The Macro Impact of Debt-Inflation Channel on Investment

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Motivation: Inflation and The Real Economy

- The post-COVID era saw inflation surge to 40-year highs, attracting interest in the real effects of inflation.
- A key mechanism: the **debt-inflation (Fisher) channel**.
  - Unexpected inflation redistributes wealth from nominal creditors to debtors.
- **Well-documented for households** (Doepke & Schneider, 2006; Auclert, 2019).
  - But effects on consumption are often found to be modest.
- Firm side studies are limited (Gomes et al, 2016)
  - Non-financial corporations hold a substantial share of nominal debt.
  - How does the Fisher channel affect **corporate investment**?
  - Is there any heterogeneity across firms and does it matter?

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Research Questions and Result Preview

Key Questions:

1. Does unexpected inflation stimulate investment and have differential effects for indebted firms? (Micro Evidence)
2. What is the aggregate impact on investment and output? (Macro Quantification)

Main Results

- More indebted firms increase investment more relative to others following unexpected increase in inflation.
- The firm-side Fisher channel is quantitatively powerful: A 1% inflation surprise raises aggregate investment by **0.83%**
- It can explain up to **50%** of the post-COVID investment surge; This effect is significantly larger than its household-side counterpart.

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Contribution to Literature

- **Debt-Inflation (Fisher) Channel:**
  - Shifts focus from households (Doepke & Schneider 2006, Auclert 2019), and representative firm to **heterogeneous firms**.
  - Shows the investment channel is quantitatively more significant.
- **Investment under Financial Frictions:**
  - Inflation is not just an amplifier, but a direct wealth shock that **endogenously relaxes constraints** (cf. BGG 1999, Ottonello & Winberry 2020).
- **Nominal Rigidities beyond Sticky Prices:**
  - Highlights **non-state-contingent nominal debt contracts** as another source of rigidity (cf. Sheedy 2014, Gomes et al. 2016).
  - Shows powerful real effects even with flexible prices.

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Roadmap

A 2-Period Model: Setup

- Two periods $t = 1, 2$, representative firm produces with $y_t = k_t^\alpha$
- Born with initial capital k_1 and nominal corporate bond B_1
- Capital fully depreciates every period
- **Key Frictions:**
  1. **Pre-existing Nominal Debt**: Interest rate i_1 and face value B_1 are fixed. Unexpected inflation Π_1 reduces the real repayment $\frac{(1+i_1)B_1}{P_1}$.
  2. **Financing Constraints**:
     - Non-negative dividend constraint, firms cannot issue equity.
     - Tight ϕ collateral constraint on new borrowing.
- By defining $b_t = \frac{B_t}{P_{t-1}}$, key balance sheet variable, net worth is

$$nw_1 = k_1^\alpha - \frac{(1 + i_1)b_1}{\Pi_1}$$

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Model Optimality Conditions

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

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

$$\text{s.t.} \quad d_1 = nw_1 - k_2 + b_2 \geq 0 \quad \text{and} \quad \phi k_2^\alpha - (1+r)b_2 \geq 0$$

- The 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 investment $k_2^\star$ when $nw_1 \leq k_2^{FB} - \phi\frac{(k_2^{FB})^\alpha}{1+r}$

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

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Model Mechanism: How Inflation Affects Investment

- **Unconstrained Firms:**
  - Low initial debt $b_1 \implies$ High net worth.
  - They invest at the first-best level (k_2^{FB}), where MPK = user cost.
  - Unexpected inflation $\uparrow \Pi_1 \implies \uparrow nw_1$, but investment is unchanged (already optimal).
- **Constrained Firms:**
  - High initial debt $b_1 \implies$ Low net worth. The $d_1 \geq 0$ constraint binds.
  - They are forced to invest less than first-best ($k_2^\star < k_2^{FB}$).
  - On the constrained region, $k_2^\star$ is strictly increasing in nw_1

$$\frac{\partial k_2^\star}{\partial nw_1} = \frac{1}{1 - \frac{\phi\alpha(k_2^\star)^{\alpha-1}}{1+r}} > 0, \qquad \frac{\partial nw_1}{\partial \Pi_1} = \frac{(1+i_1)b_1}{(\Pi_1)^2} > 0,$$

