

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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 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:

- Document new micro 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), Ottoneillo and Winberry (2020), Durante et al. (2022), Jeenah (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

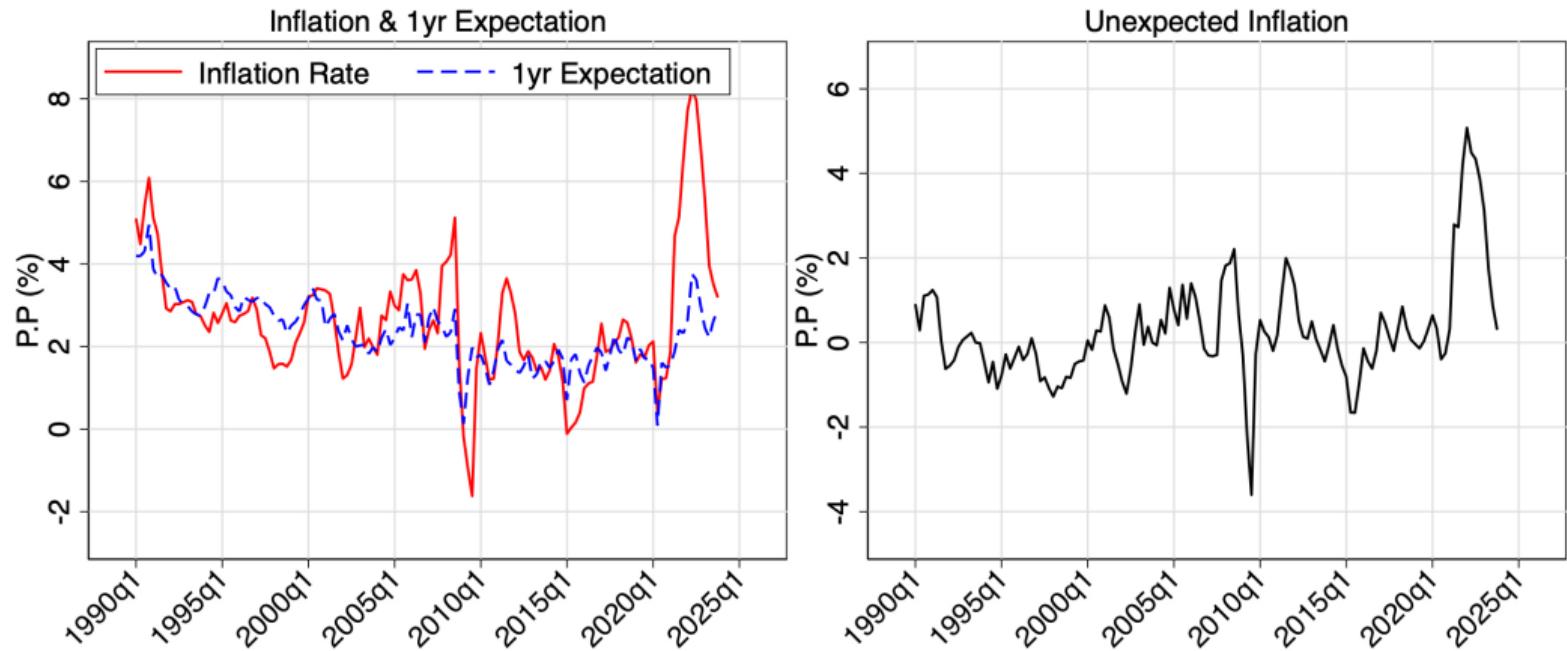
1. Empirical Analysis
2. Heterogeneous Firm GE Model
3. Quantitative Analysis
4. Conclusion

Empirical Analysis

Data and Measurement

- Firm Data: Quarterly Compustat, 1990Q1 - 2023Q4.
 - Indebtedness: $b_{j,t-1}$, Log of total nominal debt (residualized).
 - Capital Stock: $k_{j,t}$, PIM follows Ottonello and Winberry (2020).
 - Investment Rate: $inv_{j,t} = i_{j,t}/k_{j,t-1}$.
- Inflation Data:
 - Realized Inflation: Consumer Price Index (CPI) from BLS.
 - Expected Inflation: 1-year ahead from FRB Cleveland.
 - **Unexpected Inflation** ($\epsilon_t^\pi \equiv \Delta\pi = \pi_t^{\text{realized}} - \mathbb{E}_{t-4}\pi_t$)

Unexpected Inflation Series



Key episode: large inflationary surprises in 2021-22.

