Inflation Dynamics During the Financial Crisis

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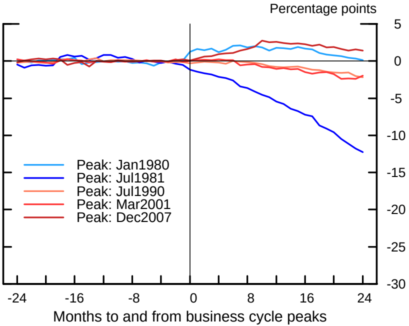
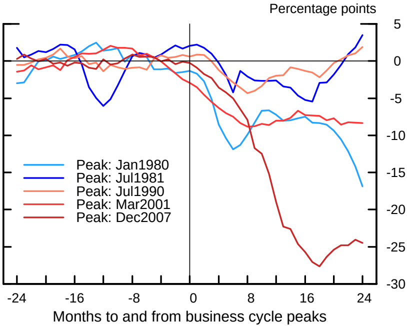
Cyclical Dynamics of Producer Prices and Inflation

Core producer prices*



* Deviations from a linear trend estimated over the 24 months preceding the specified recession.

Industrial production*



* Deviations from a linear trend estimated over the 24 months preceding the specified recession.

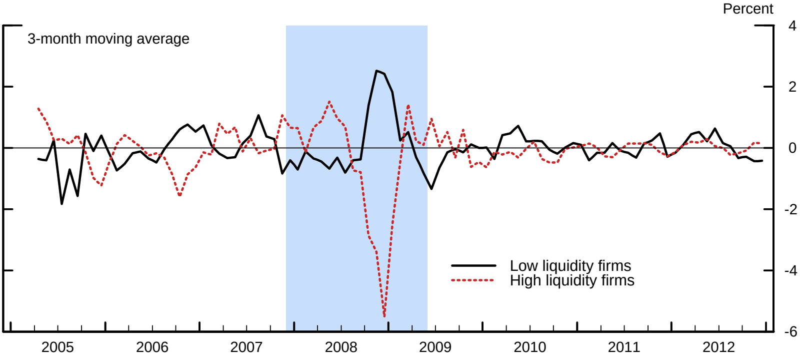
Motivation

- What accounts for the resilience of inflation in the face of significant and long-lasting economic slack?
- In particular, the absence of more substantial deflationary pressures during the "Great Recession" is difficult to square with the Phillips curve common to most macroeconomic models (including standard financial accelerator models).
- In a customer-markets model with financial frictions, firms have the incentive to raise prices to increase cash flow at the cost of future market share
  (Gottfries [1991]; Chevalier and Scharfstein [1996]).

Data Sources
Gilchrist, Schoenle, Sim and Zakrajsek (2015)

- Monthly good-level price data underlying the PPI.
  (Nakamura & Steinsson [2008]; Goldberg & Hellerstein [2009]; Bhattarai & Schoenle [2010])
- Match 584 PPI respondents to their income and balance sheet data from Compustat.
- Sample period: Jan2005–Dec2012

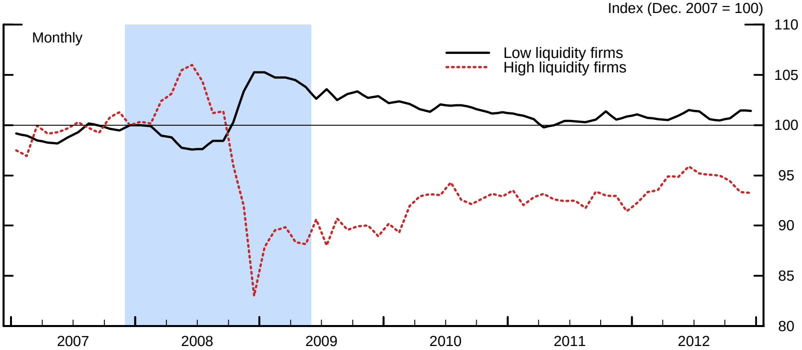
Relative Inflation
Financially unconstrained vs constrained firms



NOTE: Weighted average monthly inflation relative to industry (2-digit NAICS) inflation.

Accumulated Industry-Adjusted PPI Inflation

By selected financial characteristics in 2006



NOTE: Weighted average monthly inflation relative to industry (2-digit NAICS) inflation.

