Inflation Dynamics During the Financial Crisis

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Motivation

- In spite of substantial and persistent economic slack, U.S. saw only mild disinflation during the "Great Recession" and subsequent slow recovery.

  Hall [2011]; Ball & Mazumder [2011]; King & Watson [2012]

- What accounts for this "missing deflation?"
  - Unanchored expectations?

    Coibon & Gorodnichenko [2015]
  - Unusual labor market developments (short- vs. long-term unemployed)?

    Gordon [2013]; Krueger et al. [2014]
  - Actually, there is no missing deflation puzzle.

    Del Negro et al. [2015]; Christiano et al. [2015]

Our Paper

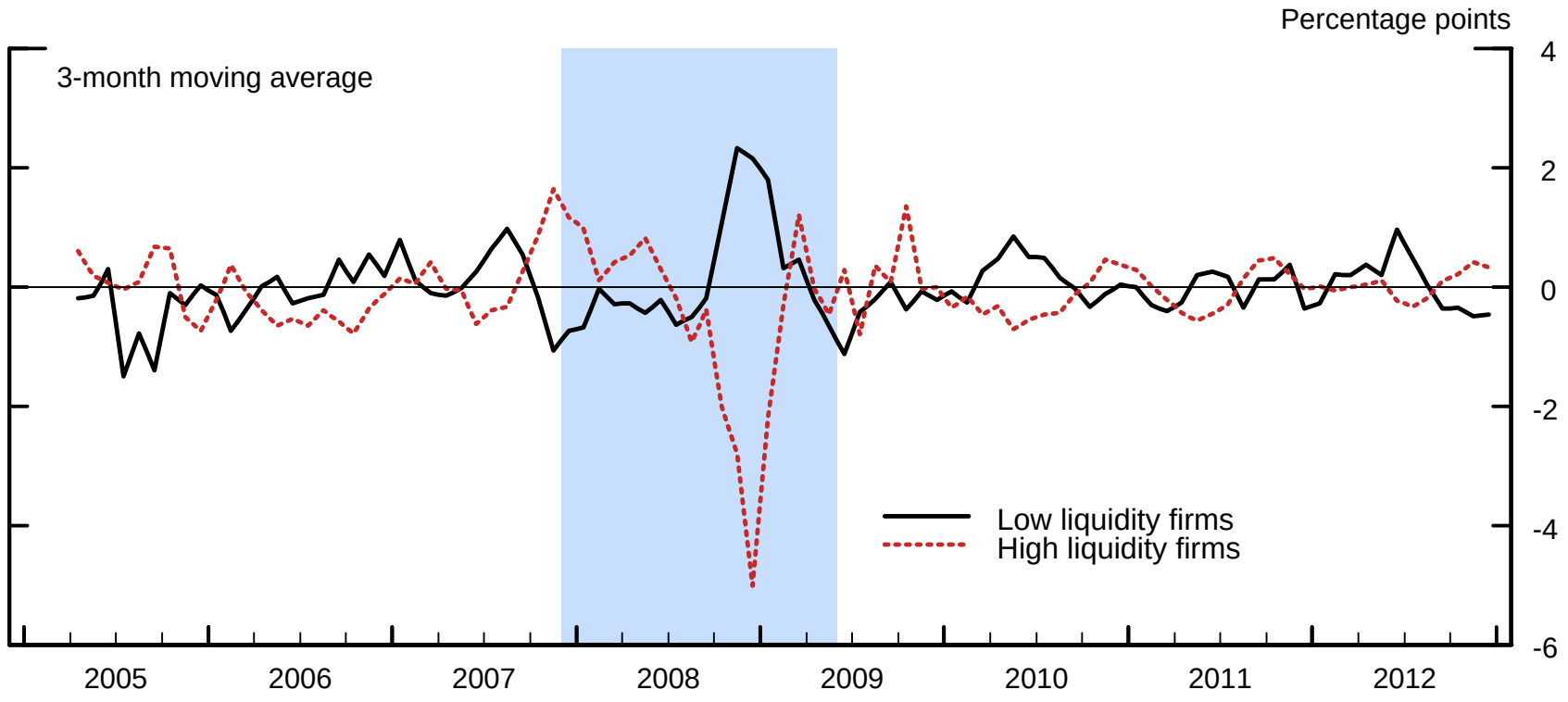
- Can interaction of customer markets and financial frictions help explain inflation dynamics during the 2007–09 crisis?
- Empirics:
  - Merge good-level prices in the Producers Price Index (PPI) to producers' income and balance sheet data from Compustat.
  - Analyze how differences in firms' internal liquidity positions affected their price-setting behavior during the crisis.
- Theory:
  - Develop a dynamic GE model that embeds financial frictions in a customer-markets framework.
  - Analyze inflation and output dynamics in response to demand and financial shocks.

Data Sources and Methods

- Monthly good-level price data underlying the PPI.
  Nakamura & Steinsson [2008]; Goldberg & Hellerstein [2009]; Bhattarai & Schoenle [2010]
- Match about 600 PPI respondents to their income and balance sheet data from Compustat.
  - Sample period: Jan2005–Dec2012
  - Matched PPI-Compustat sample is representative of broader macroeconomic trends.
- Inflation by financial and product market characteristics:
  - Liquidity ratio (LIQ) $\Rightarrow$ financial frictions
    Campello et al. [2011]
  - SG&A expense ratio (SGAX) $\Rightarrow$ customer markets
    Goriou & Rudanko [2011]