Empirical Strategy

- Two-Way Fixed Effect model to estimate investment responses

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

- 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.
- Debt-inflation channel predicts: $\beta > 0$.

Main Result: Heterogeneous Responses

$inv_{j,t}$	(1)	(2)	(3)	(4)
$b_{j,t-1} \times \epsilon_t^\pi$	0.116*** (0.029)	0.124*** (0.029)		
$b_{j,t-1} \times \pi_t$			0.089*** (0.023)	0.091*** (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.

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

Robustness

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

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: borrowing and non-negative dividend constraints.
- Exogenous entry and exit with prob. π_d .

Quantitative Model: Heterogeneous Firms

- Decreasing return to scale technology for firm i

$$y_{i,t} = z_{i,t} k_{i,t}^\alpha n_{i,t}^\nu, \quad \alpha + \nu < 1$$

$$\log(z_{i,t+1}) = \rho \log(z_{i,t}) + \sigma \varepsilon_{i,t+1}, \quad \varepsilon_{i,t+1} \sim N(0, 1)$$

with goods sold at real price p_t

- Capital Accumulation

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

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

Quantitative Model: Firm's Problem

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

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

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

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

- Distribution evolves following

$$\begin{aligned} \mu_{t+1}(z', k', b') &= \int (1 - \pi_d) \mathbf{1}\{k' = k^*(z, k, b)\} \mathbf{1}\{b' = b^*(z, k, b)\} \\ &\quad \times g(z' | z) d\mu_t(z, k, b) + m_{\text{ent}} \mu_{\text{ent}}(z') \mathbf{1}\{k' = k_0\} \mathbf{1}\{b' = 0\} \end{aligned}$$

Quantitative Model: Other Agents

- Representative Households

- Maximize expected utility subject to budget constraint:

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

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

- 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
<i>Household</i>			
Discount factor	β	0.99	Quarterly Standard
<i>Firm</i>			
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.)	$\mathbb{E}\left[\frac{i}{k}\right]$	3.936	4.398
SD Investment Rate (p.p.)	$\sigma\left(\frac{i}{k}\right)$	10.263	8.27
Leverage Auto-correlation	$\text{Corr}(lev_t, lev_{t-1})$	0.938	0.989
Share of Positive Net Debt	$\text{Frac}(b > 0)$	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

