The Macro Impact of the Debt-Inflation Channel on Investment

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Motivation: Inflation and Real Economy

- Key transmission from inflation to the real economy: **Debt-inflation (Fisher (1933)) channel**.
  - Unexpected inflation redistributes wealth from creditors to debtors.
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  1. Substantial nominal debt $\approx 72\%$ GDP.
  2. Rich heterogeneity in indebtedness across firms.
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- No existing quantitative framework captures these two simultaneously.
- **Quantify the macroeconomic impact of this channel on investment?**

Main Contributions

Empirical Evidence:

- Guided by theory, document new evidence of the Fisher channel on investment.
- Highly indebted firms invest significantly more after inflation surprises.
- Robust across specifications and persistent pattern over time.

Main Contributions

Model Quantification:

- A heterogeneous firm GE model with financial frictions and fixed nominal debt.
    - Real interest rate channel dampens aggregate investment.
    - Reproduce heterogeneous responses and micro moments.
- 1% inflation $\Rightarrow$ 0.8% $\uparrow$ aggregate investment.
    - The firm-side effect is more significant than household-side.
- Explain up to 70% of the post-COVID investment surge.

Contribution to the Literature

- **Debt-Inflation (Fisher) Channel:**
  - **Households:** Doepke and Schneider (2006), Auclert (2019), Fagereng et al. (2023), Schnorpfeil et al. (2023); **Firms:** Gomes et al. (2016), Fabiani and Fabio Massimo (2023), Brunnermeier et al. (2025).
  - Macro quantification of **investment** with rich firm **heterogeneity**.
- **Investment & Financial Frictions:**
  - Bernanke et al. (1999), Khan and Thomas (2013), Ottonello and Winberry (2020), Durante et al. (2022), Jeenas (2023).
  - Fisher channel can relax financial constraints and drive dynamics.
- **Nominal Debt Contract:**
  - Sheedy (2014), Garriga et al. (2017), Alpanda and Zubairy (2017), Alpanda and Zubairy (2019), Wang and Bai (2025)
  - Nominal debt contract rigidity has real effects.

Roadmap

1. A Conceptual Framework
2. Empirical Analysis
3. Heterogeneous Firm GE Model
4. Quantitative Analysis
5. Conclusion

A Conceptual Framework

A 2-Period Model: Setup

- Two periods $t = 1, 2$.
- Firm produces with $y_t = k_t^\alpha$.
- Initial capital k_1, fully depreciate.
- Fixed nominal debt B_1, with $R = r$.

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- Two periods $t = 1, 2$.
- Firm produces with $y_t = k_t^\alpha$.
- Initial capital k_1, fully depreciate.
- Fixed nominal debt B_1, with $R = r$.
- Let real debt $b_t = B_t / P_{t-1}$, period 1 net worth is:

$$nw_1 = k_1^\alpha - \frac{(1+r)b_1}{1+\pi_1}$$

  - Unexpected Inflation $\pi_1 \uparrow \implies$ Net Worth $nw_1 \uparrow$

A 2-Period Model: Constrained Optimality

- Firm chooses (k_2, b_2) to maximize discounted dividends

$$\max_{k_2,b_2}\{d_1 + \frac{d_2}{1+r}\}$$

- Two financial frictions
  - **Non-negative Dividend**

$$d_1 = nw_1 - k_2 + b_2 \geq 0$$
$$d_2 = k_2^\alpha - (1+r)b_2 \geq 0$$

  - **Borrowing Constraint**

$$\phi k_2^\alpha - (1+r)b_2 \geq 0$$

▸ Feasibility ▸ Optimality

From Theory to Empirics

- Constrained $k_2^\star$ relates b_1, π_1, and define $inv_1 = \frac{k_2}{k_1}$

$$\Delta inv_1^\star = \Delta\left(\frac{k_2^\star}{k_1}\right) = \underbrace{\frac{1}{k_1}\frac{1}{1-\frac{\phi\alpha(k_2^\star)^{\alpha-1}}{1+r}}\frac{(1+r)}{(1+\pi_1)^2}}_{\text{Elasticity } \beta} \times b_1 \times \Delta\pi_1$$

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- Testable Prediction $\beta > 0$:
    - Stronger $\Delta inv_1^\star$ to $\Delta\pi_1$ for firms with higher b_1

Empirical Analysis

Data and Measurement

- **Firm Data:** Quarterly Compustat, 1990Q1 - 2023Q4.
  - **Indebtedness:** $b_{j,t-1}$, Log of total nominal debt (residualized).
  - **Investment Rate:** $inv_{j,t} = i_{j,t}/k_{j,t-1}$, perpetual inventory method.