Industry-Adjusted Producer Price Inflation

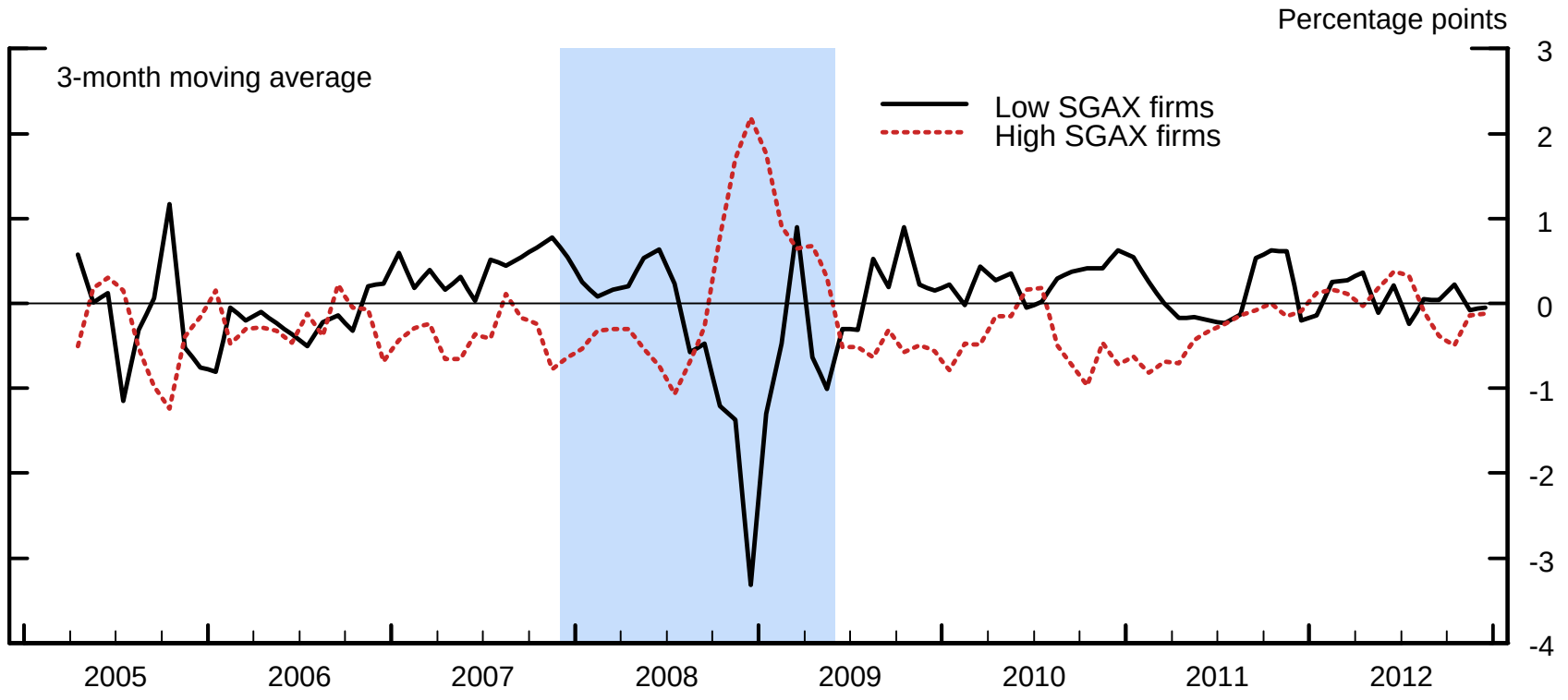
By financial characteristics



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

Industry-Adjusted Producer Price Inflation

By product market characteristics



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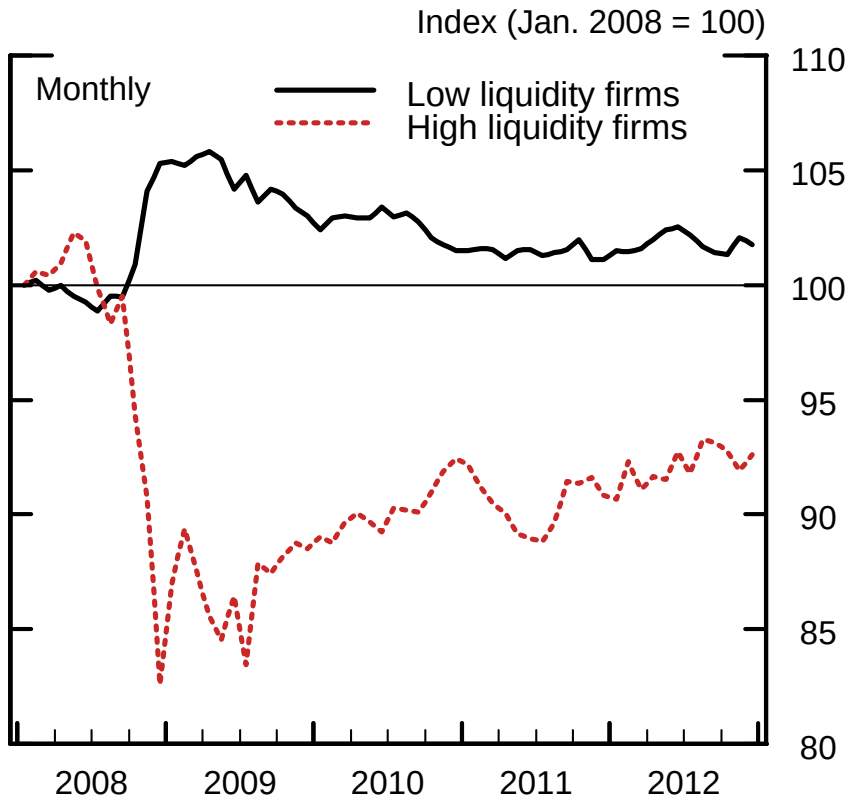
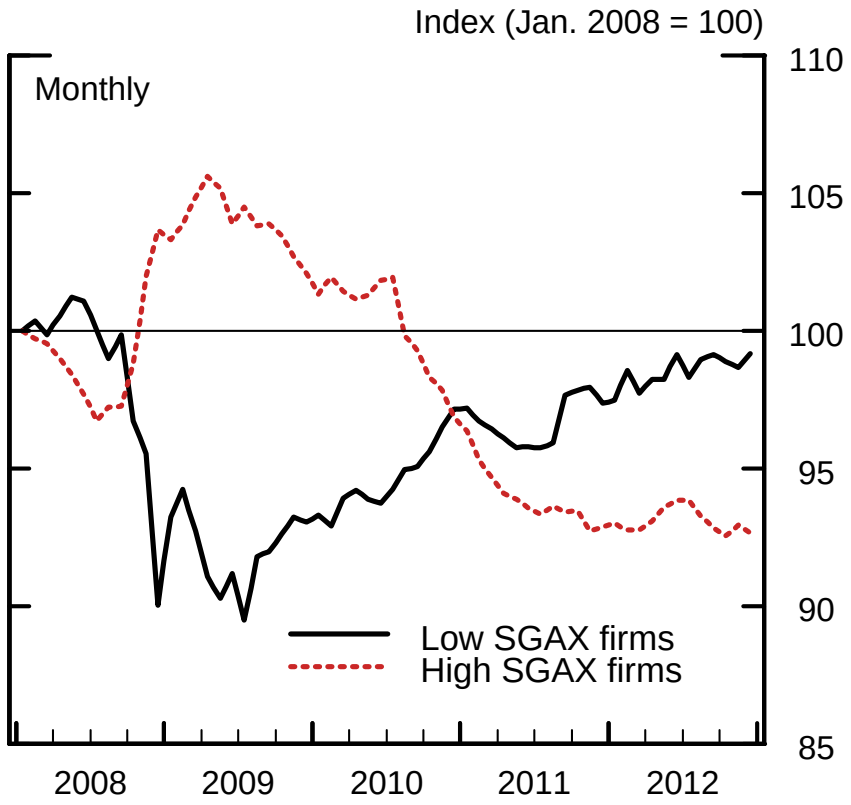
Industry-Adjusted Producer Prices