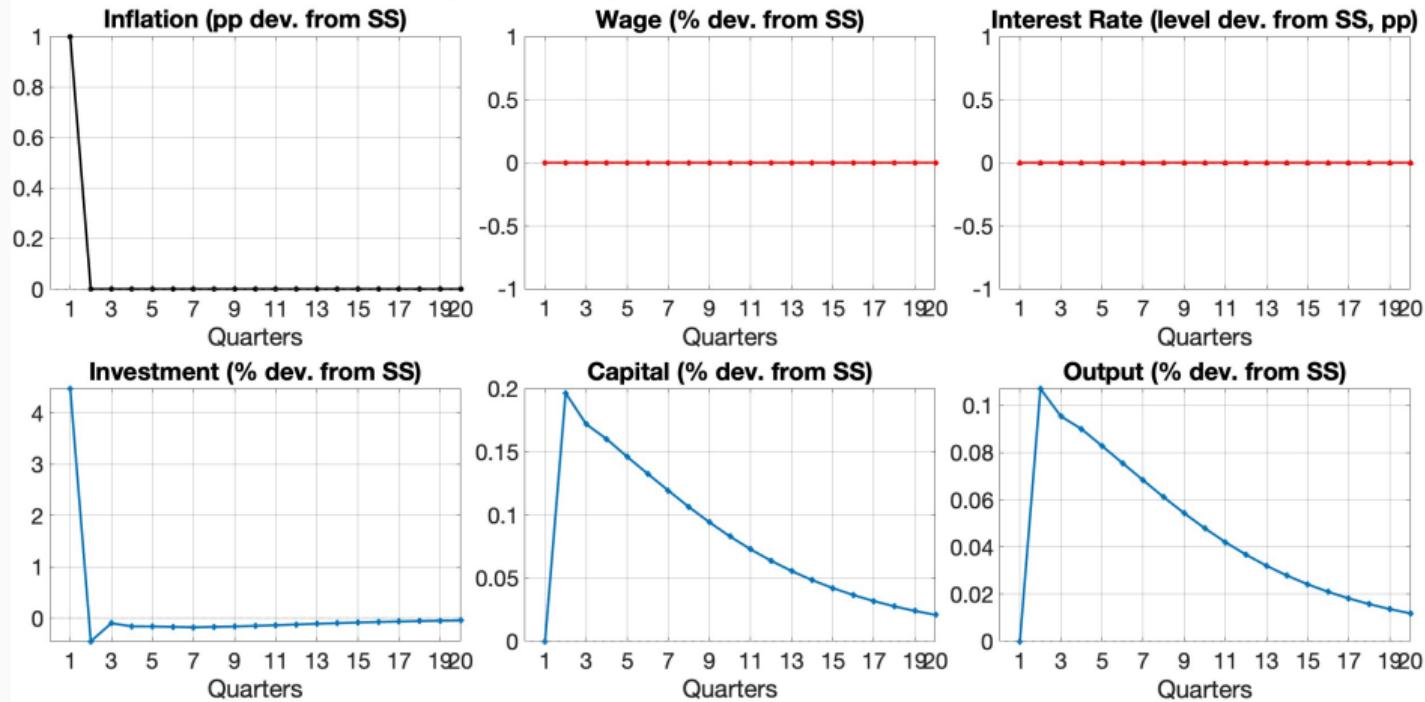
Solution Method

- Difficulty in solving heterogeneous agent with aggregate uncertainty.
 - Traditional method in state space \Rightarrow Curse of Dimensionality.
- Sufficient Statistic: Sequence Space Jacobians, Auclert et al. (2021).
 - Linear equations in perfect foresight sequence space.
- One of a few SSJ applications in firms side studies.

▶ Simulated Regression

PE Impulse Response

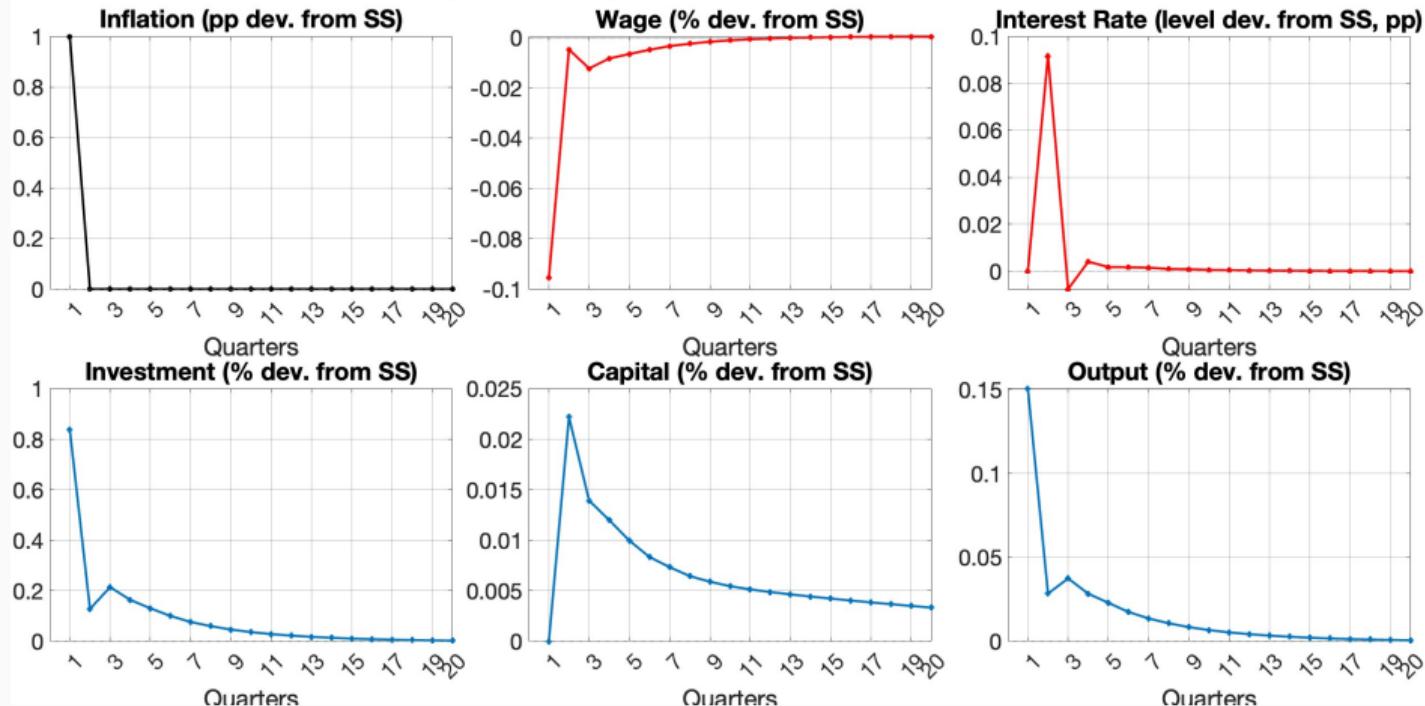
PE Impulse Responses to a 1% Inflation Shock