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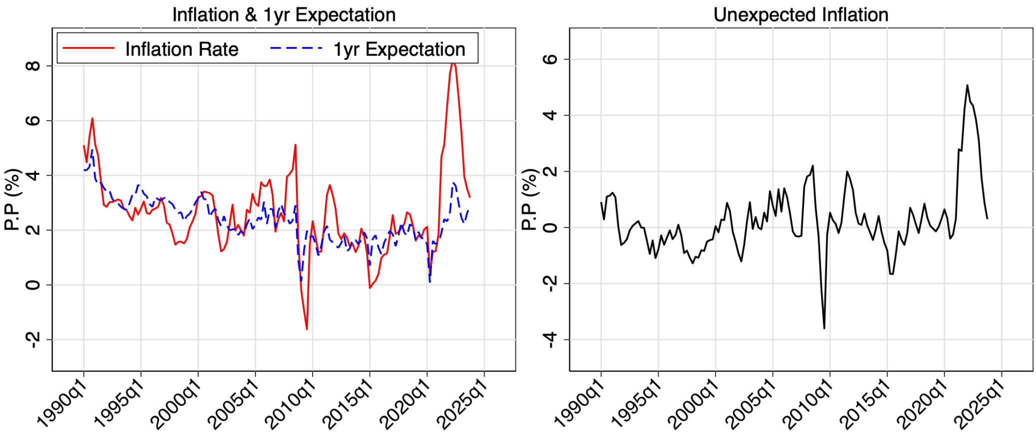
- **Inflation Data:**
  - Realized Inflation: Consumer Price Index (CPI) from BLS.
  - Expected Inflation: 1-year ahead from FRB Cleveland.
  - **Unexpected Inflation ($\epsilon_t^\pi \equiv \Delta\pi = \pi_t^{\text{realized}} - \mathbb{E}_{t-1}\pi_t$)**

Summary

Unexpected Inflation Series



Key episode: large inflationary surprises in 2021-22.

Empirical Strategy

- To test model's prediction, use following specification

$$inv_{j,t} = \alpha_j + \alpha_{s,t} + \beta(b_{j,t-1} \times \epsilon_t^{\pi}) + \gamma b_{j,t-1} + \mathbf{\Gamma}'_A(b_{j,t-1} \times \mathbf{A}_t) + \mathbf{\Gamma}'_Z \mathbf{Z}_{j,t-1} + e_{j,t}$$

  - α_j: Firm FE; $\alpha_{s,t}$: Sector $\times$ Time FE.
  - $b_{j,t-1} \times \mathbf{A}_t$ Interaction with GDP growth, FFR.
  - $\mathbf{Z_{j,t-1}}$ Standard firm level controls.
  - Two-way clustering standard errors.

- **Theory predicts:** $\beta > 0$.

Main Result: Heterogeneous Responses

$inv_{j,t}$	(1)	(2)	(3)	(4)
$b_{j,t-1} \times \epsilon_t^{\pi}$	0.116^{***}	0.124^{***}		
	(0.029)	(0.029)		
$b_{j,t-1} \times \pi_t$			0.089^{***}	0.091^{***}
			(0.023)	(0.023)
Firm Ctrl	No	Yes	No	Yes
Observations	268757	268757	268757	268757
R^2	0.118	0.125	0.118	0.124

Notes: $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$. Standard errors in parentheses; two-way clustering by firm and time. Firm, sector-time FE and aggregate controls included.

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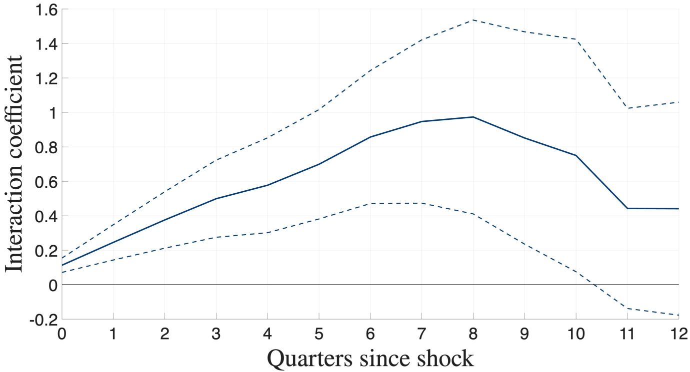
- **Magnitude:** A 1% inflation surprise $\Rightarrow$ 0.35% $\uparrow$ investment rate for a firm with 1 std. (2.99) $\uparrow$ indebtedness.

