Inflation Dynamics and Customer Markets

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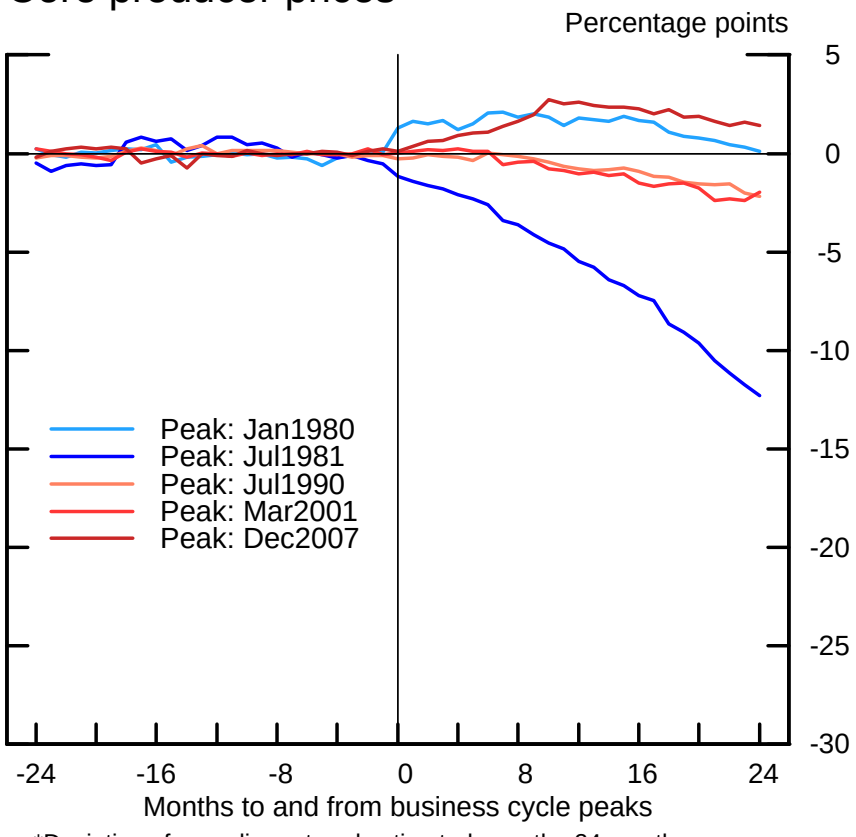
THE QUESTION

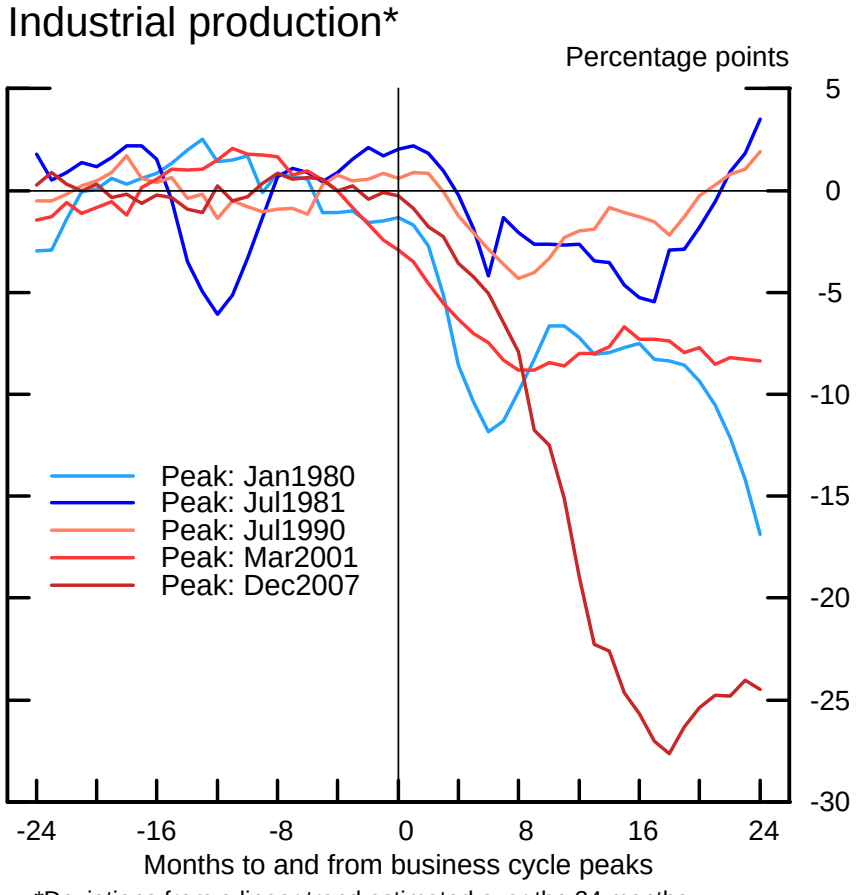
- What accounts for the resilience of inflation in the face of significant and long-lasting economic slack?
- **Example**: Absence of more substantial deflationary pressures during the "Great Recession" is difficult to square with the Phillips-curve type relations common to most macroeconomic models.

PRODUCER PRICES AND INDUSTRIAL PRODUCTION



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

(a) Core PPI



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

(b) Industrial Production

OUR ANSWER

- Forces damping the response of inflation to adverse demand or financial shocks reflect the confluence of customer markets and financial frictions:
  - **Customer markets**: markets in which customer base is “sticky” and important determinant of firms’ assets and its ability to generate profits.
  - **Financial frictions**: systematic wedge between the cost of external and internal finance due to asymmetric information and/or moral hazard problems in financial markets.

THE MECHANISM

- Customer markets $\Rightarrow$ firms view customer base as an asset, in which they can invest by lowering prices.
- Financial frictions $\Rightarrow$ firms discount more heavily future benefits from increasing customer base.
- When financial conditions tighten during a downturn:
  - Financially constrained firms raise prices to preserve current cash flows to fund operations and cover debt obligations.
  - Financially unconstrained firms lower prices and gain market share at the expense of their constrained competitors.
  - In the aggregate, this damps the response of inflation to contraction in output.

THE ROADMAP

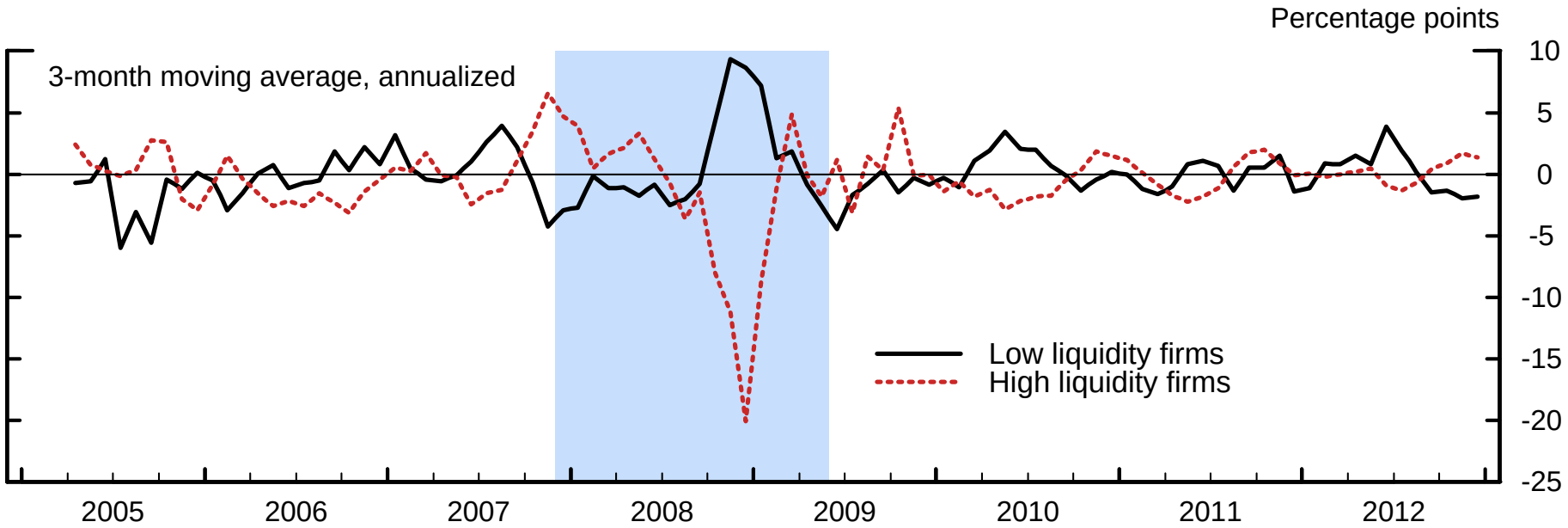
- Empirical evidence:
  - Firm-level data on pricing decisions during the 2008–09 financial crisis.
  - Narrowly defined industry-level data (1973–2013)
  - Euro area country-level data.
- Theory:
  - GE model that embeds financial frictions in a customer-markets framework
  - Analyze inflation dynamics in response to demand and financial shocks
  - Extend the model to a two-country setting (i.e., core vs. periphery) to study economic consequences of forming a monetary union among countries with varying degrees of financial distortions