Price Adjustment and Firm Characteristics

- Multinomial logit specification:

$$\Pr(p_{i,j,t+3} - p_{i,j,t}) = \begin{cases} + & \\ 0 & \text{(base)} \\ - & \end{cases} = \Lambda(\mathbf{X}_{jt}; \boldsymbol{\beta}_t)$$

- Price change regression:

$$log(p_{i,j,t+3}) - log(p_{i,j,t}) = \beta X_{j,t} + \epsilon_{i,j,t+3}$$

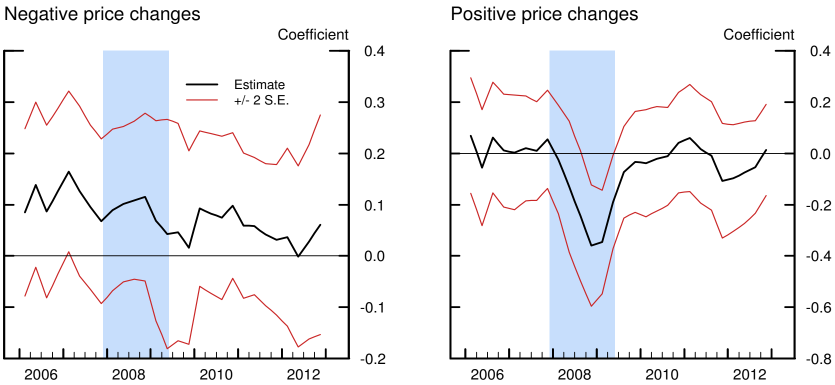
- $\mathbf{X}_{jt}$ = liquidity ratio and other controls.
  - Includes fixed time effects and 3-digit inflation.
  - Estimated using four-quarter rolling window.

Directional Price Change Regressions

Explanatory Variables	$+$	$-$
$\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 1]$	-0.433***	-0.012
	(0.107)	(0.072)
$\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 0]$	-0.143**	-0.044
	(0.068)	(0.050)
$\log(S_{j,t}/S_{j,t-12})$	-0.020	-0.042*
	(0.025)	(0.025)
$\log(C_{j,t}/C_{j,t-12})$	0.017	0.020*
	(0.013)	(0.011)
$[N/S]_{j,t}$	-0.022	-0.020
	(0.021)	(0.024)
$\pi_t^{IND(3m)}$	1.182***	-0.127
	(0.333)	(0.170)

Directional Price Change Regressions

Coefficient on liquidity ratio (4-quarter rolling window estimates)



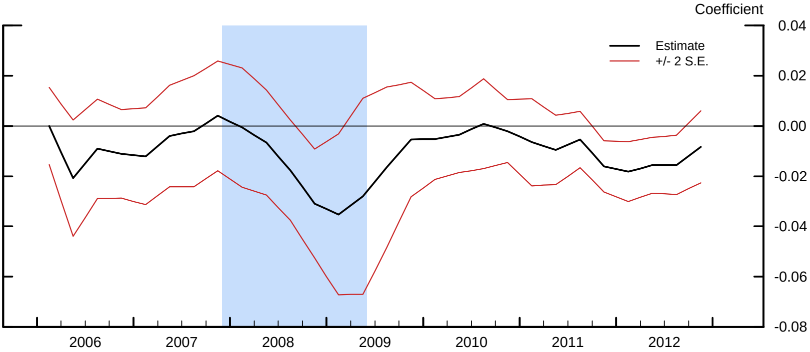
- Quantitative implication: a two std. dev. reduction in liquidity implies a 33% higher probability of a price increase.

Inflation Regressions

Explanatory Variables	
$\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 1]$	-0.029***
	(0.009)
$\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 0]$	-0.012***
	(0.004)
$\log(S_{j,t}/S_{j,t-12})$	0.004
	(0.003)
$\log(C_{j,t}/C_{j,t-12})$	-0.002
	(0.002)
$[N/S]_{j,t}$	0.001
	(0.001)
$\pi_t^{IND(3m)}$	0.134**
	(0.055)