Dynamic Effects

- Local projection to trace dynamic effects:

$$\Delta \log k_{j,t+h} = \alpha_j + \alpha_{s,t} + \beta_h (b_{j,t-1} \epsilon_t^{\pi}) + \gamma_h b_{j,t-1} + \mathbf{\Gamma}'_{Ah} (b_{j,t-1} \mathbf{A}_t) + \mathbf{\Gamma}'_{Zh} \mathbf{Z}_{j,t-1} + e_{j,t,h}$$



Robustness

- Controlling earnings, liquidity, size, age cohort interactions.
- Excluding the Great Recession and COVID periods.
- Using alternative measures of indebtedness (e.g., leverage ratio).

Takeaway: Significant and robust empirical support for the firm-side Fisher channel on heterogeneous investment responses.

Heterogeneous Firm GE Model

Quantitative Model: Features

- Flexible price economy in terms of goods and wages.
    - Isolate pure Fisher channel effects.
- Continuum of mass 1 heterogeneous firms indexed by i.
- One-period safe nominal bond predetermined in last period.
- Financial frictions on the firm side.
- Exogenous entry and exit with prob. π_d.

Quantitative Model: Heterogeneous Firms

- Decreasing return to scale technology for firm i

$$y_{i,t} = z_{i,t} k_{i,t}^{\alpha} n_{i,t}^{\nu}, \quad \alpha + \nu < 1$$
$$\log(z_{i,t+1}) = \rho \log(z_{i,t}) + \sigma \varepsilon_{i,t+1}, \quad \varepsilon_{j,t+1} \sim N(0,1)$$

  with goods sold at real price p_t

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- Capital Accumulation

$$k_{i,t+1} = i_{i,t} + (1-\delta) k_{i,t}$$

$$AC(i_{i,t}, k_{i,t}) = \frac{\gamma}{2} \frac{i_{i,t}^2}{k_{i,t}}$$

Quantitative Model: Key Frictions

- Borrowing constraint, by defining $b_t = \frac{B_t}{P_{t-1}}$.

$$b_{i,t+1} \leq \frac{1+\pi_{t+1}}{1+R_{t+1}} \phi(p_{t+1} z_{i,t+1} k_{i,t+1}^{\alpha} n_{i,t+1}^{\nu} - w_{t+1} n_{t+1} + (1-\delta) k_{i,t+1})$$

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- Non-negative dividend constraint:

$$d_{i,t} = p_t z_{i,t} k_{i,t}^{\alpha} n_{i,t}^{\nu} - w_t n_{i,t} - i_{i,t} - AC(i_{i,t}, k_{i,t}) - (1+R_t)\frac{b_{i,t}}{1+\pi_t} + b_{i,t+1} \geq 0$$

Quantitative Model: Timing

1. Enter period with state variables (z, k, b).
2. Death shocks realize and exit after production.
3. Choose (k', b') to the next period if continuing.

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- Distribution evolves following

$$\mu_{t+1}(z', k', b') = \int (1 - \pi_d)\, \mathbf{1}\{k' = k^*(z,k,b)\}\, \mathbf{1}\{b' = b^*(z,k,b)\}$$
$$\times g(z' \mid z)\, \mathrm{d}\mu_t(z,k,b) + \ m_{\text{ent}}\ \mu_{\text{ent}}(z')\, \mathbf{1}\{k' = k_0\}\, \mathbf{1}\{b' = 0\}$$

Quantitative Model: Firm's Problem

$$V_t(z,k,b) = (1-\pi_d)\,V_t^c(z,k,b) + \pi_d\,V_t^d(z,k,b)$$

$$V_t^c(z,k,b) = \max_{k',b'} \left\{ d_t(z,k,b,k',b') + \mathbb{E}_t\left[\Lambda_{t+1} V_t(z',k',b' \mid z)\right]\right\}$$

$$s.t. \qquad d_t = p_t z k^\alpha n^\nu - w_t n - i - AC(i,k) - (1+R_t)\frac{b}{1+\pi_t} + b' \geq 0$$

$$b' \leq \frac{1+\pi_{t+1}}{1+R_{t+1}}\left(p_{t+1}\underline{z}' k'^\alpha n'^\nu - w_{t+1} n' + (1-\delta)k'\right)$$

Quantitative Model: Other Agents

- Representative Households
  - Maximize expected utility subject to budget constraint:

$$E_0 \sum_{t=0}^{\infty} \beta^t (\log C_t - \chi N_t)$$

$$s.t. \qquad P_t C_t + S_{t+1} = W_t N_t + (1 + R_t) S_t + D_t$$

  - Stochastic Discount Factor Λ_{t+1} follows $\beta \frac{C_t}{C_{t+1}}$.
- Retailers and Final Goods Producer
  - Linear technology to produce differentiated goods.
  - CES Technology to produce final goods using differentiated goods.
- Central Bank
  - Control inflation π_t.