By financial and product market characteristics as of 2006



(a) By liquidity ratio

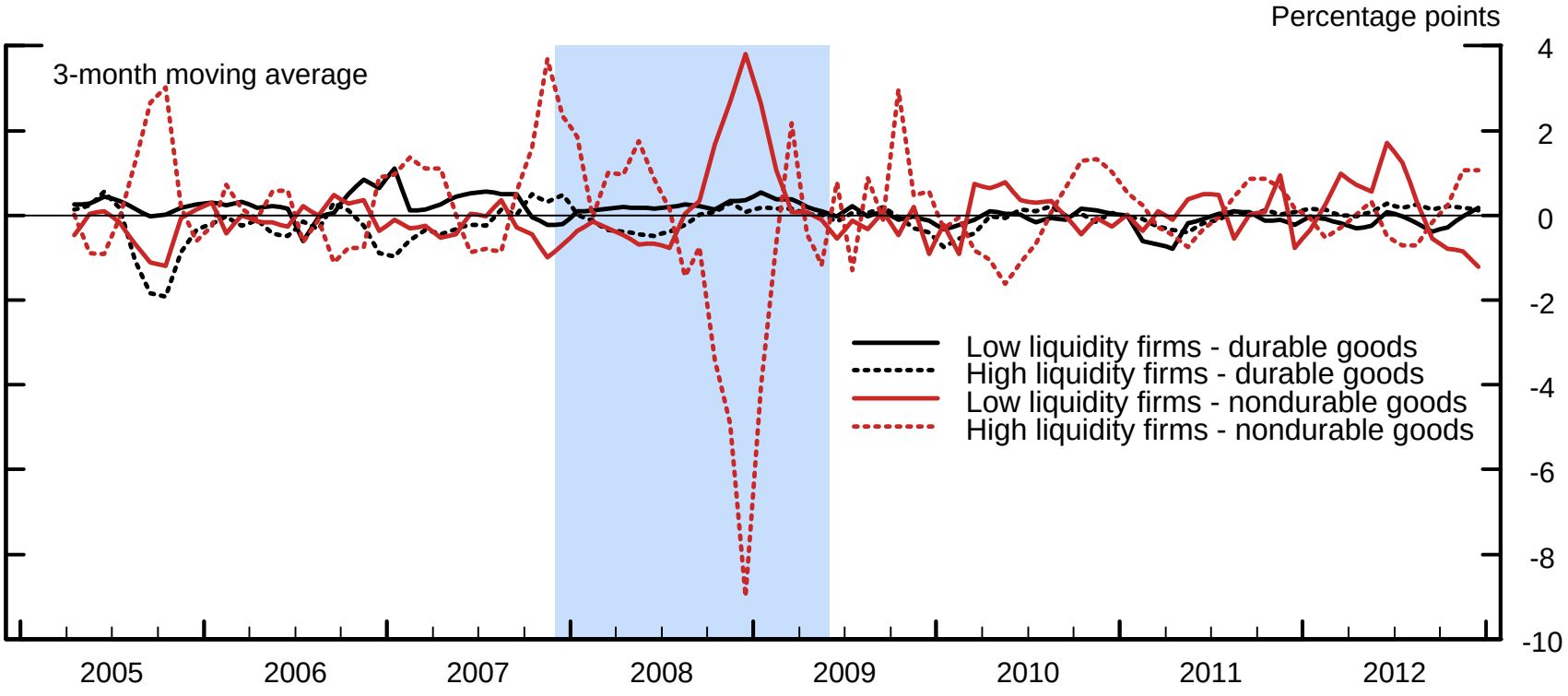


(b) By SGAX ratio

NOTE: Cumulative weighted-average industry-adjusted inflation rates.

Industry-Adjusted Producer Price Inflation

By financial characteristics and durability of output



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

Price-Setting Behavior During the Crisis

- Multinomial logit (3-month-ahead directional price change):

$$\Pr\left(\text{sgn}(\Delta_3 p_{i,j,t+3})\right) = \begin{cases} + \\ 0 \\ - \end{cases} = \Lambda(\text{LIQ}_{j,t}, \text{SGAX}_{j,t}, \mathbf{X}_{j,t}; \beta_1, \beta_2, \boldsymbol{\theta})$$

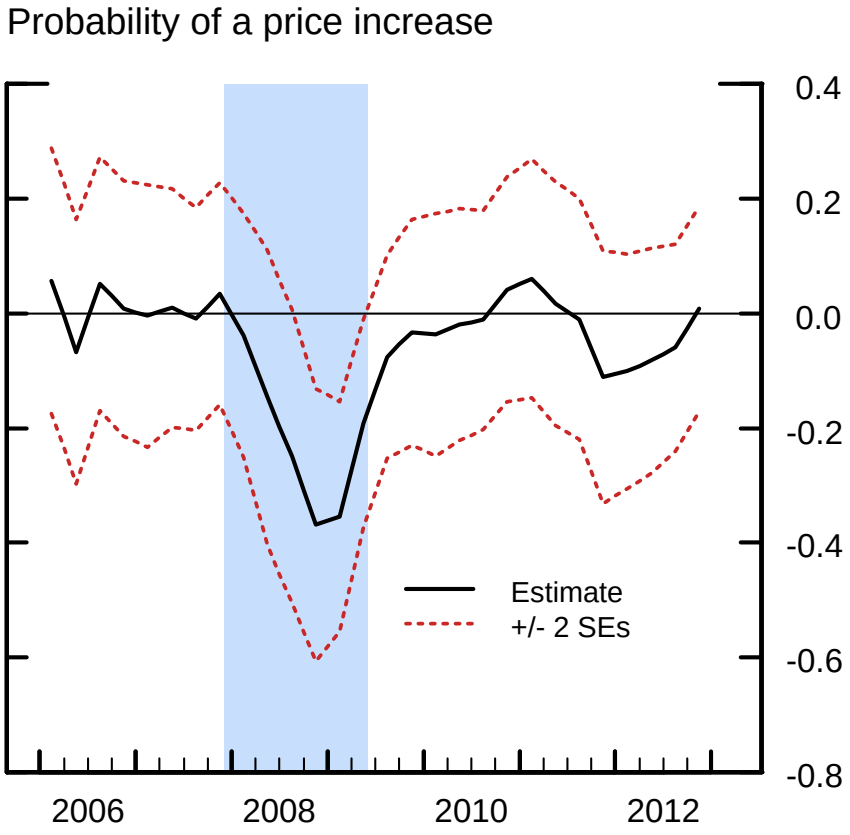
- Inflation regression (3-month-ahead):

$$\pi^{3m}_{i,j,t+3} = \beta_1 \text{LIQ}_{j,t} + \beta_2 \text{SGAX}_{j,t} + \boldsymbol{\theta}' \mathbf{X}_{j,t} + \eta_j + u_{i,j,t+3},$$