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

GE Impulse Response

GE Impulse Responses to a 1% Inflation Shock



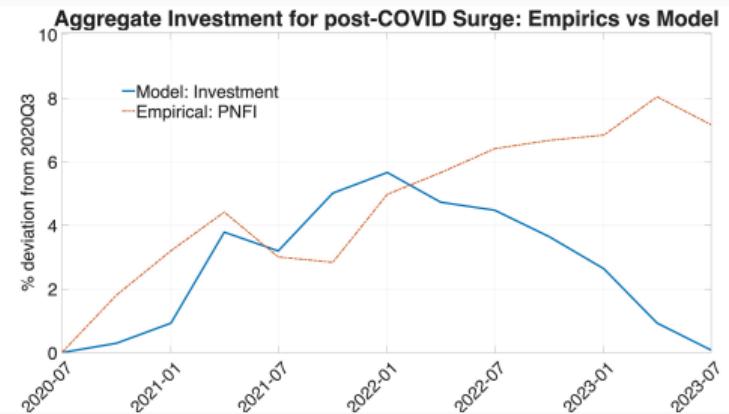
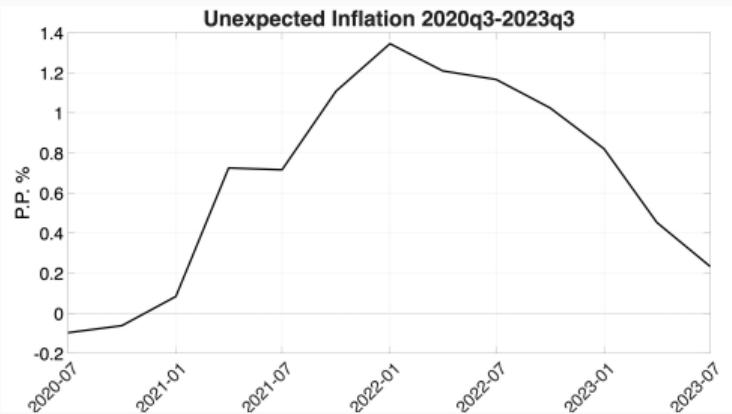
- Fisher channel effect on aggregate investment dampened to **0.83%**.