Inflation

Marginal effect with respect to liquidity ratio

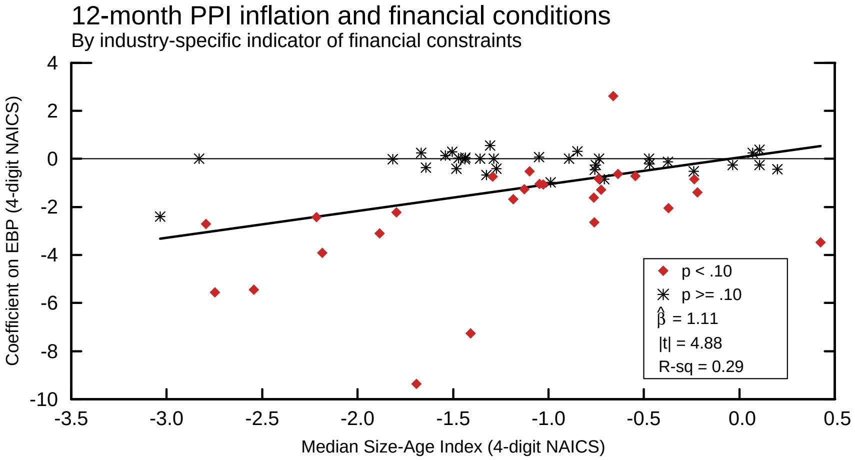


- Quantitative implication: A two std. dev. reduction in liquidity implies a 5% increase in annualized inflation.

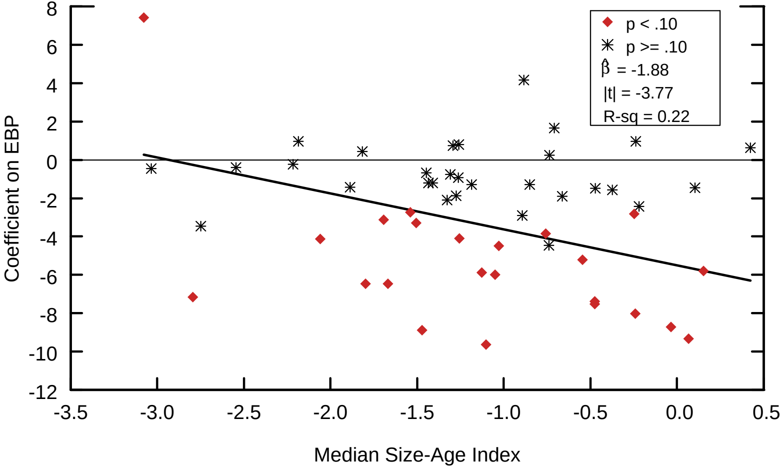
Industry-level evidence (1973-2012

- Examine sensitivity of 6-digit industry-level PPI inflation to changes in aggregate financial conditions.
- Regress industry-specific year-ahead inflation on
  - Current and lagged inflation and industrial production.
  - Current financial conditions – excess bond premium (EBP)
- Coefficient on EBP varies across 4-digit industry groups.
  - Is variation in industry-specific EBP coefficieent related to financial constraints across industries?
  - Measure severity of financial constraints using size-age index.

Inflation Response to EBP



Output Response to the EBP



GE MODEL

- Customer markets imply that firms trade off current profits for future market share.
- Financial market frictions imply that firms discount the future more when demand is low—and therefore charge high markups.
- Embed this intuition into a GE model with nominal price rigidities.

Deep habits
Ravn, Schmitt-Grohe and Uribe [2006]

- Demand for monopolistically competitive good:

$$c_{it} = \left(\frac{p_{it}}{\tilde{p}_t} \right)^{-\eta} s_{i,t-1}^{\theta(1-\eta)} c_t$$

  where

$$s_{it} = \rho s_{i,t-1} + (1-\rho) c_{it}$$

- Firms are forward looking – set low price today to build future stock of customer base.

Financial Frictions

- Firms make production decisions prior to realization of marginal cost.

$$y_{it} = \left[\frac{h_{it}}{a_{it}}\right]^{\alpha} - \phi_i; \quad 0 < \alpha \leq 1$$

- If realized operating income is negative, firms must raise costly equity finance:
  - $\varphi \in (0, 1) =$ constant per-unit dilution costs of new equity
- Expected shadow value of internal funds:

$$\mathbb{E}_t^a[\xi_{it}] > 1$$

Optimal Pricing without Deep Habits

- Assume flexible prices and no customer markets.
- When $\alpha = 1$, optimal pricing $\Rightarrow$

$$p_{i,t} = \underbrace{\underbrace{\frac{\eta}{\eta - 1}}_{\text{accounting markup}} \times \frac{\mathbb{E}^a_t[\xi_{it} a_{it}]}{\mathbb{E}^a_t[\xi_{it}]}}_{\text{economic markup}} \times \underbrace{\left[\frac{w_t/p_t}{A_t}\right]}_{\text{real marginal cost}}$$