Quantitative Model: Equilibrium

Equilibrium The steady state equilibrium for the flexible price economy is given by a set of value functions $V_t(z, k, b)$, decision rules k', b', n for capital, debt and labor, a measure of firms $\mu_t(z, k, b)$, and a set of prices $w_t, r_t, p_t, \Lambda_{t+1}$ such that:

1. given prices, all firms optimize: V solves bellman equation with associated policy rules;
2. household optimizes;
3. goods market, labor market and asset market all clear;
4. the distribution of firms μ is stationary.

Quantitative Analysis

Calibration

Description	Parameter	Value	Source
Household			
Discount factor	β	0.99	Quarterly Standard
Firm			
TFP persistence	ρ_z	0.90	O&W 2020
SD of TFP innovations	σ_z	0.10	Literature $0.03 - 0.15$
Depreciation rate	δ	0.025	Annual Rate 10%
Capital coefficient	α	0.25	O&W 2020
Labor coefficient	ν	0.60	O&W 2020
Borrowing limit	ϕ	1.00	Gross Leverage
Exogenous exit probability	π_d	0.02	Annual Rate 8%
Investment adj. cost	γ	1.00	Literature $0.04 - 2.5$
Entrant initial capital	k_0	0.20	Employment Size

Model Fit

Description	Moment	Data	Model
Mean Gross Leverage	$\mathbb{E}\left[\frac{b}{k}\right]$	0.316	0.286
Mean Investment Rate (p.p.)	$\mathbb{E}[\frac{i}{k}]$	3.936	4.398
SD Investment Rate (p.p.)	$\sigma\left(\frac{i}{k}\right)$	10.263	8.27
Leverage Auto-correlation	$\mathrm{Corr}(lev_t, lev_{t-1})$	0.938	0.989
Share of Positive Net Debt	$\mathrm{Frac}(b > 0)$	0.708	0.632
Annual Exit Rate	$\mathbb{E}[\text{Exit}]$	0.08	0.08
Employment Size Ratio	$\frac{N_{\text{age}<1\text{yr}}}{N_{\text{age}>10\text{yr}}}$	0.022	0.02

Solution Method

- Calibrated Steady State Equilibrium.
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- Difficulty in solving heterogeneous agent with aggregate uncertainty.
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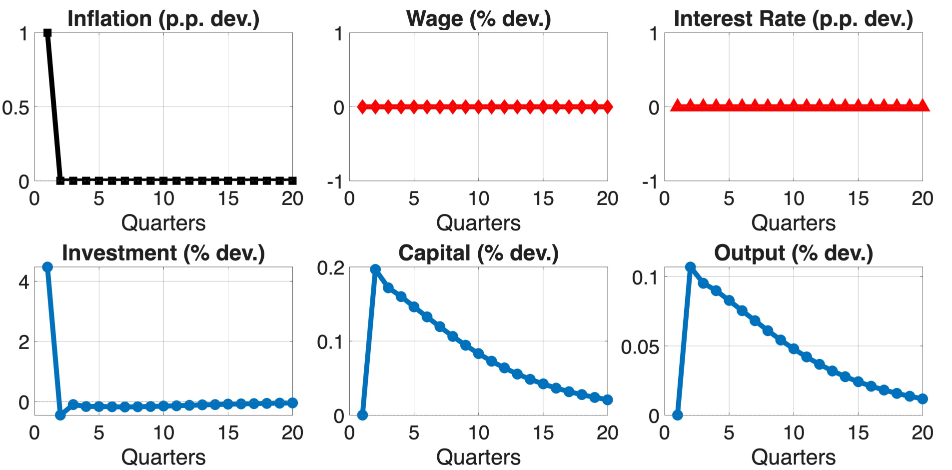
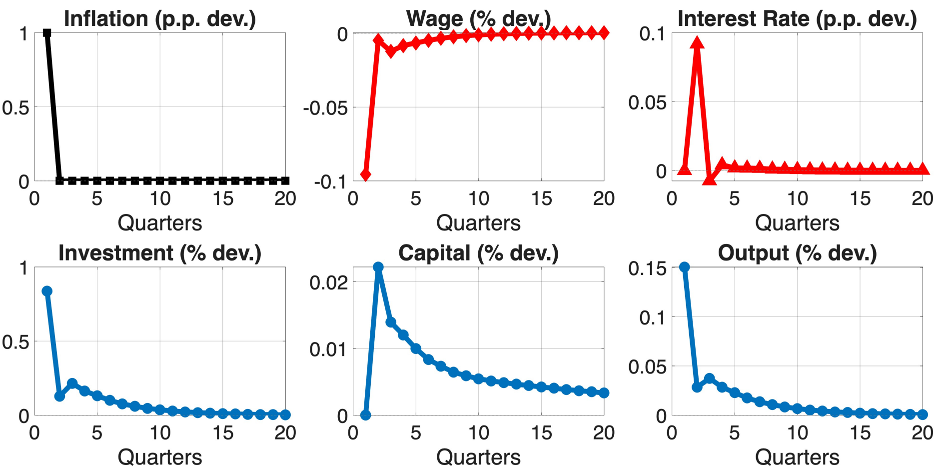
    - Tracking state variables including infinite dimensional distribution.
- Sufficient Statistic: Sequence Space Jacobians, Auclert et al. (2021).
    - Linear equations in perfect foresight sequence space.
    - Highly efficient to get full impulse responses.
- One of a few SSJ applications in firms side studies.