Significant Effect: Firm vs. Household

- Fisher channel effect on household is modest.
 - Auclert (2019): "fairly small" redistribution elasticity for price.
- In contrast, firm side effect is **significant**.
 - PE effect large on impact; GE effect quantitatively meaningful.
 - **Shifting the Fisher channel focus from households to firms.**

Application: Post-COVID Investment Surge

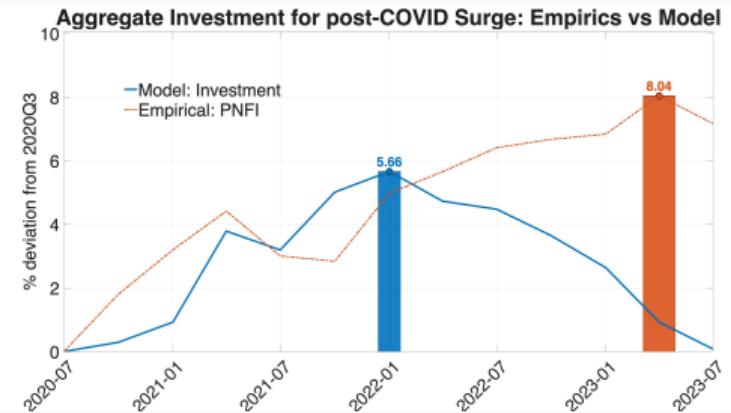
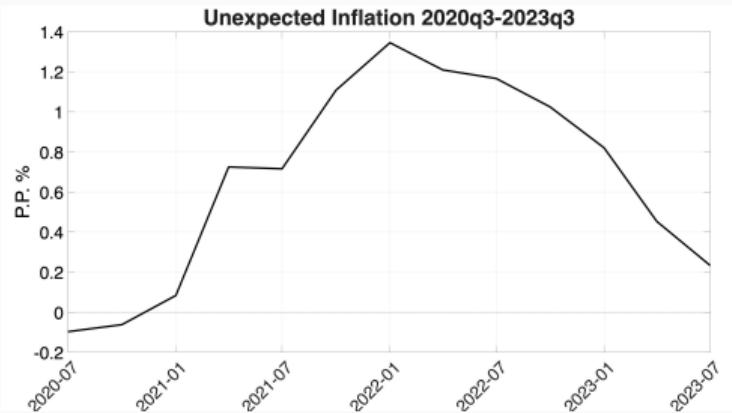
- How much does the channel explain?



- Up to **70%** (peak share) investment surge.

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Conclusion

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- 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 $\implies 0.83\%$ aggregate investment.
 - More significant Fisher effects on firms than households.
 - Reproduce 70% post-COVID investment surge.

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 $R = r$.
- 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

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

- 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

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

From Theory to Empirics

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

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

- Testable Prediction $\beta > 0$:
 - Stronger Δinv_1^* to $\Delta\pi_1$ for firms with higher b_1

2-Period Model: Feasibility

Single feasibility inequality

$$h(k_2) \equiv k_2 - \frac{\phi}{1+r} k_2^\alpha \leq nw_1$$

Unconstrained benchmark. optimum k_2^{FB} satisfies

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

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

2-Period Model: Optimality Conditions

- Unconstrained maximizer k_2^{FB} is

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

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

- Constrained optimal k_2^* solves otherwise

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

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^*) is increasing in net worth (nw_1).
$$\frac{\partial k_2^*}{\partial nw_1} > 0 \quad \text{and} \quad \frac{\partial nw_1}{\partial \Pi_1} > 0$$

- 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 $k_2 \uparrow$

2-Period Model: Core Mechanism

- Constrained Firm cross derivative

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

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

Different Specifications

	2Way FE	No GDP, FFR	TobinsQ	Sales InterAct
$b_{j,t-1} \times \epsilon_t^\pi$	0.117*** (0.035)	0.126*** (0.036)	0.120*** (0.029)	0.115*** (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.

Different Specifications

	NetDebt	Liquidity	Size	Age	LongDebt	Div
$b_{j,t-1} \times \epsilon_t^\pi$	0.065** (0.028)	0.082*** (0.030)	0.109*** (0.032)	0.109*** (0.027)	0.127*** (0.033)	0.119*** (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.

Sample Selection

	(1)	(2)	(3)	(4)	(5)	(6)
$b_{j,t-1} \times \epsilon_t^\pi$	0.124*** (0.029)	0.108*** (0.029)	0.129*** (0.031)	0.127*** (0.032)	0.126*** (0.029)	0.076* (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.