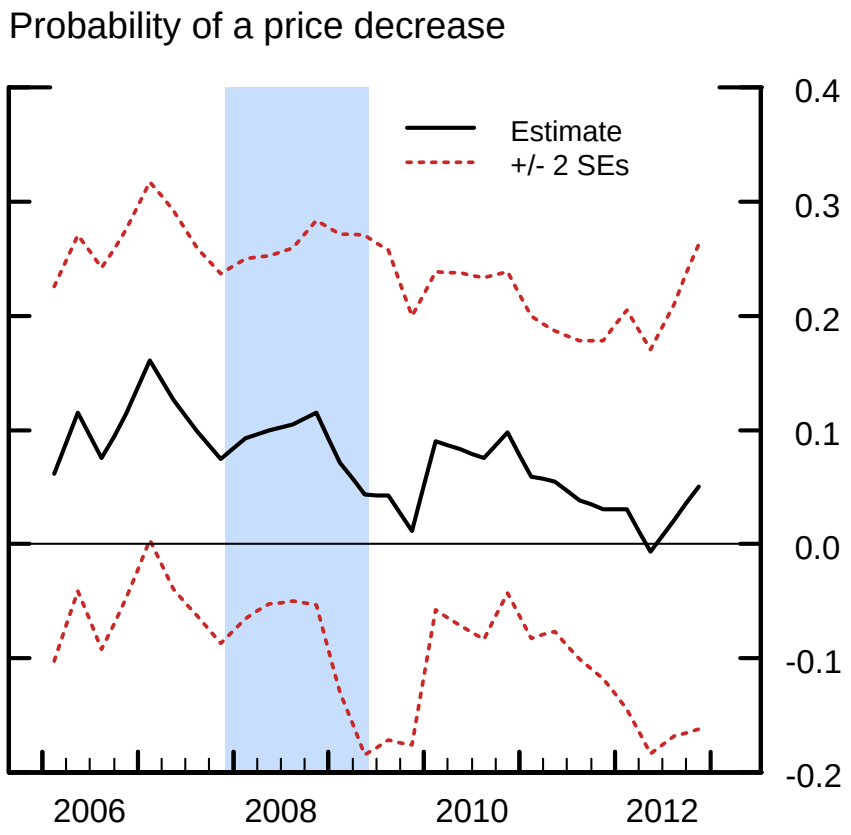
- Estimation:
  - Coefficients β_1 and β_2 are allowed to switch in 2008.
  - 4-quarter rolling window

Directional Price Change Marginal Effects

With respect to liquidity ratio (4-quarter rolling window estimates)



(c) Marginal effect of liquidity ratio

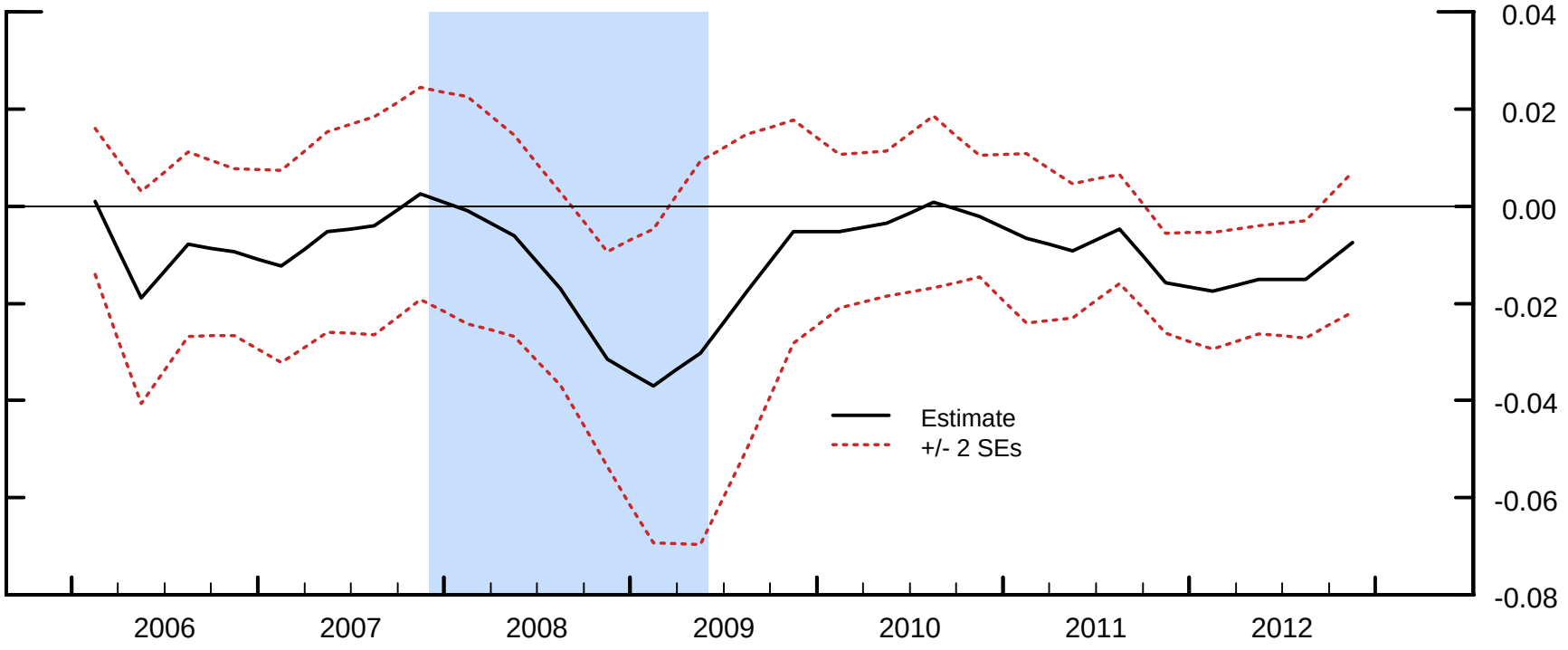


(d) Marginal effect of liquidity ratio

- **Implications**: 2 std. deviation difference in LIQ $\Rightarrow$ 11 pps. difference in probability of a price increase.

Inflation Effects

With respect to liquidity ratio (4-quarter rolling window estimates)



- **Implications**: 2 std. deviation difference in LIQ $\Rightarrow$ 4 pps. difference in annualized inflation.