PE Impulse Response



- Strong PE effects: 1% $\uparrow$ inflation $\Rightarrow$ 4.5% $\uparrow$ aggregate investment.

GE Impulse Response



- Fisher channel effect on aggregate investment dampened to 0.83%.

Significant Effect: Firm vs. Household

- Fisher channel effect on household is modest.
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- Fisher channel effect on household is modest.
  - Doepke et al. (2015): Consumption drops after inflationary surprise.
  - Auclert (2019): Empirical redistribution elasticity for price is small.
- In contrast, firm side effect is significant.
  - Positive investment responses with firm heterogeneity in indebtedness.
  - PE effect large on impact; GE effect quantitatively meaningful.
  - Shifting the Fisher channel focus from households to firms.

Model vs. Empirics: Reproducing the Heterogeneity

- Run the same regressions on the model-simulated panel.

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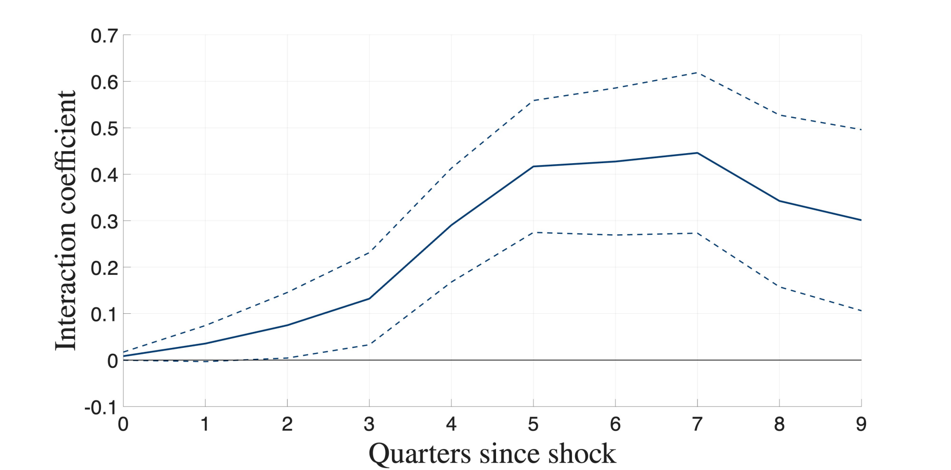
Investment Rate	Empirical Estimate		Model Implied Results	
	(1)	(2)	(3)	(4)
$b_{j,t-1} \times \epsilon_t^{\pi}$	0.116***	**0.124*** **	0.048*	**0.024*** **
	(0.029)	(0.029)	(0.026)	(0.005)
Firm Control	No	Yes	No	Yes
Observations	268757	268757	192801	192801
R^2	0.118	0.125	0.272	0.968

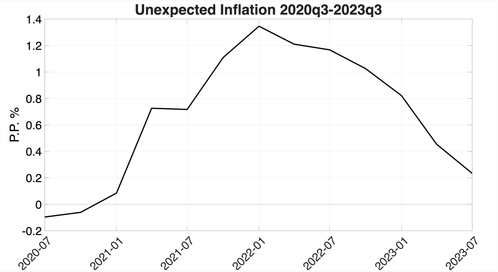
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses; two-way clustering by firm and time. Column (1) and (2) include firm, sector-time FE and aggregate controls; (3) and (4) exclude sector-time FE.