- Financial frictions $\Rightarrow$

$$\frac{\mathbb{E}^a_t[\xi_{it} a_{it}]}{\mathbb{E}^a_t[\xi_{it}]} = 1 + \text{Cov}[\xi_{it} a_{it}] \geq 1$$

Optimal Pricing with Deep Habits

- Bring back customer markets (still flexible prices!)
- Growth-adjusted, compounded discount rate:

$$\tilde{\beta}_{t,s} \equiv m_{s,s+1} \frac{s_{s+1}/s_s - \rho}{1-\rho} \times \prod_{j=1}^{s-t} \left[\rho + \chi \frac{s_{t+j}/s_{t+j-1} - \rho}{1-\rho} \right] m_{t+j-1,t+j}$$

- Optimal pricing $\Rightarrow$

$$p_{i,t} = \frac{\eta}{\eta-1} \frac{\mathbb{E}_t^a[\xi_{it} a_{it}]}{\mathbb{E}_t^a[\xi_{it}]} \left[\frac{w_t/p_t}{A_t} \right] - \frac{\chi}{\eta-1} \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} \tilde{\beta}_{t,s} \frac{\mathbb{E}_s^a[\xi_{i,s}]}{\mathbb{E}_t^a[\xi_{i,t}]} \left(p_{h,s} - \frac{w_s/p_{h,s}}{A_s} \right) \right]$$

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Log-Linearized Phillips Curve

New Keynesian model with cost channel

$$\hat{\pi}_t = -\frac{\omega(\eta-1)}{\gamma_p}\left[\hat{\mu}_t + \mathbb{E}_t \sum_{s=t}^{\infty} \chi \tilde{\delta}^{s-t+1} \hat{\mu}_{s+1}\right] + \beta \mathbb{E}_t[\hat{\pi}_{t+1}]$$
$$+\frac{1}{\gamma_p}\left[\eta - \omega(\eta-1)\right] \mathbb{E}_t \sum_{s=t}^{\infty} \chi \tilde{\delta}^{s-t+1}\left[(\hat{\xi}_t - \hat{\xi}_{s+1}) - \hat{\beta}_{t,s+1}\right]$$

- $\hat{\mu}_t$ = (financially-adjusted) mark-up
- $\hat{\beta}_{t,s+1}$ = capitalized growth of customer base
- $\hat{\xi}_t$ = shadow value of internal funds

Log-Linearized Phillips Curve

The role of "deep habits"

$$\hat{\pi}_t = -\frac{\omega(\eta-1)}{\gamma_p}\left[\hat{\mu}_t + \mathbb{E}_t \sum_{s=t}^{\infty} \chi \tilde{\delta}^{s-t+1} \hat{\mu}_{s+1}\right] + \beta \mathbb{E}_t[\hat{\pi}_{t+1}]$$

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Log-Linearized Phillips Curve

The role of financial frictions

$$\hat{\pi}_t = -\frac{\omega(\eta-1)}{\gamma_p}\left[\hat{\mu}_t + \mathbb{E}_t \sum_{s=t}^{\infty} \chi\tilde{\delta}^{s-t+1}\hat{\mu}_{s+1}\right] + \beta\mathbb{E}_t[\hat{\pi}_{t+1}]$$
$$+\frac{1}{\gamma_p}\left[\eta-\omega(\eta-1)\right]\mathbb{E}_t \sum_{s=t}^{\infty} \chi\tilde{\delta}^{s-t+1}\left[\left(\hat{\xi}_t - \hat{\xi}_{s+1}\right) - \hat{\beta}_{t,s+1}\right]$$