DATA SOURCES

- Monthly good-level price data underlying the PPI.
  Nakamura & Steinsson [2008]; Goldberg & Hellerstein [2009]; Bhattarai & Schoenle [2010]
- Match approx. 600 PPI respondents to their income and balance sheet data from Compustat.
- Sample period: Jan2005–Sep2012

INDUSTRY-ADJUSTED PPI INFLATION

By liquidity ratio



PRICE DYNAMICS AND FINANCIAL CONDITIONS

- Multinomial logit:

$$\Pr\big(\text{sgn}[p_{i,j,t+3} - p_{i,j,t}]\big) = \begin{cases} - \\ 0 \\ + \end{cases} = \Lambda(\beta' \mathbf{X}_{j,t} + \gamma \pi_t^{IND(3m)} + d_t)$$

- Linear pricing regression:

$$\pi_{i,j,t+3}^{3m} = \beta' \mathbf{X}_{j,t} + \gamma \pi_t^{IND(3m)} + d_t + u_{i,j,t+3}$$

- Firm-specific explanatory variables:
  - Financial positions: $\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 0]$ and $\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 1]$
  - Controls: $\log(S_{j,t}/S_{j,t-12})$, $\log(C_{j,t}/C_{j,t-12})$, $[N/S]_{j,t}$

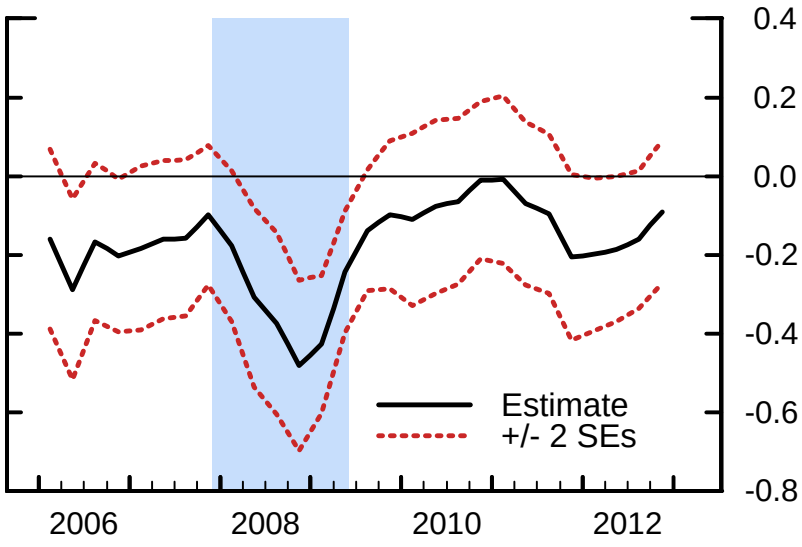
PRICE DYNAMICS AND FINANCIAL CONDITIONS

Time-varying liquidity ratio

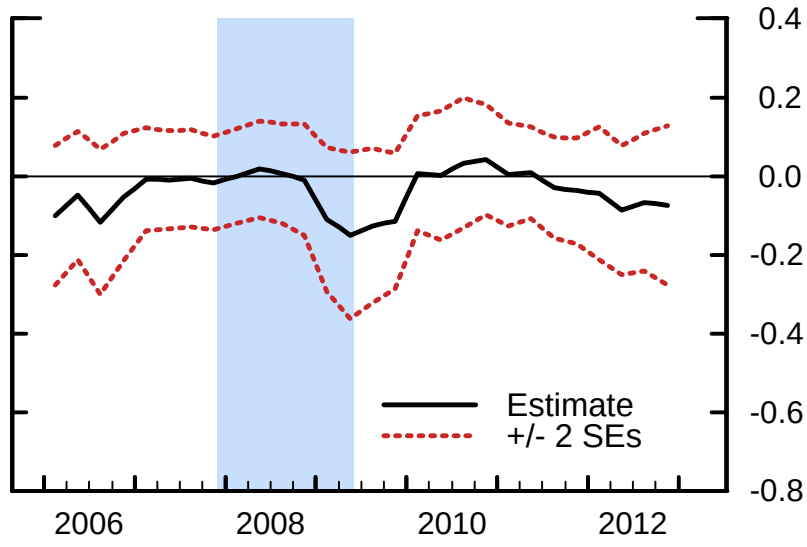
	(1)		(2)
Explanatory Variables	$+$	$-$	π^{3m}
$\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 1]$	-0.433^{***}	-0.012	-0.029^{***}
	(0.107)	(0.072)	(0.009)
$\text{LIQ}_{j,t} \times \mathbf{1}[\text{CRISIS}_t = 0]$	-0.143^{**}	-0.044	-0.012^{***}
	(0.068)	(0.050)	(0.004)
$\log(S_{j,t}/S_{j,t-12})$	-0.020	-0.042^{*}	0.004
	(0.025)	(0.025)	(0.003)
$\log(C_{j,t}/C_{j,t-12})$	0.017	0.020^{*}	-0.002
	(0.013)	(0.011)	(0.002)
$[N/S]_{j,t}$	-0.022	-0.020	0.001
	(0.021)	(0.024)	(0.001)
$\pi_t^{IND(3m)}$	1.182^{***}	-0.127	0.134^{**}
	(0.333)	(0.170)	(0.055)

NOTE: Robust standard errors are clustered at the firm level; *** $p < .01$, ** $p < .05$, * $p < .10$.