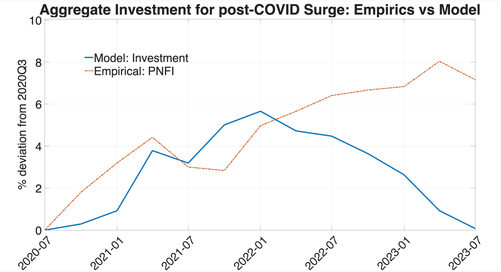
Model vs. Empirics: Reproducing the Dynamics



Application: Post-COVID Investment Surge

- How much does the channel explain?





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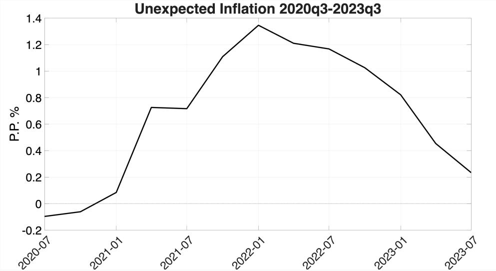

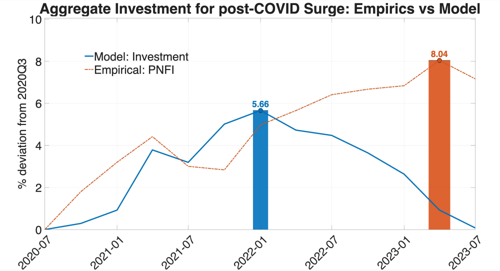

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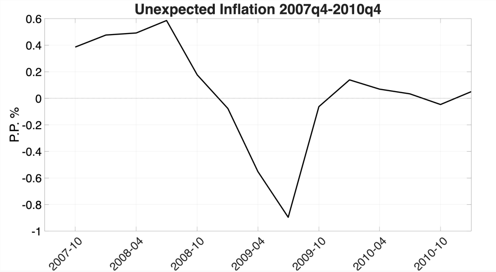

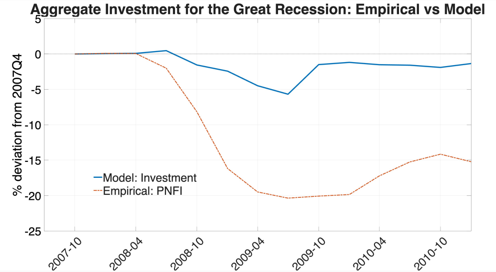

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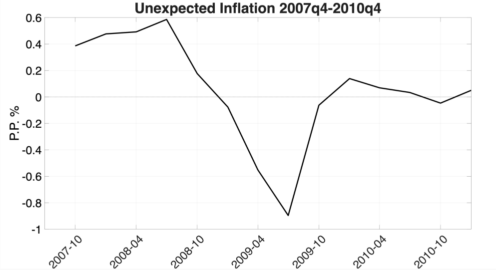

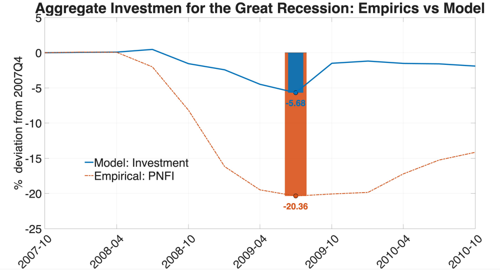

- Explain 25% investment decline.

Conclusion

Conclusion

- **Empirically Heterogeneous.**
  - Evidence for the debt-inflation (Fisher) channel on investment.
  - High indebted firms increase investment relatively more.
- **Quantitatively Significant.**
  - Develop a heterogeneous firm model to quantify macro impacts.
  - 1% inflation surprise $\Longrightarrow$ **0.83%** aggregate investment.
  - More significant Fisher effects on firms than households.
  - Reproduce 70% post-COVID investment surge.