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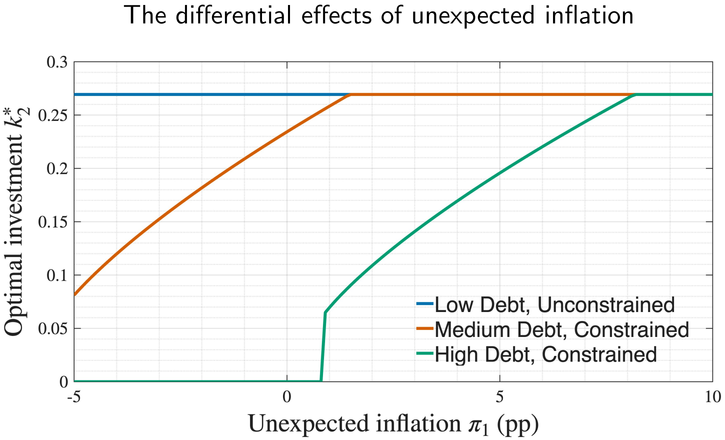
Model Prediction: Comparative Statics



Theory Guide for Empirical Analysis

- Constrained $k_2^\star$ relates b_1, Π_1, and define $inv_1 = \frac{k_2}{k_1}$

$$\Delta inv_1^\star = \Delta \left(\frac{k_2^\star}{k_1} \right) = \underbrace{\frac{1}{1 - \frac{\phi\alpha(k_2^\star)^{\alpha-1}}{1+r}} \frac{(1+i_1)}{(\Pi_1)^2}}_{\text{state-dependent}} \times b_1 \Delta \Pi_1 \tag{1}$$

  - Monotonicity in b_1: higher $b1$ leads to a larger response of i_1 to Π_1.
  - Constraint interaction: effects concentrate where constraint binds.
  - Sorting by productivity: for given $b1$, higher MPK shows stronger investment responses.

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Data and Measurement

- **Firm-level Data:** Quarterly Compustat, 1990Q1 - 2023Q4.
  - Dependent Variable: Investment Rate ($i_{j,t}/k_{j,t-1}$).
  - Key Regressor: **Indebtedness**, $b_{j,t-1}$, measured as log of total nominal debt, residualized to remove firm and time fixed effects.
- **Inflation Data:**
  - Realized Inflation: CPI from BLS.
  - Expected Inflation: 1-year ahead from FRB Cleveland.
  - Unexpected Inflation: $\epsilon_t^\pi = \pi_t^{\text{realized}} - \mathbb{E}_{t-4}[\pi_t]$.

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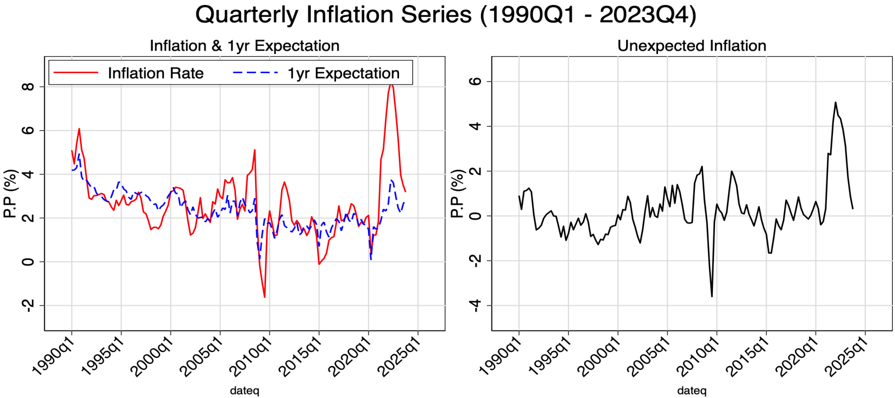
Unexpected Inflation Series (1990-2023)



Notes: Large deflationary surprise during the Great Recession (2008-2009) and large inflationary surprises post-COVID

Empirical Strategy

To test the model's prediction, I use a difference-in-differences specification inspired by the conceptual framework:

$$i_{j,t} = \alpha_j + \alpha_{s,t} + \beta(b_{j,t-1} \times \epsilon_t^{\pi}) + \gamma b_{j,t-1} + \mathbf{\Gamma}'_A(b_{j,t-1} \times \mathbf{A}_t) + \mathbf{\Gamma}'_Z \mathbf{Z}_{j,t-1} + e_{j,t} \quad (2)$$

- α_j: Firm Fixed Effects. $\alpha_{s,t}$: Sector $\times$ Time Fixed Effects.
- Interaction between indebtedness and GDP growth, FFR.
- Standard firm level controls including size, liquidity, sales growth etc.
- Two-way clustering standard errors by firm and quarter.
- **Prediction from theory:** $\beta > 0$.
  - Higher indebtedness amplifies the positive investment response to an inflation surprise.