TIME-VARYING EFFECT OF LIQUIDITY



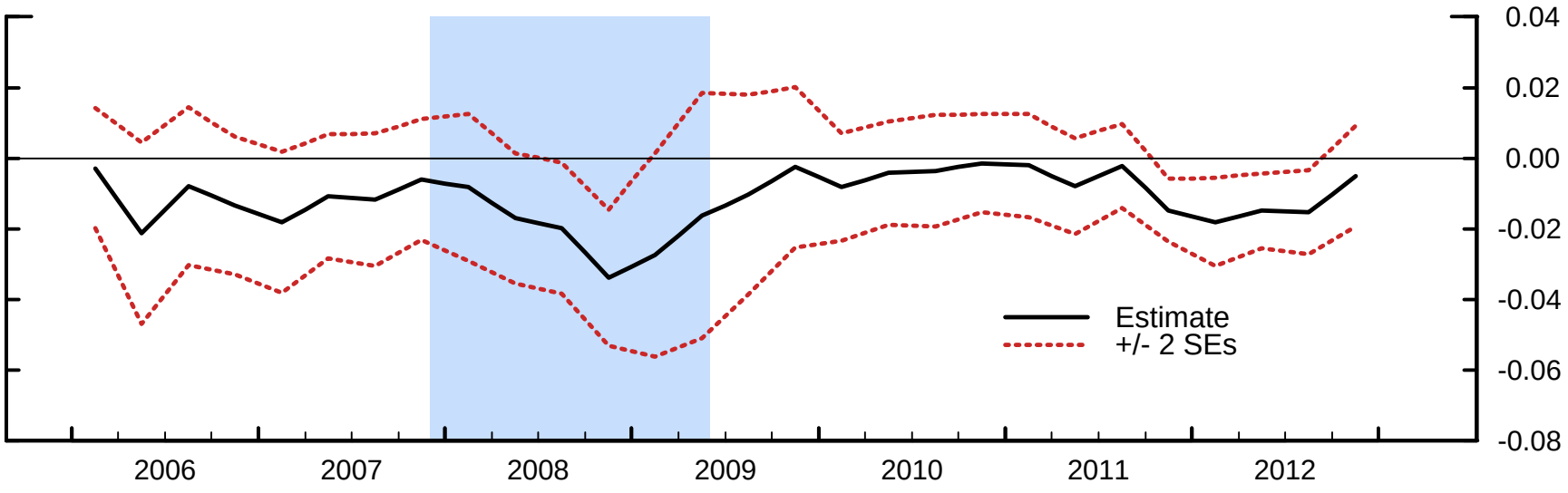
(a) Prob. of a price increase



(b) Prob. of a price decrease

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

TIME-VARYING EFFECT OF LIQUIDITY



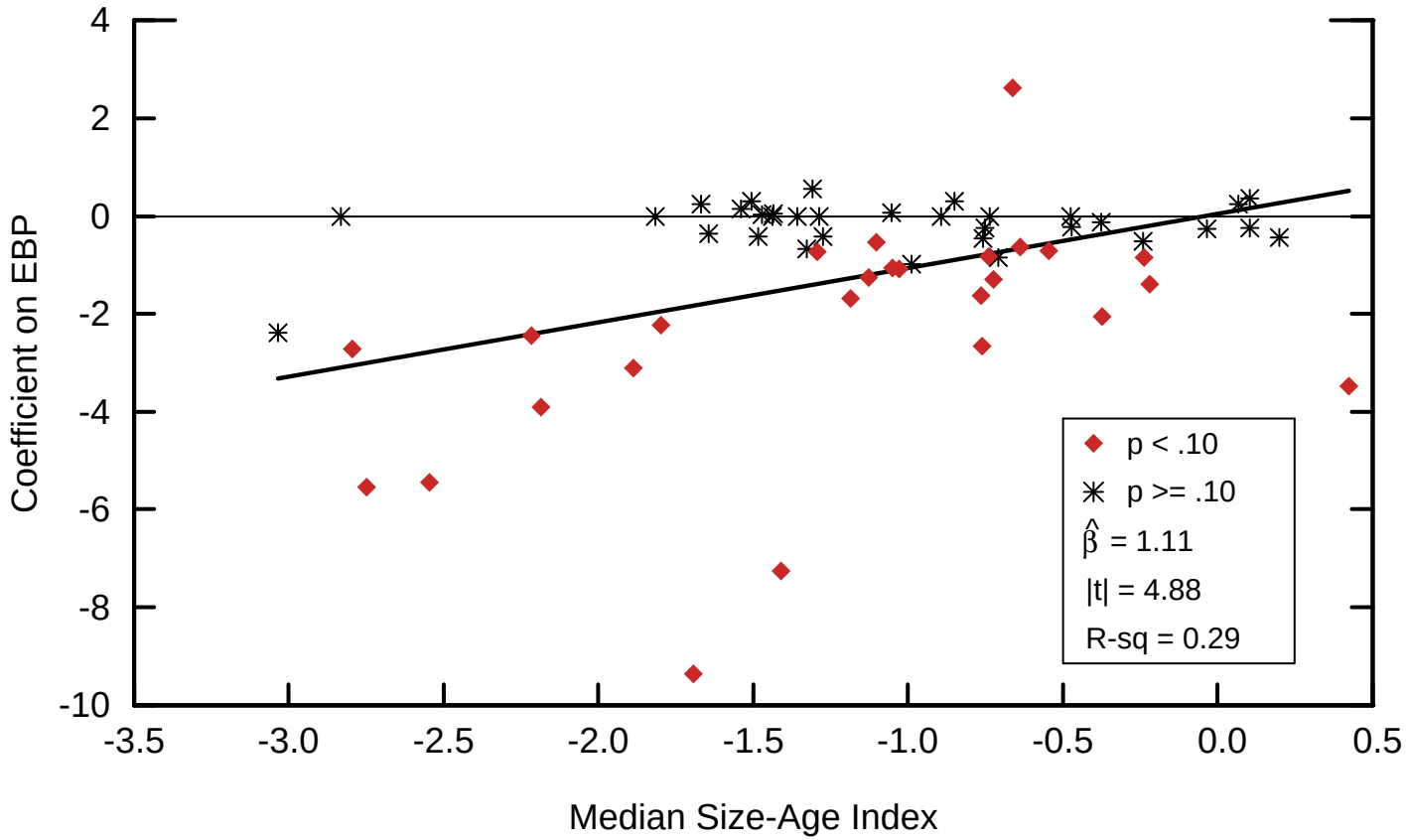
- **Quantitative implication**: two std. deviation reduction in liquidity implies a 5 pps. increase in annualized inflation.

IS THIS A ONE-OFF EVENT?

- Item-level price data underlying PPI are not available before 2005.
- Use industry-level (6-digit NAICS) PPIs to examine sensitivity of inflation to changes in financial conditions over the 1973–2013 period.
  - Regress inflation in industry i from month t to $t + h$ on:
    - current and lagged inflation
    - current and lagged growth in industry-level IP
    - current commodity price inflation
    - indicator of financial conditions in month t—excess bond premium (EBP)
  - Coefficients on EBP and commodity price inflation are allowed to vary across 4-digit NAICS industry groups.
  - Is variation in industry-specific EBP coefficients related to the likelihood of financial constraints across industries?

PPI INFLATION AND FINANCIAL CONDITIONS

By industry-specific indicator of financial constraints



NOTE: Smaller values of the size-age index indicate a smaller likelihood of financial constraints.

Euro Area Inflation and Economic Activity

	1992–2007		2008–2013	
Average (%)	Core	GIIPS	Core	GIIPS
Inflation	1.74	4.02	1.49	0.55
Output gap	−0.07	0.81	−0.73	−2.98
Unemployment gap	0.46	−0.60	−0.09	1.27

Core = AUT, DEU, BEL, FIN, FRA, NLD; GIIPS = GRC, IRL, ITA, ESP, PRT
SOURCE: AMECO database.

- Is lack of disinflationary pressures in the periphery during the crisis related to financial strains?

Financial Conditions and Inflation Dynamics

- Panel-versions of the price and wage Phillips Curves:
  - Prices (backward looking):

$$\pi_{it} = \alpha_i + \beta\pi_{i,t-1} + \lambda_i(u_{it} - \bar{u}_{it}) + \phi\Delta\text{VAT}_{it} + \psi\mathbf{1}[i \in €] + \epsilon_{it};$$

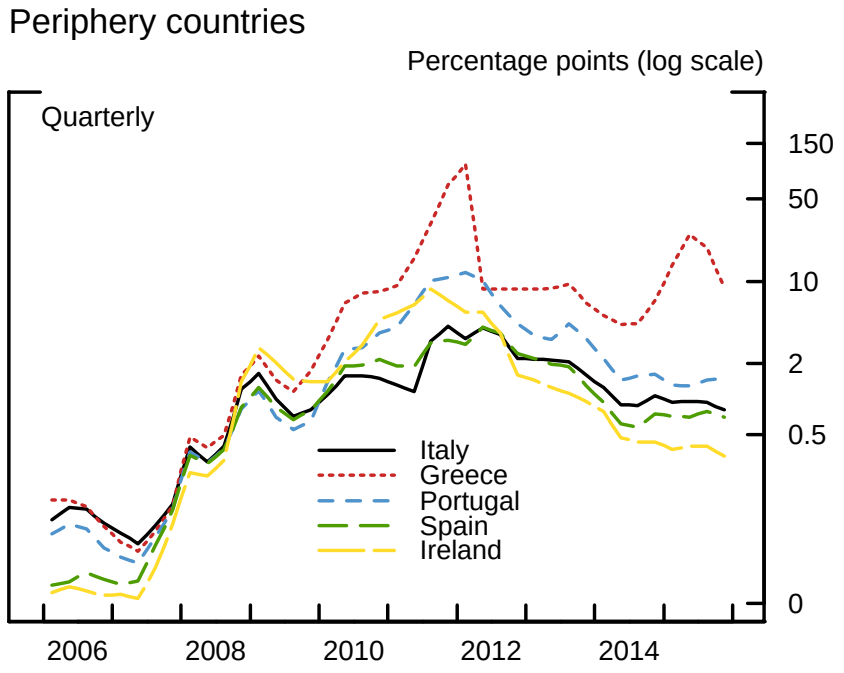
  - Wages (backward looking):