GE Model

- Customer markets imply that firms trade off current profits for future market share.

  Phelps & Winter [1970]; Bils [1989]

- Financial market frictions imply that firms discount the future more when demand is low—and therefore maintain high markups.

  Gottfries [1991]; Chevalier & Scharfstein [1996]

- Embed this intuition into a GE model with nominal price rigidities.

PREFERENCES: "DEEP HABITS"

Ravn, Schmitt-Grohe and Uribe [2006]

- Problem of household $j \in [0,1]$:

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s U(x^j_{t+s} - \psi_{t+s}, h^j_{t+s})$$

- Habit-adjusted consumption bundle:

$$x^j_t \equiv \left[\int_0^1 \left(\frac{c^j_{it}}{s^{\theta}_{i,t-1}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}; \quad \theta < 0 \text{ and } \eta > 0$$

  - Law of motion for the external habit:

$$s_{it} = \rho s_{i,t-1} + (1-\rho) c_{it}; \quad 0 < \rho < 1$$

  - $\psi_t =$ demand shock

TECHNOLOGY

- Continuum of monopolistically competitive firms producing a variety of differentiated goods indexed by $i \in [0, 1]$.
- Production function (labor input only):

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

  - A_t = aggregate technology level
  - a_{it} = i.i.d. idiosyncratic technology shock with $\log a_{it} \sim N(-0.5\sigma^2, \sigma^2)$
  - ϕ_i = fixed operating costs

- Baseline case: homogeneous firms ($\phi_i = \phi, \ \forall i$)

Frictions and Monetary Policy

- Frictions:
  - Nominal rigidities:
    Rotemberg [1982]

$$\frac{\gamma_p}{2}\left(\frac{P_{it}}{P_{i,t-1}}-\bar{\pi}\right)^2 c_t = \frac{\gamma_p}{2}\left(\pi_t\frac{p_{it}}{p_{i,t-1}}-\bar{\pi}\right)^2 c_t; \quad p_{it}\equiv\frac{P_{it}}{P_t}$$

  - Costly external equity financing:
    Myers & Majluf [1984]; Gomes [2001]; Stein [2003]
    - dilution cost ($0<\varphi_t<1$) $\Rightarrow$ 1\$ of issuance brings in $(1-\varphi_t)$\$

- Monetary authorities:

$$r_t = (1+r_{t-1})^{\tau_r}\left[(1+\bar{r})\left(\frac{\pi_t}{\pi^*}\right)^{\tau_\pi}\left(\frac{y_t}{y_t^*}\right)^{\tau_y}\right]^{1-\tau_r}-1.$$

  - Baseline case: central bank cares only about inflation ($\tau_y=0$)

Timing and Equilibrium

- Within-period sequence of events:
  (1) Aggregate information arrives in the morning
  (2) Post prices based on aggregate information
  (3) Take orders, plan production based on expected marginal cost
  (4) Idiosyncratic shock a_{it} realized after orders have been taken
  (5) Meet demand based on originally posted prices and orders

- Risk-neutrality, timing, and i.i.d. shocks imply symmetric equilibrium:
  - All firms choose identical price ($p_{it} = p_t = 1$) and scale ($c_{it} = c_t$)
  - Symmetry does not apply to h_{it} and d_{it}.