Main Empirical Result: Heterogeneous Responses

	(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)
Obs	268757	268757	268757	268757
R^2	0.118	0.125	0.118	0.124
Firm Ctrl	No	Yes	No	Yes
Sector-time FE	Yes	Yes	Yes	Yes

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Firm fixed effects included and standard errors clustered at firm-quarter level.

- β is positive and highly significant, consistent with theory.
- **Magnitude:** A 1 p.p. inflation surprise leads to a 3.5 bps higher investment rate for a firm with 1 std. dev. higher debt.

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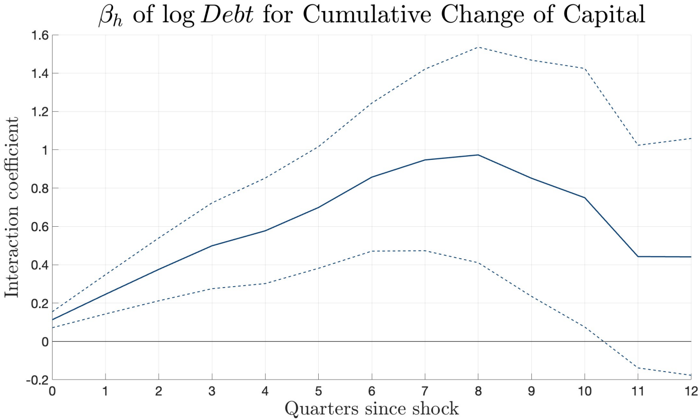
Dynamic Effects: Local Projections

To trace the dynamic effect, I estimate the local projection regression

$$\Delta \log k_{j,t+h} = \alpha_j + \alpha_{s,t} + \beta_h(b_{j,t-1}\epsilon_t^\pi) + \gamma_h b_{j,t-1} + e_{j,t,h} \quad (3)$$



- The differential effect on capital is positive and persistent, peaking around the 8th quarter.

Robustness

The main empirical finding is robust to:

- Excluding the Great Recession and COVID periods.
- Using alternative measures of indebtedness (e.g., leverage ratio).

Takeaway: Strong and robust empirical support for the firm-side Fisher channel.

Roadmap

Quantitative Model: Heterogeneous Firms

Continuum of mass 1 production firms indexed by i

- Production Technology

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

  Production goods sold at competitive real price p_t

- Labor Choice

$$n_{i,t}^{*} = \left(\frac{\nu p_t z_{i,t} k_{i,t}^{\alpha}}{w_t} \right)^{\frac{1}{1-\nu}}$$

  Labor hiring at real wage w_t

- Capital Accumulation

$$k_{i,t+1} = i_{i,t} + (1-\delta) k_{i,t}$$
$$AC(i_{i,t}, k_{i,t}) = \frac{\gamma}{2} \frac{i_{i,t}^2}{k_{i,t}}$$

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- Exogenous Entry and Exit with death prob. π_d
  - New firms draw idiosyncratic productivity and enter with k_0 to keep mass unchanged.
- Key Frictions
  - One-period risk-free nominal corporate bonds B_t with predetermined nominal rate R_t and repayments.
  - Collateral constraint to ensure safety, by defining $b_t = \frac{B_t}{P_{t-1}}$.

$$(1 + R_{t+1})b_{i,t+1} \leq \Pi_{t+1}(p_{t+1}\underline{z}_{i,t+1}k_{i,t+1}^{\alpha}n_{i,t+1}^{\nu} - w_{t+1}n_{t+1} + (1-\delta)k_{i,t+1})$$

    New borrowings must be within the lowest possible net worth in the next period.
  - Non-negative dividend constraint (No equity issuance) for continuing firms:

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

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Quantitative Model: Firm's Problem

1. Enter period with state variables (z, k, b).
2. Productivity and death shocks realize.
3. Exogenously exist after production.
4. Choose (k', b') to the next period if continuing.

The firm's problem in Bellman equation:

$$\begin{aligned}
V_t(z,k,b) &= (1-\pi_d)\, V_t^c(z,k,b) + \pi_d\, V_t^d(z,k,b) \\
V_t^c(z,k,b) &= \max_{k',b'} \left\{ d_t(z,k,b,k',b') + \mathbb{E}_t\left[\Lambda_{t+1} V_t(z',k',b' \mid z)\right] \right\} \\
s.t. \qquad d_t &= p_t z k^{\alpha} n^{\nu} - wn - i - AC(i,k) - (1+R)\frac{b}{\Pi_t} + b' \geq 0 \\
b' &\leq \frac{\Pi_{t+1}}{1+R_{t+1}} (p_{t+1} \underline{z}' k'^{\alpha} n'^{\nu} - w_{t+1} n' + (1-\delta)k')
\end{aligned} \tag{4}$$