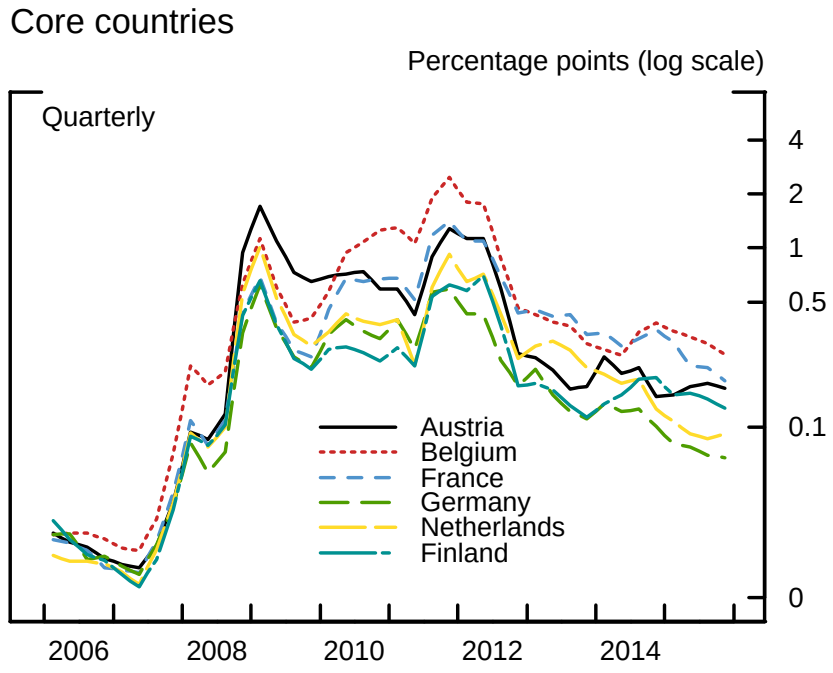
$$\pi^w_{it} = \alpha_i + \beta\pi_{i,t-1} + \lambda_i(u_{it} - \bar{u}_{it}) + \phi\Delta\tilde{z}_{it} + \psi\mathbf{1}[i \in €] + \epsilon_{it};$$

- Data
  - Countries: AUT, DEU, BEL, FIN, FRA, NLD, GRC, IRL, ITA, ESP, PRT
  - Estimation period: 1970–2007
- Are the PC prediction errors during the crisis related to the degree of financial strains across countries?

Financial Conditions in the Euro Area

Sovereign (5-year) CDS spreads





SOURCE: Markit.

Financial Conditions and PC Prediction Errors

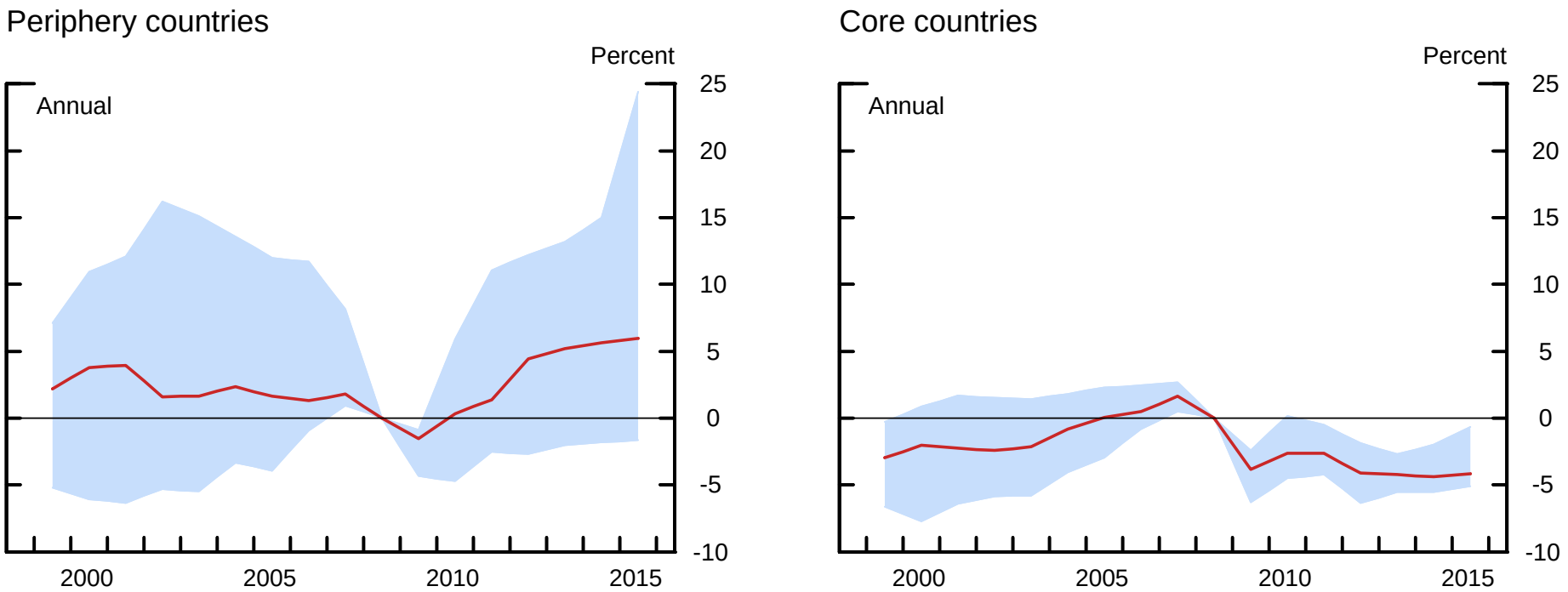
With time fixed effects, 2008–2013

PC Prediction Error	Explanatory Variable		R^2
	$\ln \text{CDS}_{i,t-1}$	$\ln \text{CDS}_{i,t-1} \times \mathbf{1}[i \in \text{P}]$	
(2) Prices	0.684	0.275	0.419
	$[0.369, 0.999]$	$[0.031, 0.519]$	
(5) Wages	-2.196	-1.469	0.542
	$[-2.731, -1.661]$	$[-2.550, -0.389]$	

NOTE: Bootstrapped 95% confidence intervals in brackets.

Price Markups

Euro area, 2000–2015



NOTE: The markup is equal to minus (100 times) the log or real unit labor costs (2008 = 1).
SOURCE: AMECO database.

Financial Conditions and Price Markups

Euro area, 2008–2013

Specification	Explanatory Variable		R^2
	$\ln \text{CDS}_{i,t-1}$	$\ln \text{CDS}_{i,t-1} \times \mathbf{1}[i \in \text{P}]$	
A. *Aggregate markups*			
With time fixed effects	-0.312 $[-0.528, -0.095]$	1.148 $[0.926, 1.372]$	0.681
B. *Sectoral markups*			
With time fixed effects	-0.331 $[-1.915, 1.254]$	1.974 $[1.244, 2.704]$	0.152

NOTE: Bootstrapped 95% confidence intervals in brackets.

SUMMARY

- Internal liquidity positions played an important role in shaping the firms? price-setting behavior during the U.S. financial crisis.
- Industry-level evidence over long time period implies that industries dominated by small/young firms are less likely to lower prices in response to financial disruptions.
- Euro area country-level data implies similar missing “deflation puzzle”—missing deflation is systematically linked to financial conditions.

MODEL OVERVIEW

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

PREFERENCES: "DEEP HABITS"

Ravn, Schmitt-Grohe & Uribe [2006]

- Household problem:

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s U(x^j_{t+s} - \psi_{t+s}, h^j_{t+s}); \quad j \in [0,1]$$

- 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:

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

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

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

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]
  - Equity dilution cost: $0 < \varphi_t < 1$
  - 1\$ of issuance brings in $(1-\varphi_t)$\$
- Financial shock: $\varphi_t = \bar{\varphi} f_t; \quad \log f_t = 0.90 \log f_{t-1} + \epsilon_{f,t}$

TIMING

- 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

IMPLICATIONS

- A low markup is an aggressive but risky investment.
- Exposes the firm to the risk of operating losses, which must be covered by costly external finance.