- $\hat{\mu}_t$ = (financially adjusted) mark-up
- $\hat{\beta}_{t,s+1}$ = capitalized growth of customer base
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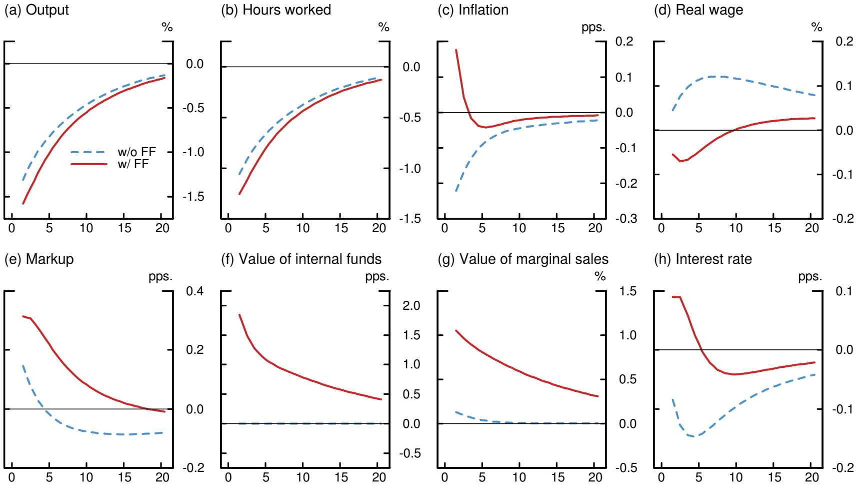
Calibration

Benchmark model: homogeneous firms

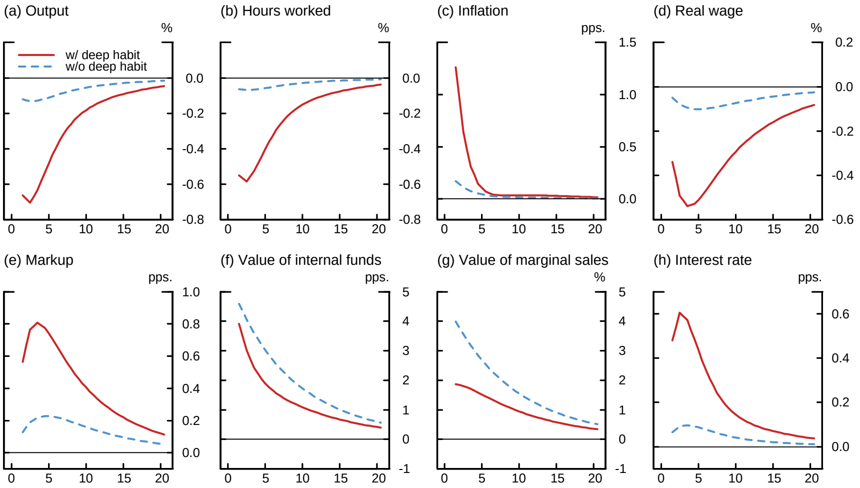
Parameter		Value
Preferences and Technology		
Relative risk aversion: γ_x		1.00
Deep habit: θ		-0.80
Persistence of deep habit: ρ		0.95
Elasticity of labor supply: $1/\gamma_h$		5.00
Elasticity of substitution: η		2.00
Fixed operating costs: ϕ		0.21
Idiosyncratic volatility (a.r.): σ		0.20
Financial Frictions		
Equity dilution costs: φ	0.30	0.50
Persistence of financial shock: ρ_φ		0.90

DEMAND SHOCK: FINANCIAL CRISIS$(\varphi = 0.5)$



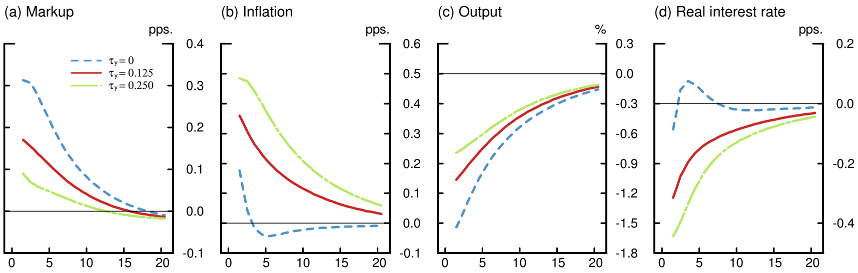
Financial Shock: $(\varphi = 0.3)$

With vs Without Customer Markets



Alternative monetary policy rules

Demand Shock During a Financial Crisis



Policy Implications: "Divine Coincidence" breaks down!