2-Period Model: Feasibility

Single feasibility inequality

$$h(k_2) \;\equiv\; k_2 \;-\; \frac{\phi}{1+r}\, k_2^{\alpha} \;\leq\; n w_1$$

Unconstrained benchmark. optimum k_2^{FB} satisfies

$$1 \;=\; \frac{1}{1+r}\,\alpha\,(k_2^{FB})^{\alpha-1} \qquad \Longrightarrow \qquad k_2^{FB} \;=\; \left(\frac{\alpha}{1+r}\right)^{\frac{1}{1-\alpha}}$$

Evaluate the feasibility function at k_2^{FB}:

$$h(k_2^{FB}) = k_2^{FB} - \frac{\phi}{1+r}(k_2^{FB})^{\alpha} = k_2^{FB}\left[1 - \frac{\phi}{\alpha}\right], \quad \text{since } \frac{1}{1+r}(k_2^{FB})^{\alpha} = \frac{k_2^{FB}}{\alpha}.$$

2-Period Model: Feasibility

Implication. The sign of $h(k_2^{FB})$ depends only on $\alpha - \phi$:

- If $\boxed{\alpha > \phi}$, then $h(k_2^{FB}) > 0$.
  - Net worth $nw_1 \geq h(k_2^{FB}) > 0 \Rightarrow k_2^{FB}$
  - $nw_1 \in [0,\, h(k_2^{FB})) \Rightarrow$ on the boundary $k_2 - \frac{\phi}{1+r} k_2^{\alpha} = nw_1 \Rightarrow$ Nonempty constrained region
- If $\alpha \leq \phi$, then $h(k_2^{FB}) \leq 0$.
  - Feasible firms satisfy $nw_1 \geq 0 \Rightarrow nw_1 \geq h(k_2^{FB}) \Rightarrow$ choose k_2^{FB} (unconstrained) $\Rightarrow$ no constrained region

Back

2-Period Model: Optimality Conditions

- Unconstrained maximizer k_2^{FB} is

$$k_2^{FB} = (\frac{\alpha}{1+r})^{\frac{1}{1-\alpha}}$$

when $nw_1 \geq k_2^{FB} - \phi \frac{(k_2^{FB})^\alpha}{1+r}$

- Constrained optimal $k_2^\star$ solves otherwise

$$k_2^\star - \phi \frac{(k_2^\star)^\alpha}{1+r} = nw_1$$

Back

2-Period Model: Core Mechanism

- **Unconstrained Firms (Low Debt):**
  - Low $b_1 \iff$ High nw_1
  - $k_2 = k_2^{FB}$ unchanged, independent of net worth
- **Constrained Firms (High Debt):**
  - High $b_1 \iff$ Low nw_1
  - Investment $(k_2^\star)$ is increasing in net worth (nw_1).

$$\frac{\partial k_2^\star}{\partial nw_1} > 0 \quad \text{and} \quad \frac{\partial nw_1}{\partial \Pi_1} > 0$$

  - **Unexpected inflation $\Pi_1 \uparrow \implies$ Real Debt $\frac{b_1}{\Pi_1} \downarrow \implies$ Net worth $nw_1 \uparrow \implies$ Constraint relaxes $\implies$ Investment $k_2 \uparrow$**

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2-Period Model: Core Mechanism

- Constrained Firm cross derivative

$$\boxed{\frac{\partial^2 k_2^*}{\partial \pi_1\, \partial b_1} = \underbrace{\frac{1+i_1}{(1+\pi_1)^2} \cdot \frac{1}{D}}_{\text{(I)}} + \underbrace{\frac{\phi\alpha(1-\alpha)}{1+r} \cdot \frac{(1+i_1)^2\, b_1\, (k_2^*)^{\alpha-2}}{(1+\pi_1)^3} \cdot \frac{1}{D^3}}_{\text{(II)}}}$$

where

$$D \equiv 1 - \frac{\phi\alpha(k_2^*)^{\alpha-1}}{1+r}.$$

Summary Statistics

Statistic	$\Delta \log k_{j,t}$	$i_{j,t}$	$\Delta \log(ppe)_{j,t+1}$	$capx_{j,t}$	$b_{j,t-1}$
Mean	0.362	3.936	0.315	8.673	3.984
Median	-0.443	2.723	-0.464	4.115	4.149
S.D.	8.729	10.263	13.707	588.098	2.993
95th Percentile	11.182	14.997	15.066	19.788	8.520
Observations	268757	268757	268362	266708	268757

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Different Specifications

	2Way FE	No GDP, FFR	TobinsQ	Sales InterAct
$b_{j,t-1} \times \epsilon_t^{\pi}$	0.117***	0.126***	0.120***	0.115***
	(0.035)	(0.036)	(0.029)	(0.032)
Observations	268757	268757	255045	268757
R^2	0.118	0.124	0.125	0.125
Firm Control	No	Yes	Yes	Yes
Agg InterAct	No	No	Yes	Yes
Sales InterAct	No	No	No	Yes

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses; two-way clustering by firm and time. Firm, sector-time FE and aggregate controls included.