LOG-LINEARIZED PHILLIPS CURVE

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

- $\hat{\mu}_t =$ (financially adjusted) markup
- $\hat{\xi}_t =$ shadow value of internal funds
- $\hat{\beta}_{t,s+1} =$ capitalized growth of customer base
- ω, $\tilde{\delta}$, and χ are functions of the model's structural parameters:
  - No external habit $(\theta = 0) \Rightarrow \omega = 1$ and $\chi = 0$

LOG-LINEARIZED PHILLIPS CURVE

The role of "deep habits"

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

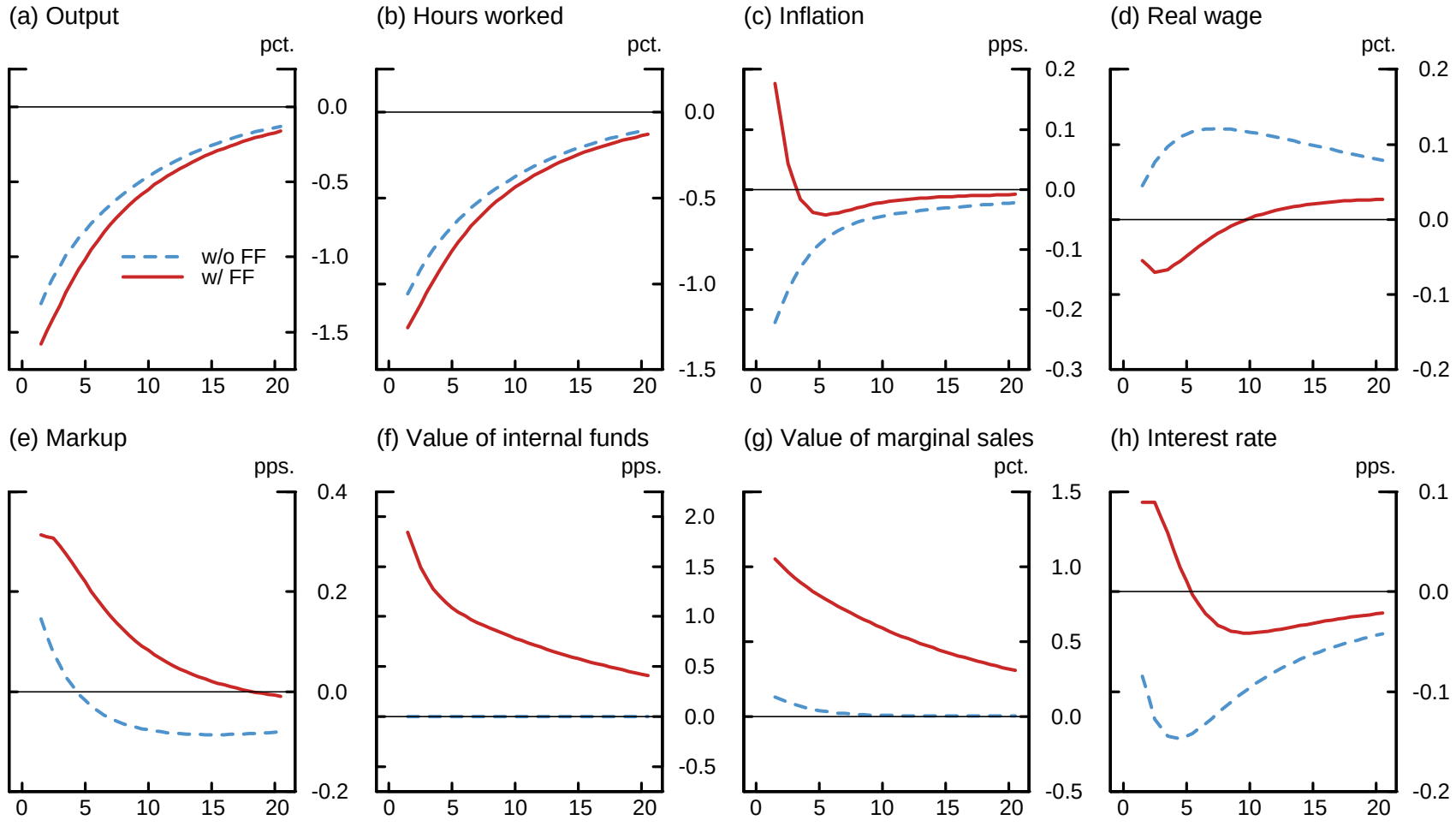
LOG-LINEARIZED PHILLIPS CURVE

The role of financial frictions

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

DEMAND SHOCK DURING THE FINANCIAL CRISIS

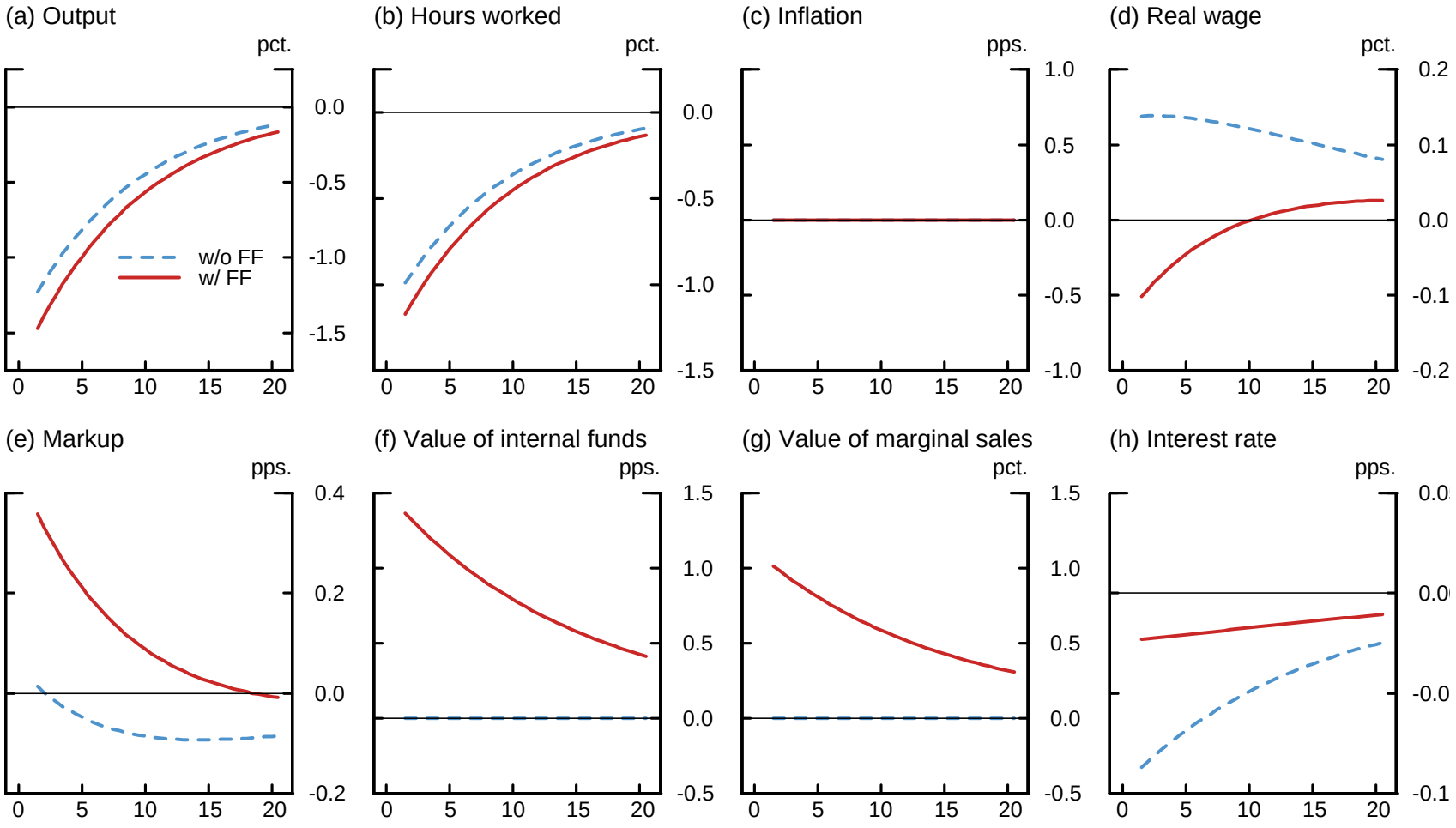
Homogeneous firms with nominal rigidities