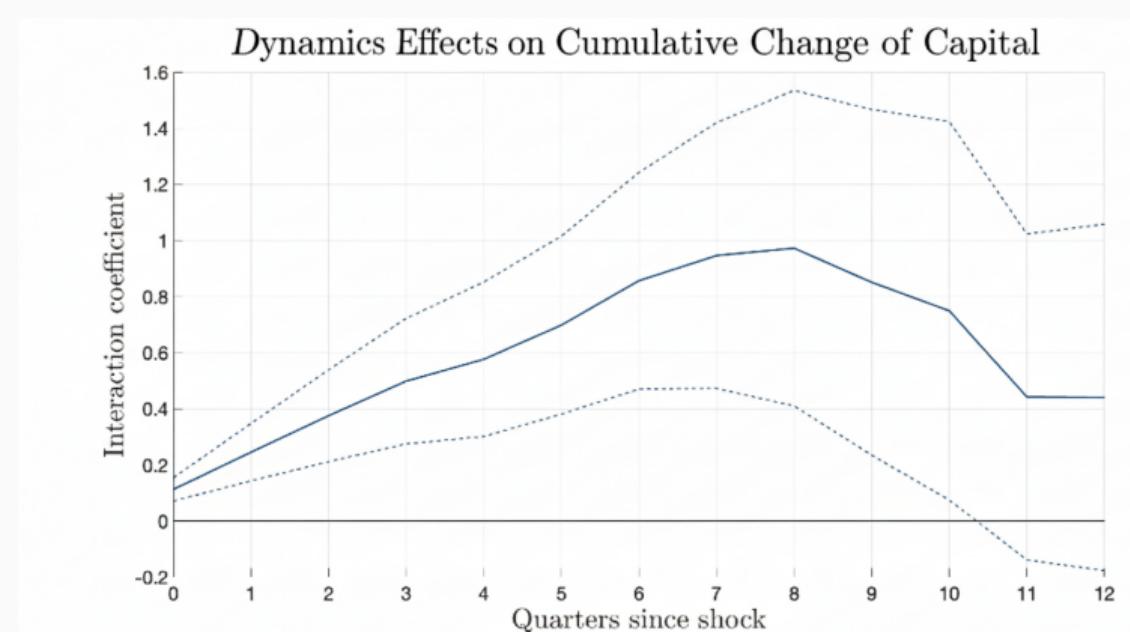
Leverage Ratio

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

Dynamic Effects

- Local projection to trace dynamic effects:

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



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 $p = \frac{\epsilon_p - 1}{\epsilon_p}$.

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

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

Model vs. Empirics: Reproducing the Heterogeneity

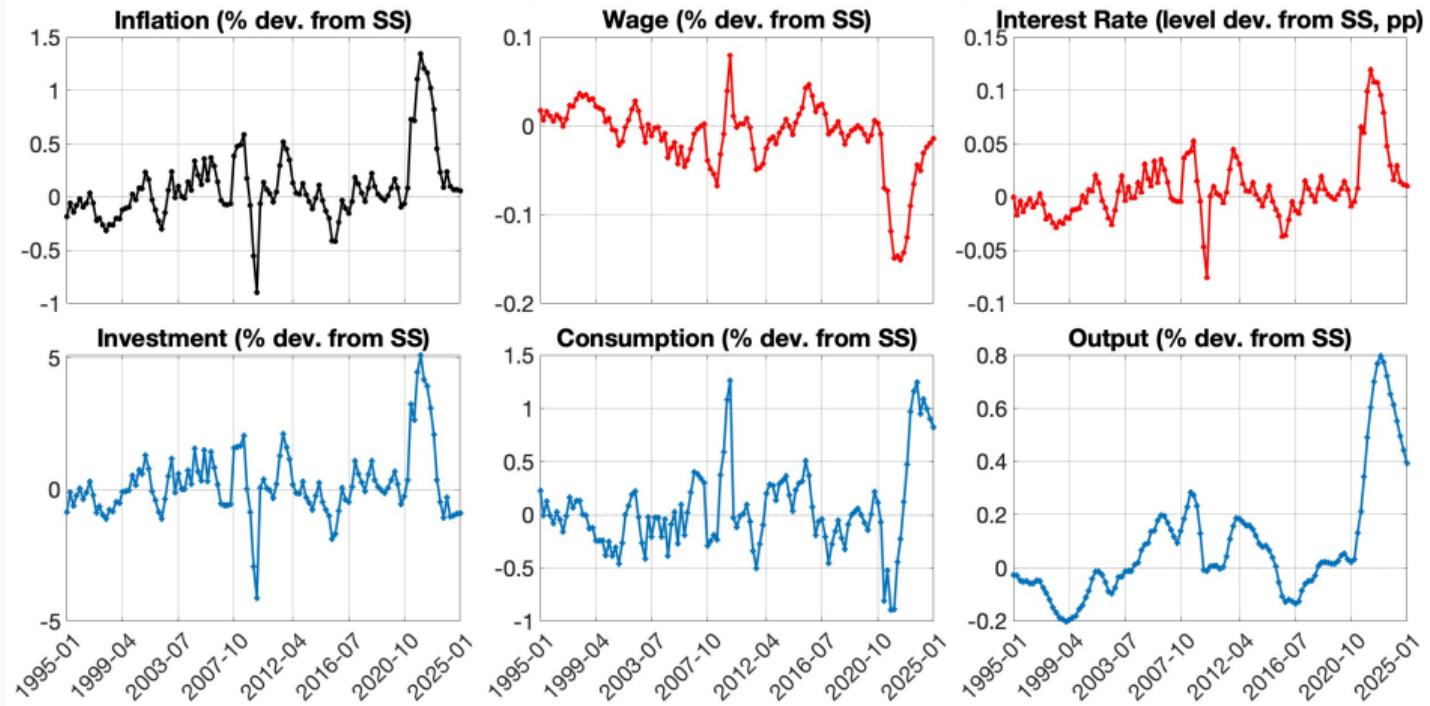
- Run the same regressions on the model-simulated panel.