Quantitative Model: Other Agents

- Retailers and Final Goods Producer
  - Linear technology transferring homogeneous production goods into differentiated goods.
  - CES Technology to produce final goods using differentiated goods.
- Representative Households
  - Maximize expected utility subject to budget constraint:

$$
\begin{aligned}
& E_0 \sum_{t=0}^{\infty} \beta^t (\log C_t - \chi N_t) \\
s.t. \quad & P_t C_t + S_{t+1} = W_t N_t + (1 + R_t) S_t + D_t
\end{aligned} \tag{5}
$$

  - Stochastic Discount Factor Λ_{t+1} follows $\beta \frac{C_t}{C_{t+1}}$.
- Central Bank supplies money to clear money market with nominal rate determined by Fisher equation $R_t = r_t + E_{t-1} \pi_t$.

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 optimize;
3. goods market, labor market and asset market all clear;
4. the distribution of firms μ is stationary.

Calibration and Model Fit

- Model is calibrated to match key moments of the U.S. economy and Compustat firm distribution at a quarterly frequency.

Calibration (Parameters)

Description	Param	Value
Discount factor	β	0.99
TFP persistence	ρ_z	0.90
Innovations SD	σ_z	0.10
Depreciation rate	δ	0.025
Capital share	α	0.25
Labor coefficient	ν	0.60
Adj. cost	γ	1.00
Initial capital	k_0	0.20
Exit rate	π_d	0.02
Elasticity of subs.	ϵ_p	10

Model Fit (Moments)

Moment	Data	Model
$\mathbb{E}[b/k]$	0.316	0.286
$\mathbb{E}[i]$ (p.p.)	3.936	4.398
SD(i) (p.p.)	10.263	8.27
AutoCorr(Lev)	0.938	0.989
Frac($b > 0$)	0.708	0.632
Annual Exit	0.08	0.08
Emp. Ratio	0.022	0.021

Note: Employment ratio source: U.S. Census Bureau – BDS (2022).

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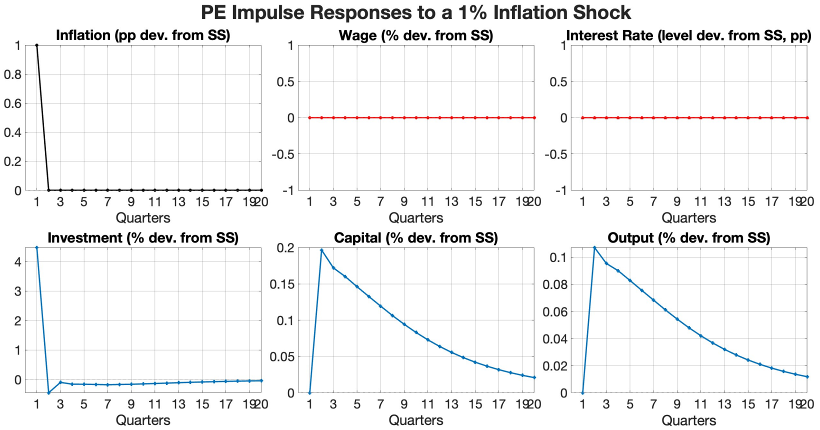
Roadmap

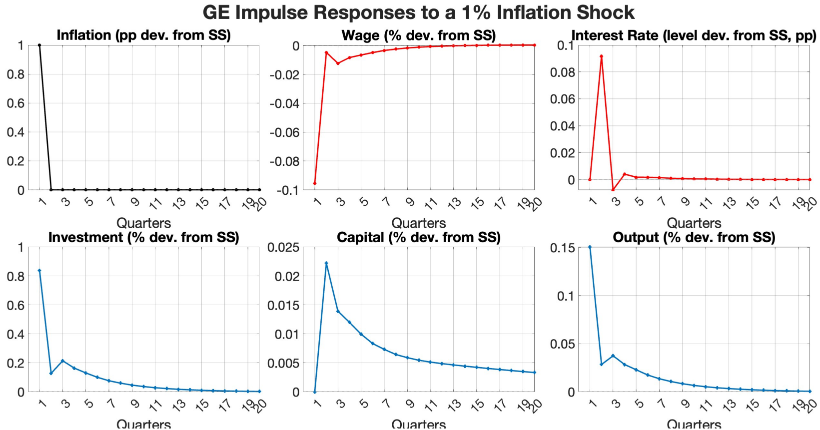
1. A Conceptual Framework
2. Empirical Analysis
3. Heterogeneous Firm GE Model
4. Quantitative Analysis
5. Conclusion

PE Impulse Response



- Strong PE effects: 4.5% increase in aggregate investment with 1% transitory inflation.