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

DEMAND SHOCK DURING THE FINANCIAL CRISIS

Homogeneous firms without nominal rigidities



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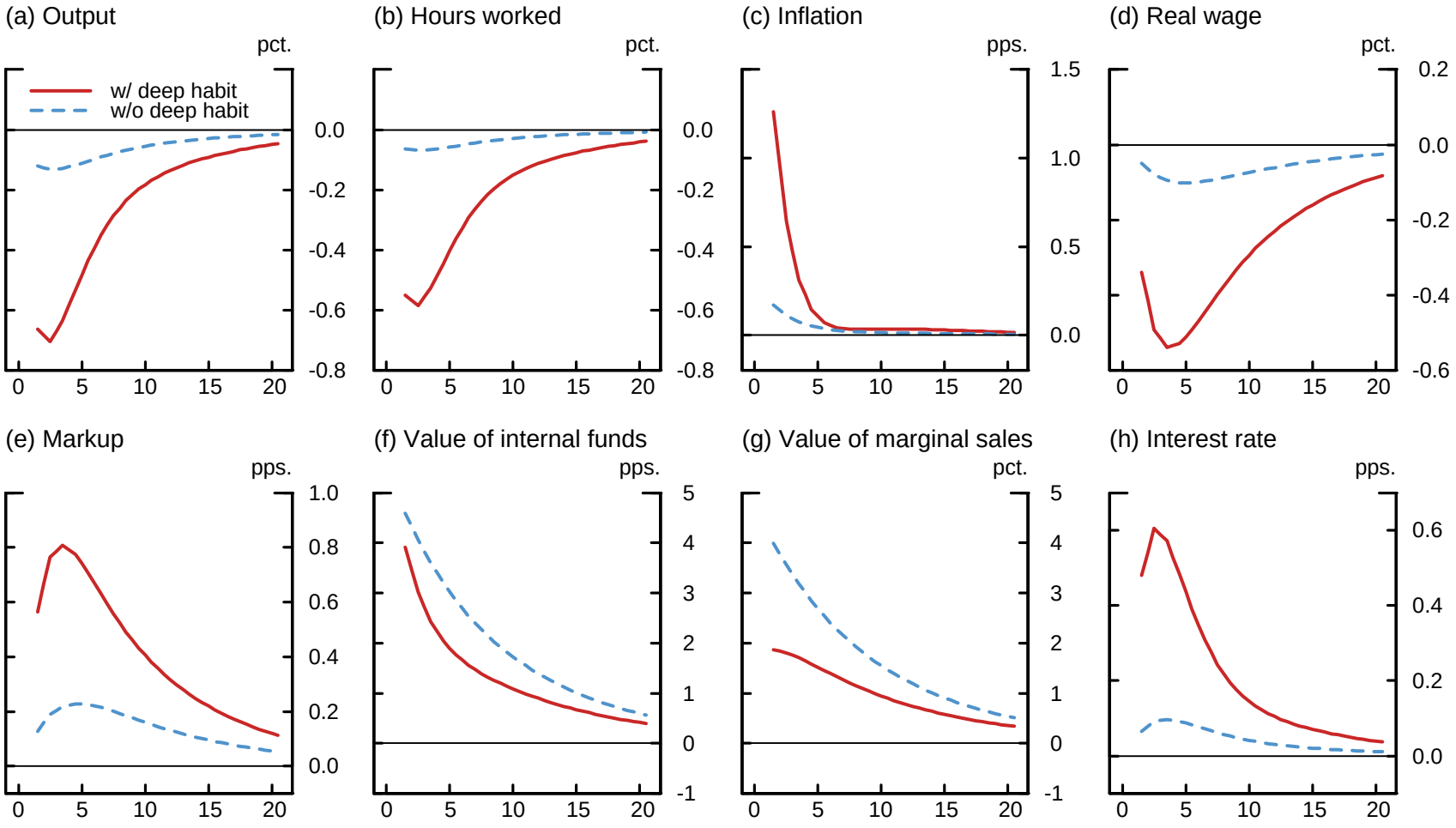
FINANCIAL SHOCK

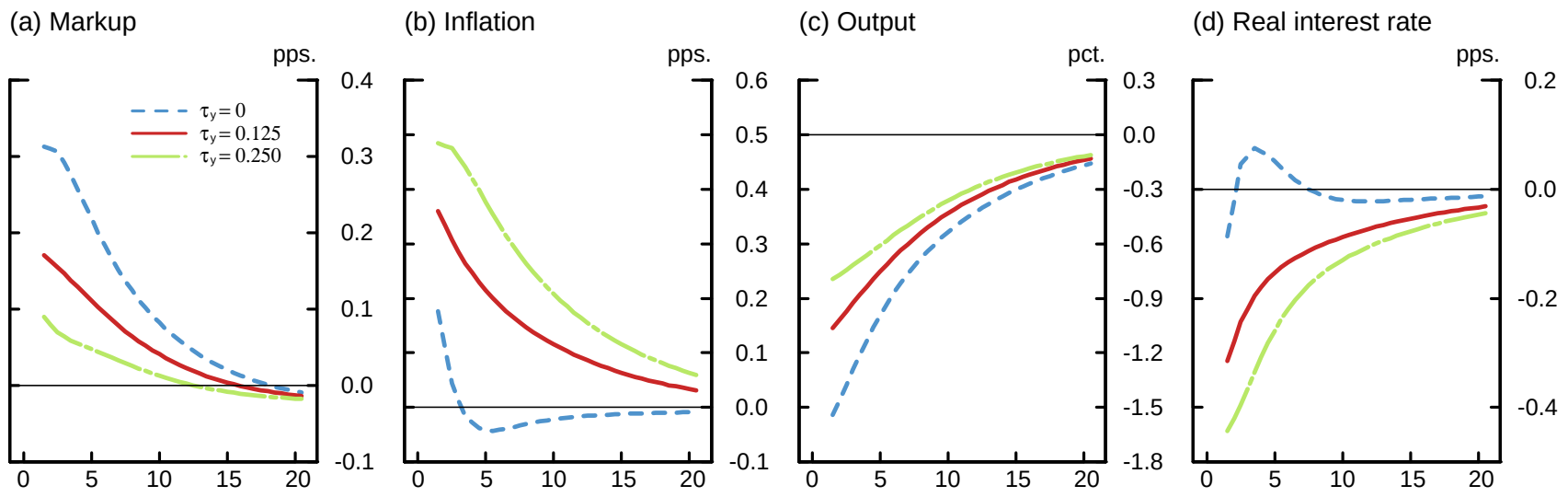
Homogeneous firms without nominal rigidities



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

DEMAND SHOCK DURING THE FINANCIAL CRISIS

Alternative monetary policy rules



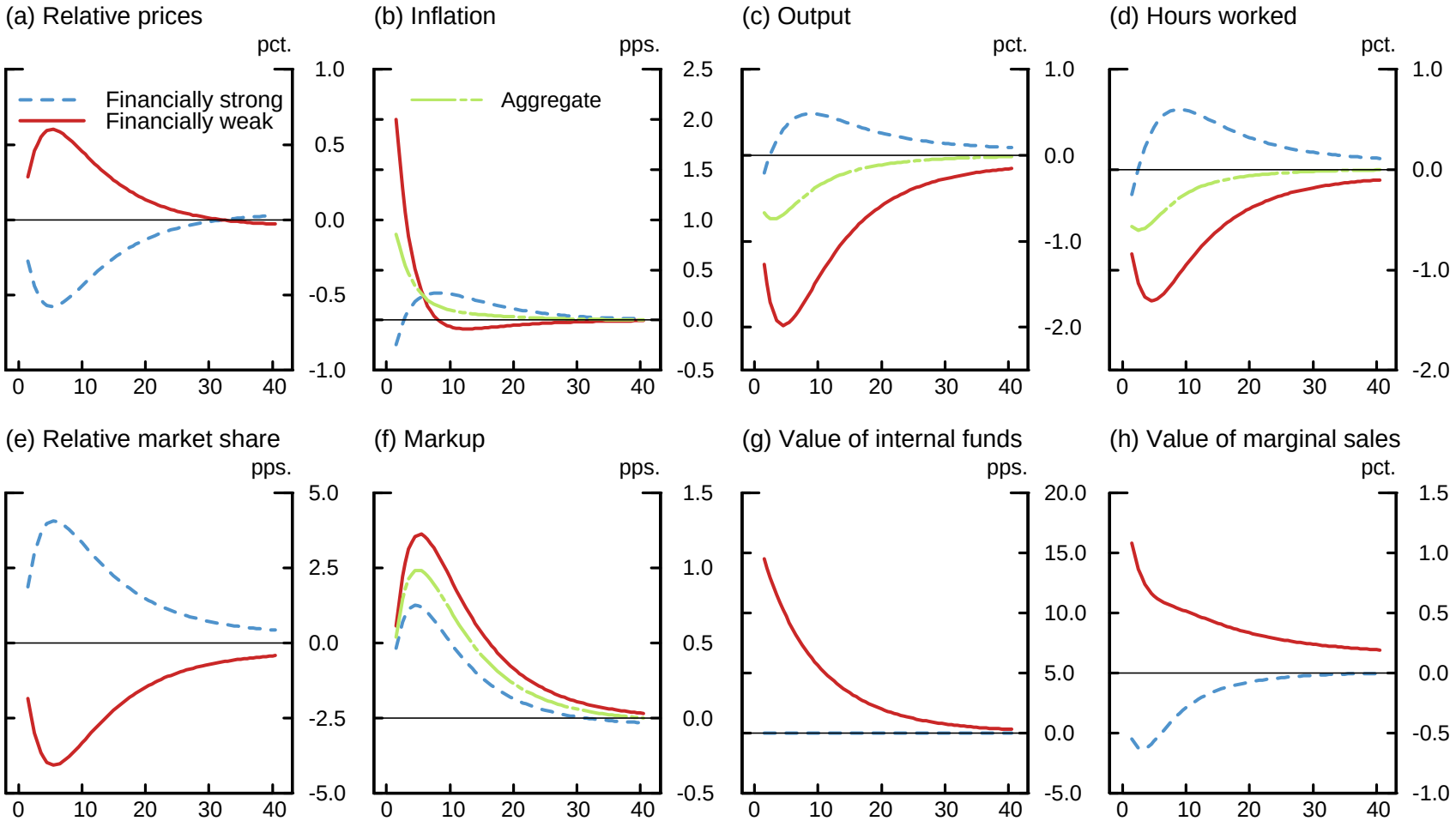
- Financial crisis: $\varphi_t = \bar{\varphi} = 0.5$ (external finance premium = 20%)

