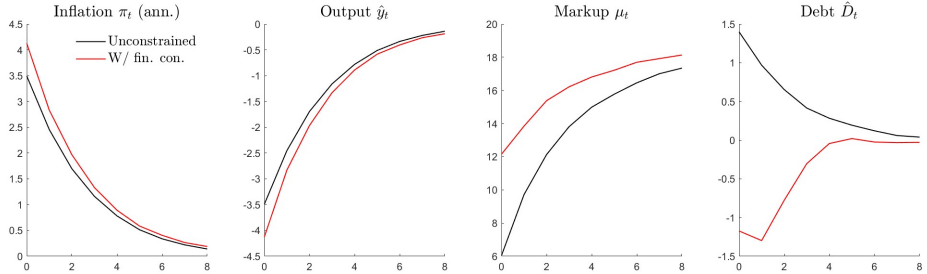
Small A Shock

- π_t upon impact: Small amplification
- Cumulative π_t in 4Q: No amplification at all



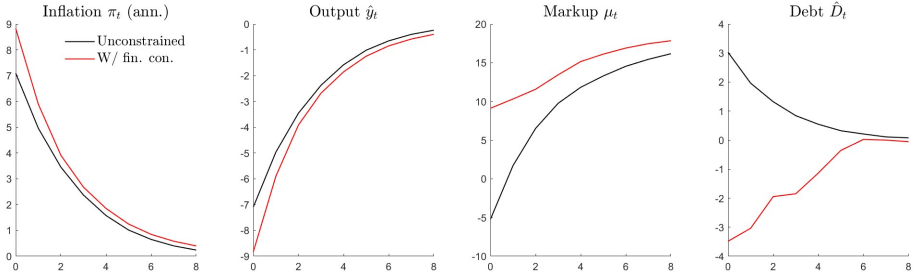
A Larger Shock

- π_t upon impact: 18.2% higher
- Cumulative π_t in 4Q: 16.5% higher



Even Larger

- π_t upon impact: 24.4% higher
- Cumulative π_t in 4Q: 19.2% higher



Aggregate Trends

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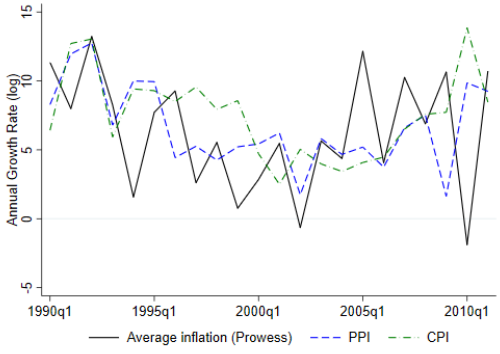
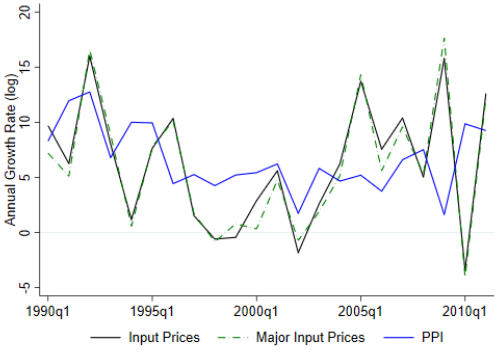


(a) Output Prices



(b) Input Prices

Within-Firm Variation

- A firm is classified as a low-EBITDA firm at t if its EBITDA ratio (after removing medians) at $t-2$ is below the 25th percentile in the final regression sample.
- 65% are considered low-EBITDA for at least once. 19% of firms are considered low-EBITDA for over 50% of the time, and 7.5% of firms for over 80% of the time. Only 2.7% of firms are always low-EBITDA. Low-EBITDA firms account for around 18% of sales in the regression sample.
- For the low-ICR dummy, the statistics are 73%, 14%, 3.6%, 0.5% (of firms), and 18% (of sales). For the low-DSCR dummy: 71%, 14%, 4.6%, 1.3% (of firms), and 20% (of sales).

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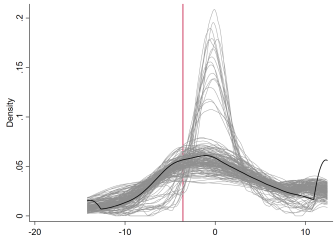
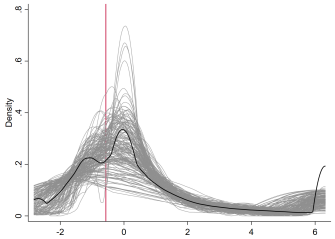
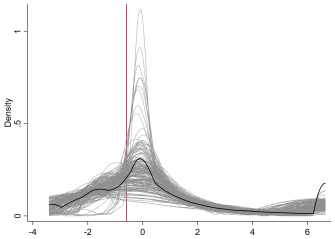
Financial Variables



EBITDA



ICR



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Major Inputs

Code	Name	Code	Name
2404	Foodgrain	5008	Organic chemicals
2408	Non-grain food crops	5012	Drugs, medicines & allied products
2412	Non-food agricultural crops	5024	Paints & dyes, etc.
2704	Non-metallic minerals	5028	Cosmetics, toilet preparations, soap &
2708	Metallic ores, slag, ash	5056	Plastics & rubbers
2712	Mineral fuels	5406	Cement, asbestos, abrasives, etc.
3008	Vegetable oils	5424	Pearls and precious stones
3024	Oil cakes, meals and animal feeds	5704	Ferrous metals & products
3316	Sugar and allied products	5708	Non-ferrous metals & products
3368	Tea incl. instant tea	6006	Coke & semi-coke of coal, lignite or pe
3612	Cotton textiles	6036	Petroleum products
3620	Man-made textiles	6304	Non-electrical machinery
4606	Pulp, waste, etc.	6308	Electrical machinery other than electro
4612	Paper, newsprint & paper board	6312	Electronics
5000	Chemicals & chemical products	7048	Miscellaneous items in electronics
5004	Inorganic chemicals		

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