Log-Linearized Phillips Curve

Standard New Keynesian model

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

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

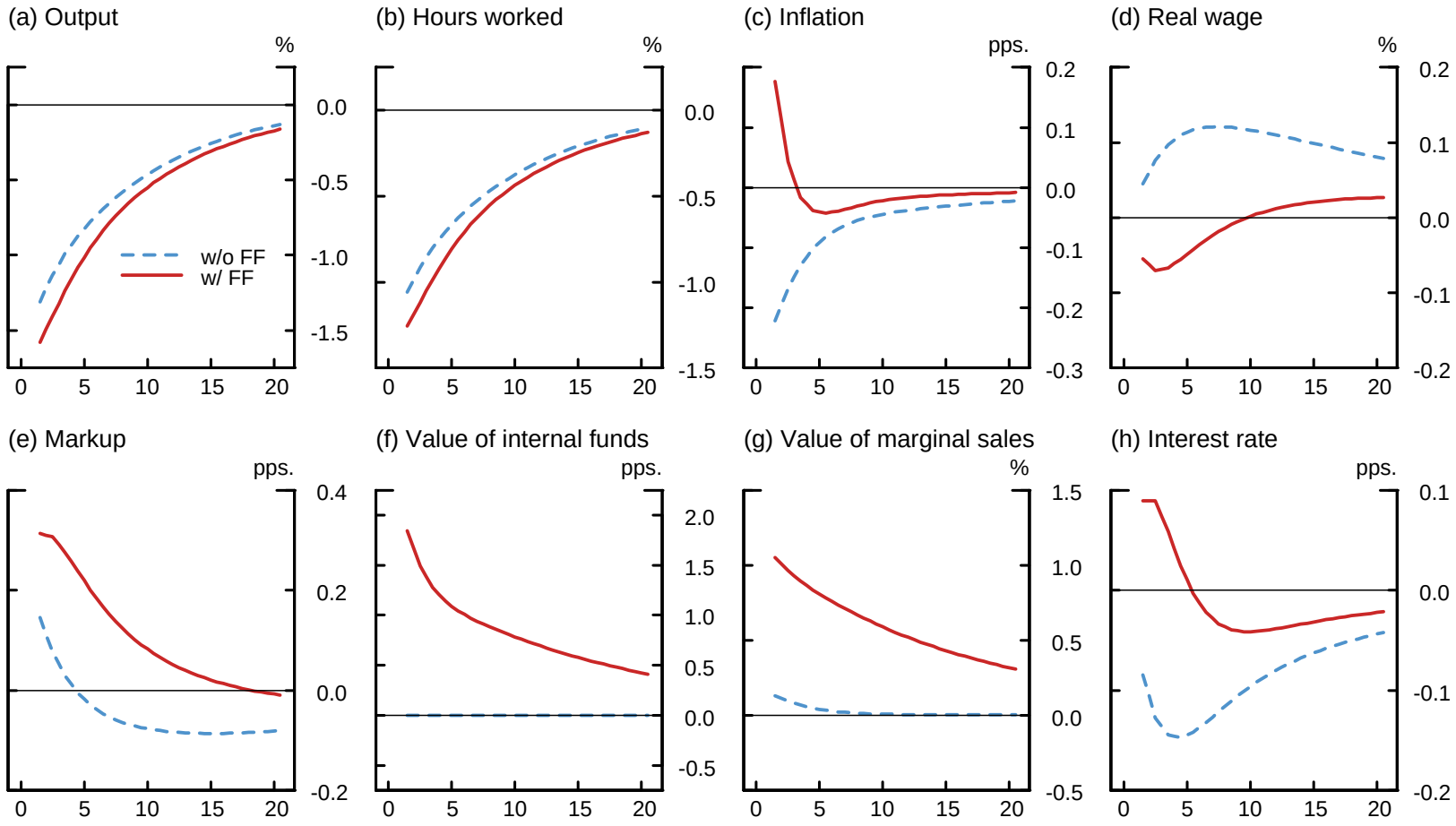
The role of financial frictions

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

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

Demand Shock During the Financial Crisis

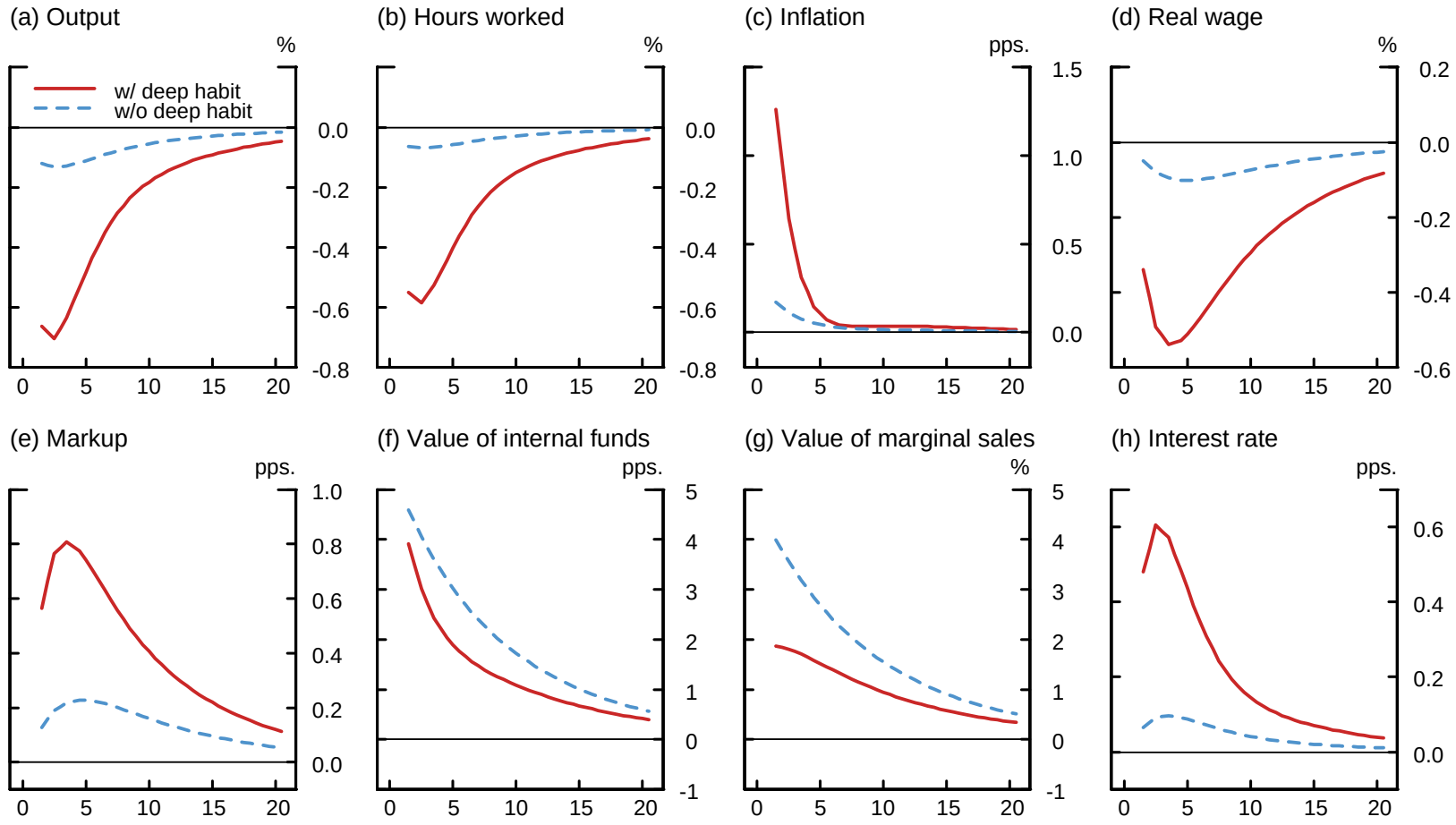
Homogeneous firms with nominal rigidities



- Financial crisis: $\varphi_t = \bar{\varphi} = 0.5$ (external finance premium = 20%)

FINANCIAL SHOCK

Homogeneous firms with nominal rigidities



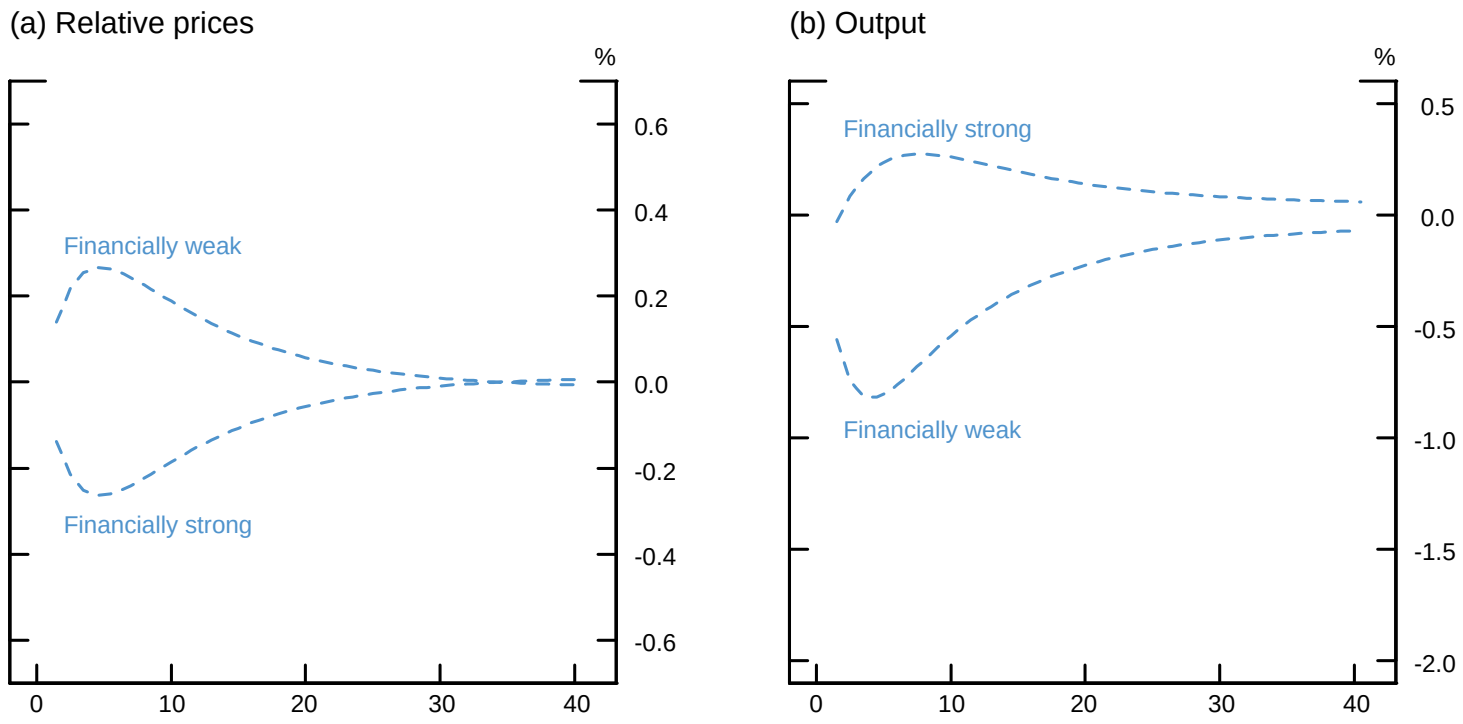
- Financial shock: $\varphi_t = 0.3 \rightarrow 0.375$ (AR(1) dynamics)