Differences in Financial Capacity

- 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.
- Calibration: $\phi_1 = 0$ and $\phi_2 = 0.3$
- Financial shock: $\varphi_t = 0.3 \rightarrow 0.375$ (AR(1) dynamics)

FINANCIAL SHOCK

Heterogeneous firms with nominal rigidities



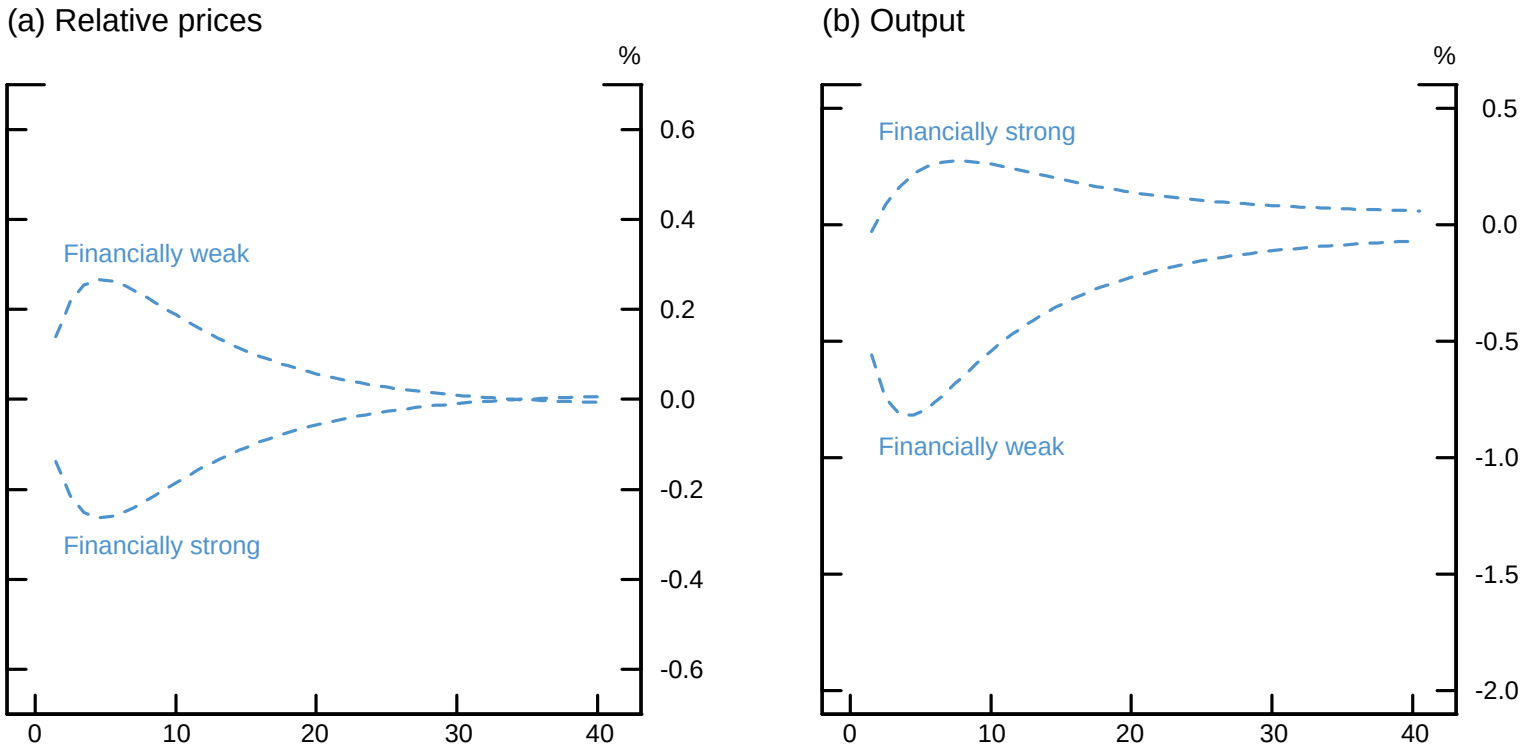
- Calibration: $\phi_1 = 0$, $\phi_2 = 0.3$

Paradox of Financial Strength

- 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: $\phi_1 = 0.8\phi$, $\phi_2 = 0.3$
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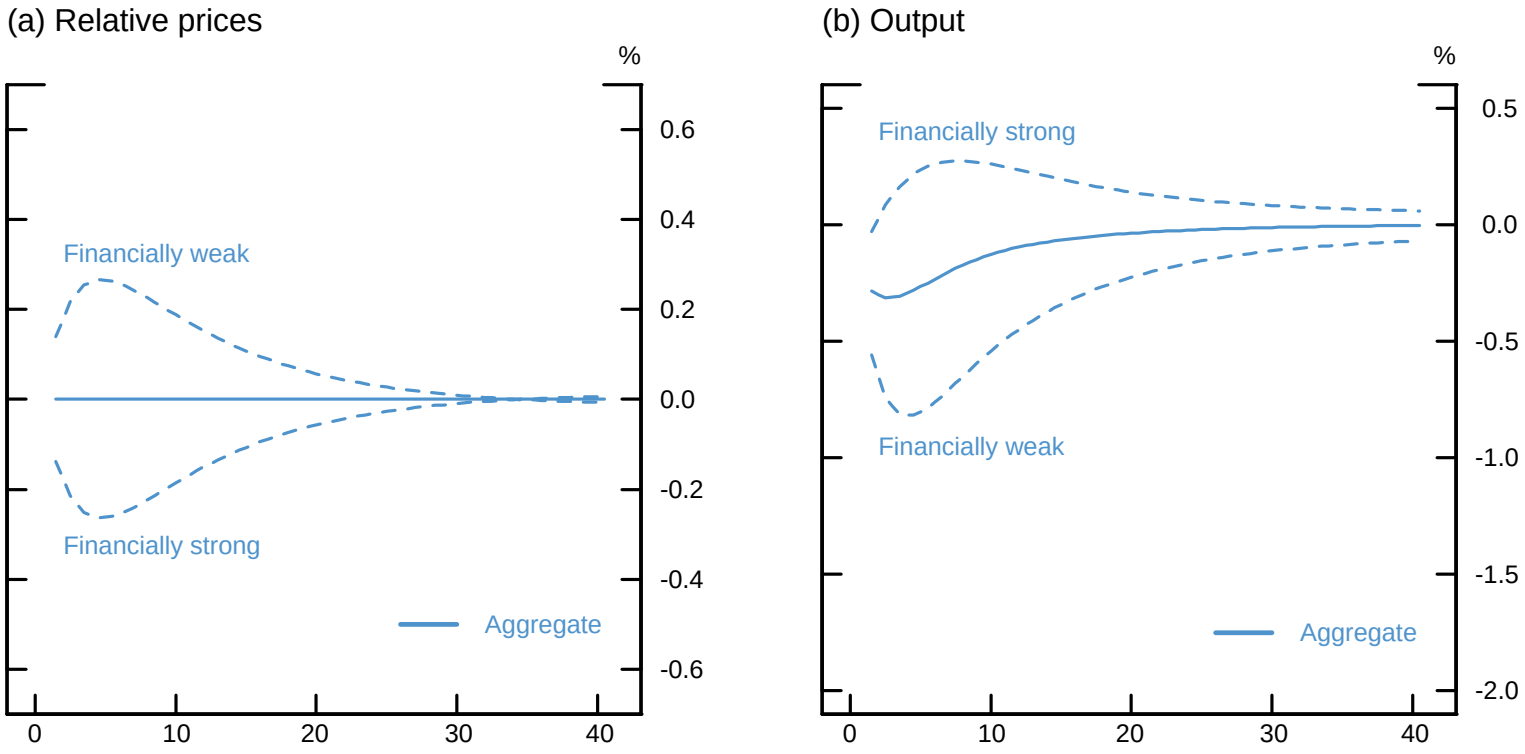