Heterogeneous Firms

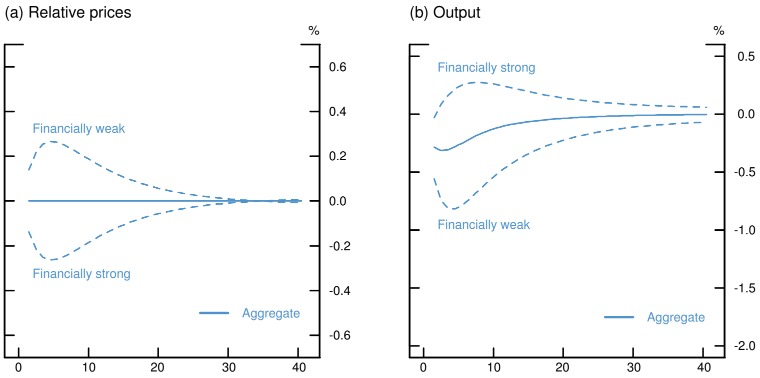
- Sectors differ by operating efficiency: $0 \leq \phi_1 < \phi_2$
- Fixed measures of firms: $\Xi_1 = \Xi_2 = \frac{1}{2}$
- Equilibrium dispersion of relative prices:

$$\pi_t = \left[\sum_{k=1}^{2} \Xi_k p_{k,t-1}^{1-\eta} \pi_{kt}^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

  - $p_{kt} \equiv \frac{P_{kt}}{P_t}$ = sector-specific relative price
  - $\pi_{kt} \equiv \frac{P_{kt}}{P_{k,t-1}}$ = sector-specific inflation rate
- Benchmark case:
  - $\phi_1 = 0 \Rightarrow$ financially “strong” firms
  - $\phi_1 = 0.3 \Rightarrow$ financially “weak” firms

"PRICE WAR" IN RESPONSE TO FINANCIAL SHOCKS

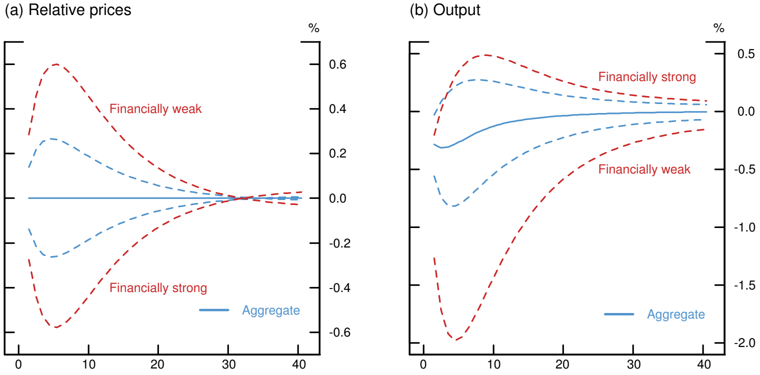
Heterogeneous firms



- Case I: $\phi_1 = 0.8\bar{\phi}$, $\phi_2 = \bar{\phi}$ and $\omega_1 = \omega_2 = 0.5$
- Case II: $\phi_1 = 0$, $\phi_2 = \bar{\phi}$ and $\omega_1 = \omega_2 = 0.5$

Paradox of Financial Strength

Heterogeneous firms



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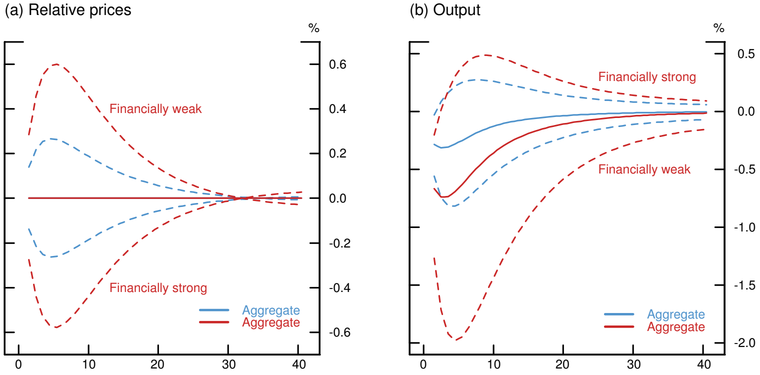

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Conclusion

- Empirical results imply that financially healthy firms decreased prices, while financially weak firms increased prices during the financial crisis.
  - Industry-level and Eurozone evidence suggest this is a regular feature of business cycles.
- DSGE model: financial theory of countercylical markups
  - implies attenuation of inflation dynamics in response to demand shocks and severe contraction in response to temporary financial shocks.
- Implications for monetary policy:
  - Tradeoff between inflation and output in response to demand and financial shocks.