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Different Specifications

	NetDebt	Liquidity	Size	Age	LongDebt	Div
$b_{j,t-1} \times \epsilon_t^{\pi}$	0.065**	0.082***	0.109***	0.109***	0.127***	0.119***
	(0.028)	(0.030)	(0.032)	(0.027)	(0.033)	(0.029)
Observations	179450	254991	255045	255045	255045	255045
R^2	0.140	0.128	0.126	0.129	0.126	0.126

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses; two-way clustering by firm and time. Firm, sector-time FE and aggregate controls included. Net debt and long debt columns replace the debt in the main specification. All controls the interaction with GDP growth and federal funds rate.

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Sample Selection

	(1)	(2)	(3)	(4)	(5)	(6)
$b_{j,t-1} \times \epsilon_t^{\pi}$	0.124***	0.108***	0.129***	0.127***	0.126***	0.076*
	(0.029)	(0.029)	(0.031)	(0.032)	(0.029)	(0.042)
Observations	268757	244950	251150	255870	264037	232390
R^2	0.125	0.129	0.127	0.126	0.126	0.136
Firm Control	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Column (1) is the main result. Column (2) considers post-1994 sample. Column (3) excludes the Great Recession and COVID period. (4) and (5) exclude two recessions respectively. (6) considers the pre-COVID sample and excludes the Great Recession.

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Leverage Ratio

Investment Rate	(1)	(2)	(3)	(4)
$b_{j,t-1} \times \epsilon_t^{\pi}$	0.055*	0.056*		
	(0.030)	(0.030)		
$b_{j,t-1} \times \pi_t$			0.052**	0.054**
			(0.024)	(0.024)
Observations	316147	316147	316147	316147
R^2	0.110	0.117	0.110	0.117
Firm Control	No	Yes	No	Yes

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Retailer and Final Goods Producer

- Retailer j
  - Linear technology $\tilde{y}_j = y$
- Final Goods Producer
  - Constant elasticity of substitution (CES) technology

$$Y_t = \left(\int_0^1 \tilde{y}_{jt}^{\frac{\epsilon_p - 1}{\epsilon_p}} \, dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

  - Price index $P_t = \left(\int_0^1 \tilde{P}_{jt}^{1-\epsilon_p} dj \right)^{\frac{1}{1-\epsilon_p}}$
  - SS real price of wholesale goods is $p = \frac{\epsilon_p - 1}{\epsilon_p}$.

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Market Clearing Conditions

- Goods Market

$$\int y_{jt} d\mu_t = Y_t = C_t + (1-\pi_d)\int (i_{jt} + AC_{jt}) d\mu_t + \mu_{ent} k_0 - \pi_d (1-\delta) K_t$$

- Asset Market

$$\int b_{i,t} d\mu_t = \frac{S_t}{P_{t-1}}$$

- Labor Market

$$\int n_{i,t} d\mu_t = N_t$$

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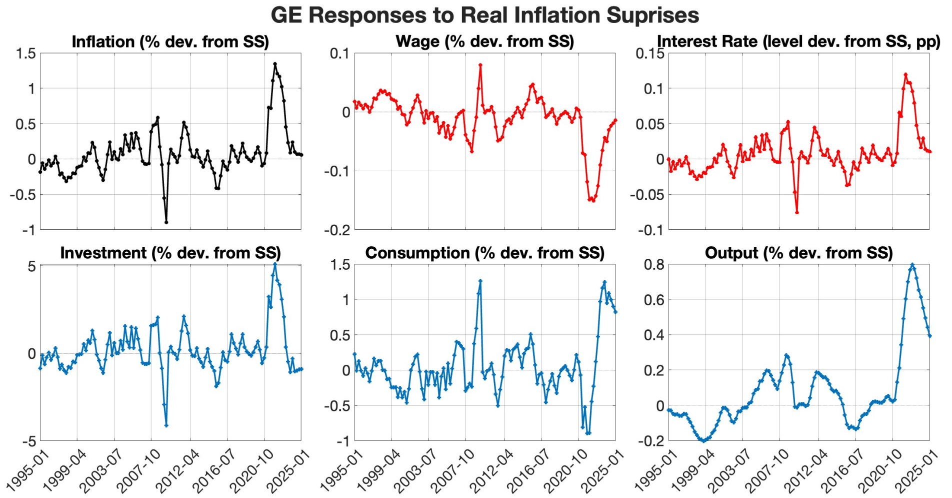
Full Historical Application



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