Investment Rate	Empirical Estimate		Model Implied Results	
	(1)	(2)	(3)	(4)
$b_{j,t-1} \times \epsilon_t^\pi$	0.116*** (0.029)	0.124*** (0.029)	0.048* (0.026)	0.024*** (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.

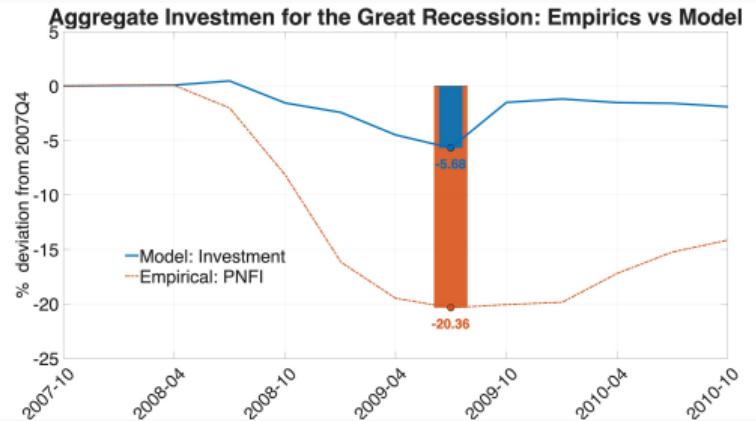
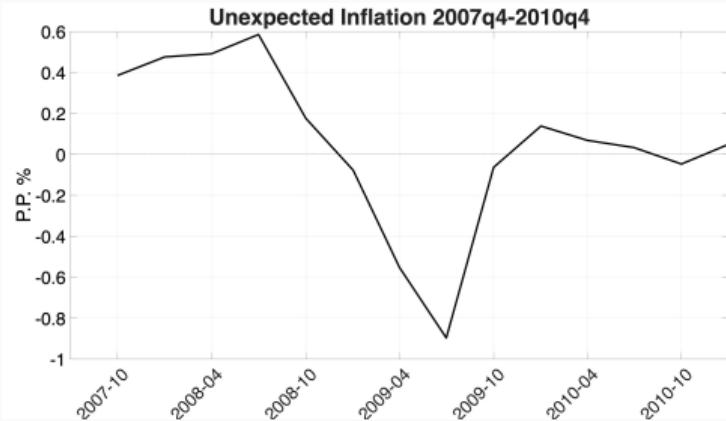
Full Historical Application

GE Responses to Real Inflation Surprises



Application: the Great Recession

- How about deflationary scenario?



- Explain 25% investment decline.

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