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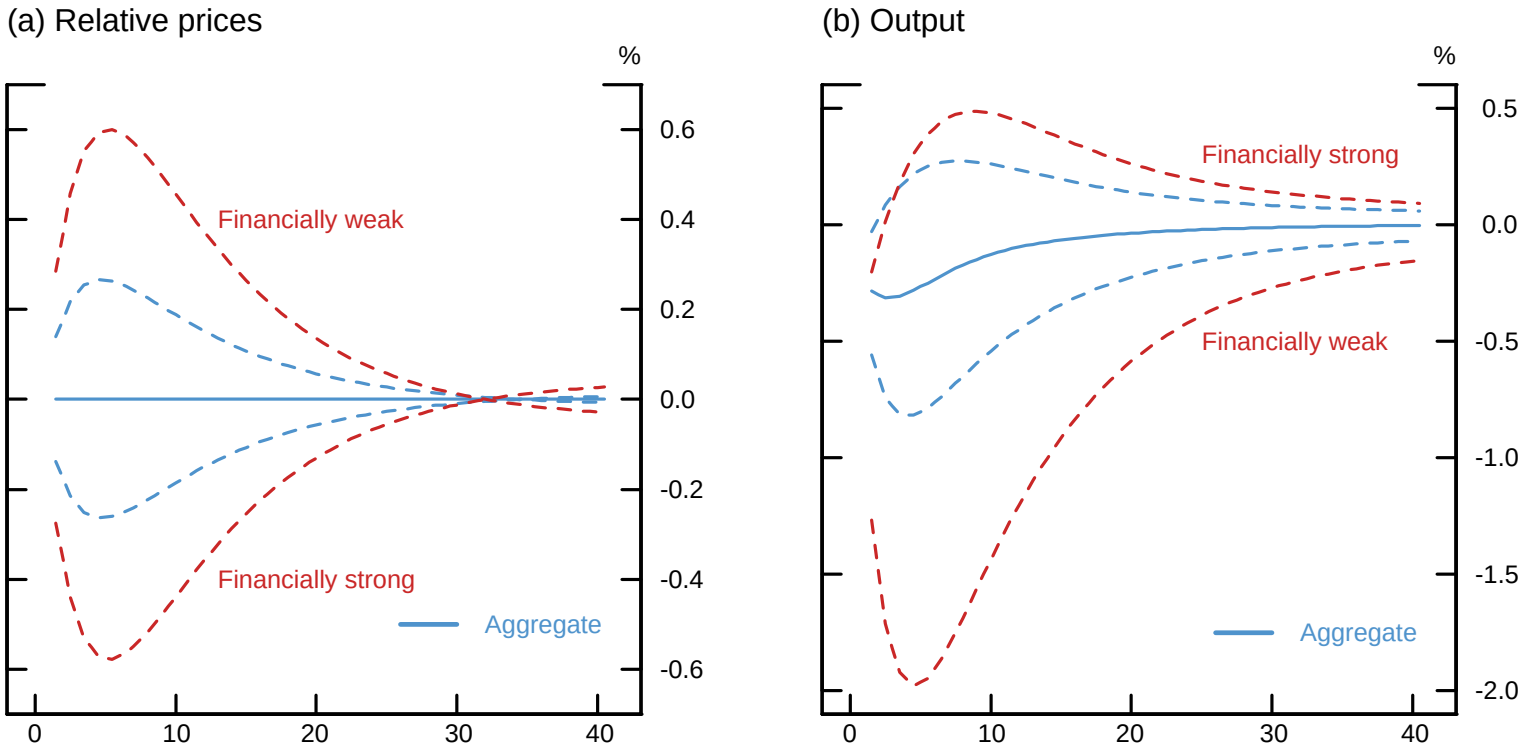

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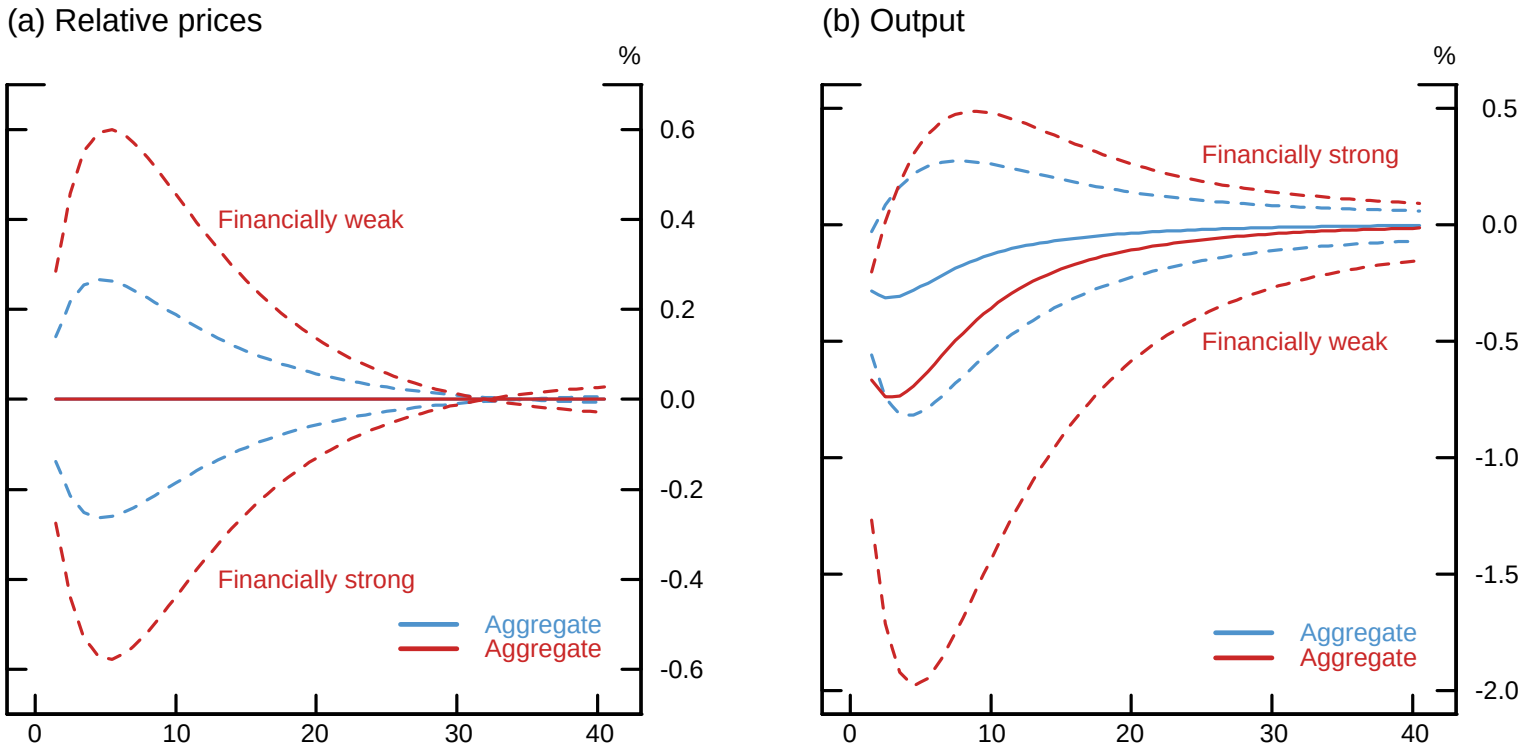

- Case I: $\phi_1 = 0.8\phi$, $\phi_2 = 0.3$
- Case II: $\phi_1 = 0$, $\phi_2 = 0.3$

SUMMARY

- Internal liquidity positions and customer markets importantly influenced firms' price-setting behavior during the 2007–08 crisis:
  - Liquidity unconstrained firms decreased prices, while liquidity constrained firms increased prices.
- 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.