GE Impulse Response



- GE prices: decrease in wages and increase in real rates.
- Fisher channel effect on aggregate investment dampened to **0.83%**.

Model vs. Empirics: Replicating the Heterogeneity

- I feed the historical unexpected inflation series into the model to generate a simulated panel of firms.
- Then, I run the same regressions on the model-generated data.

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

- The model qualitatively reproduces the key empirical finding: more indebted firms invest more after an inflation surprise.

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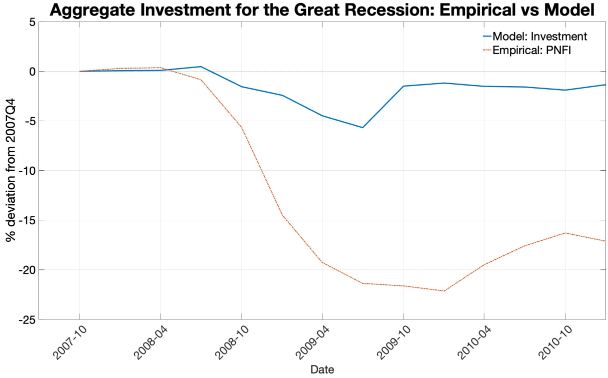
- During the Great Recession, large deflationary surprises increased the real debt burden.
- How much of the investment collapse can the Fisher channel explain?



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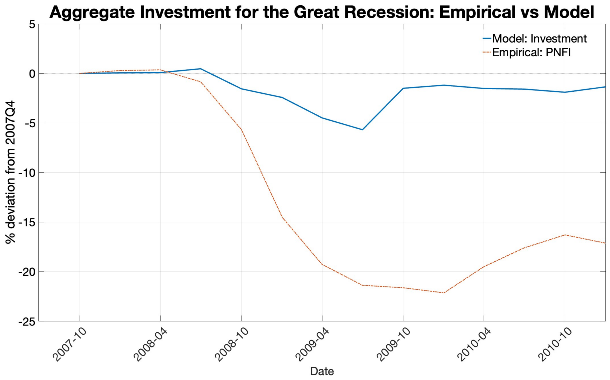

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Counterfactual: The Post-COVID Inflation Surge

- The post-COVID period saw a series of large positive inflation surprises.
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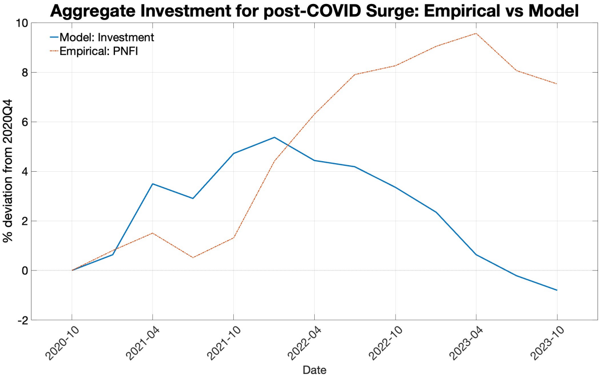

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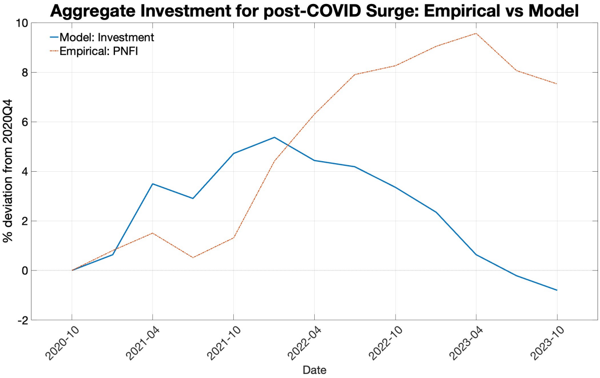

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Roadmap

Conclusion

- This paper studies the **debt-inflation (Fisher) channel** on investment.
- **Empirically**, I show that more indebted firms invest disproportionately more following an unexpected inflation surprise. This finding is robust and persistent.
- **Quantitatively**, a calibrated GE model shows the channel is macroeconomically significant.
  - A 1% inflation surprise raises investment by 0.83%.
  - The channel is a major contributor to investment dynamics during the Great Recession (23%) and post-COVID era (50%).
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