Heterogeneous Firms

- Two sectors that differ in operating efficiency: $\phi_1 \neq \phi_2$
  - Equal fixed measures of firms in each sector.
  - Symmetric equilibrium within each sector.
- Case I: $\phi_1 = 0.8\phi_2$ and $\phi_2 = 0.3$
  - Financially more fragile economy with limited heterogeneity.
- Case II: $\phi_1 = 0$ and $\phi_2 = 0.3$
  - Financially more robust economy with greater heterogeneity.
- Financial shock: $\varphi_t = 0.3 \rightarrow 0.375$ (AR(1) dynamics)

"Price War" in Response to a Financial Shock

Heterogeneous firms with nominal rigidities



- Case I: $\phi_1 = 0.8\phi$, $\phi_2 = 0.3$
- Case II: $\phi_1 = 0$, $\phi_2 = 0.3$

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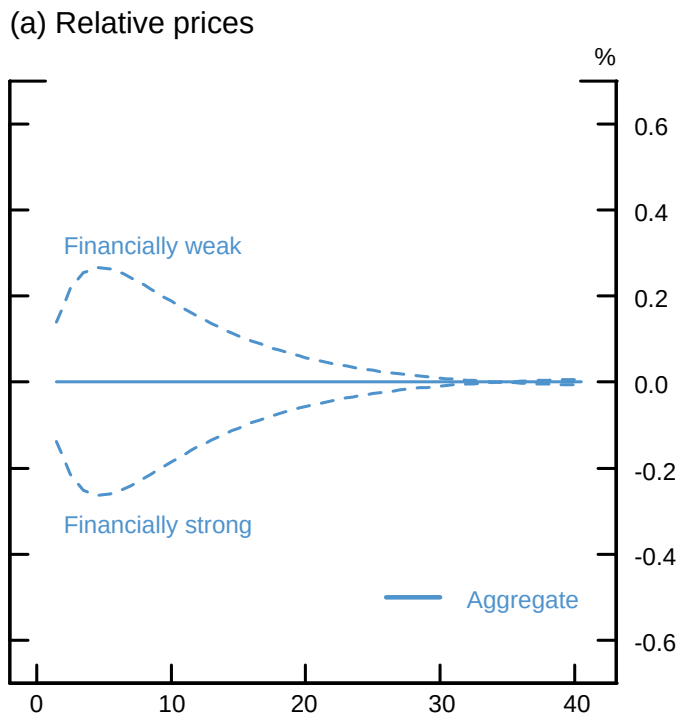

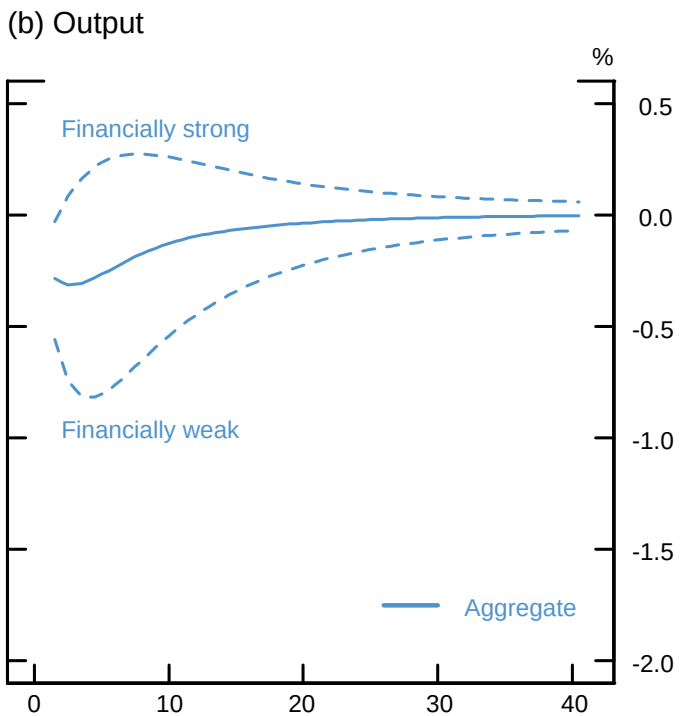

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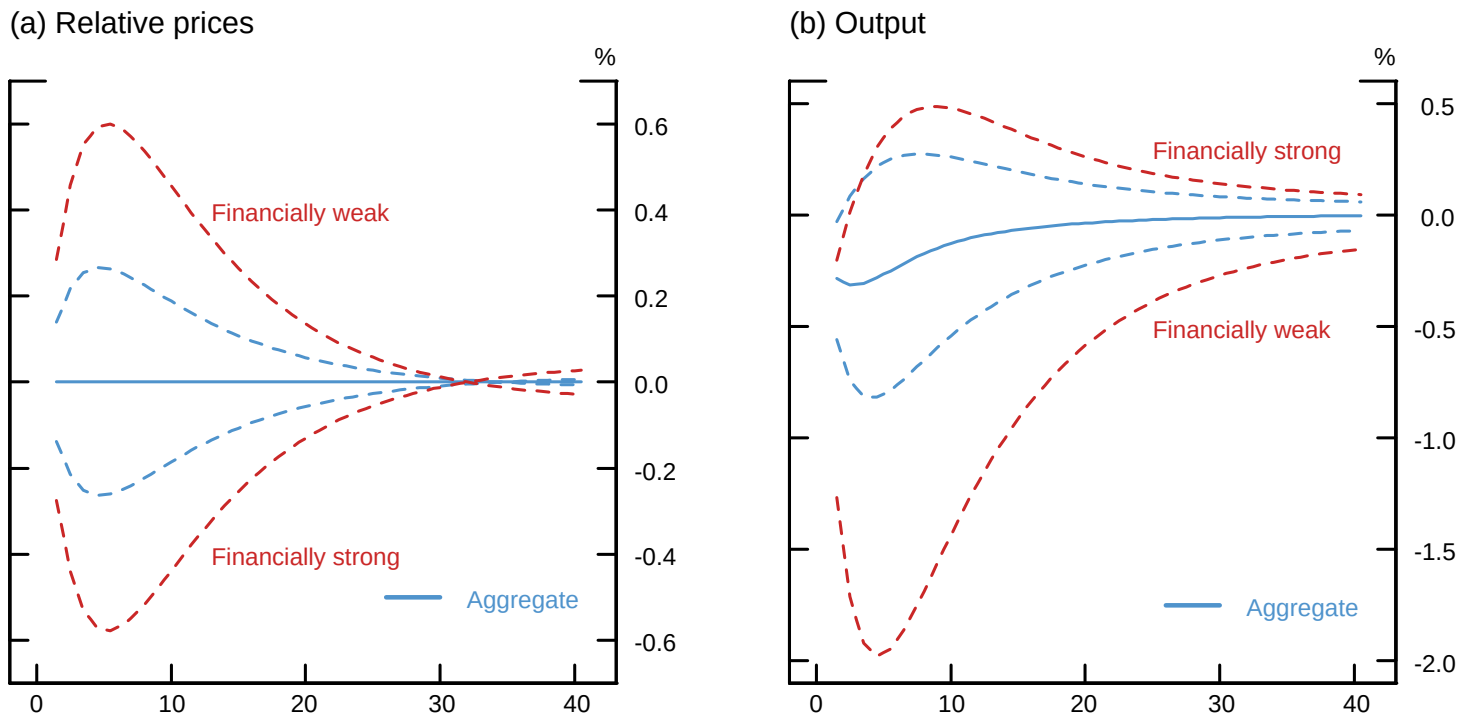

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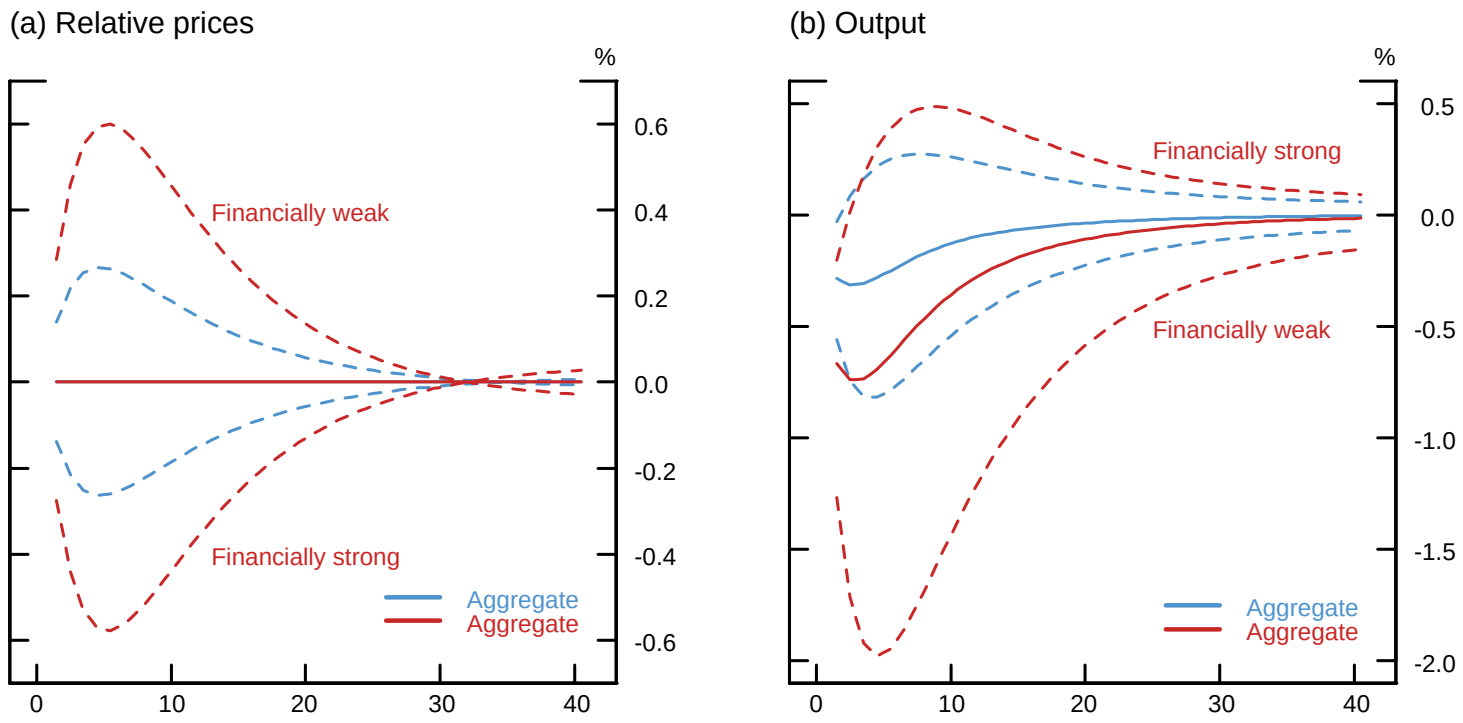

- Case I: $\phi_1 = 0.8\phi$, $\phi_2 = 0.3$
- Case II: $\phi_1 = 0$, $\phi_2 = 0.3$

Conclusion

- Internal liquidity positions and customer markets importantly influenced firms' price-setting behavior during the 2007–09 crisis:
  - Liquidity unconstrained firms decreased prices, while liquidity constrained firms increased prices.
  - Differences in price-setting behavior concentrated in nondurable goods industries.
- DSGE model with customer markets and financial frictions:
  - Significant attenuation of inflation dynamics in response to demand and financial shocks.
  - Severe downturn in response to temporary financial shocks.
  - Tradeoff regarding inflation vs. output stabilization in response to demand and financial shocks.
  - "Paradox of financial strength" with heterogeneous firms.