Inflation Dynamics During the Financial Crisis

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Motivation

- In spite of massive contraction in economic activity during the 2007–09 financial crisis, the general level of prices has remained surprisingly stable.
- What accounts for the absence of deflationary pressures in light of the enormous and persistent resource slack in the economy?
- This paper investigates the effect of financial conditions on firms' price-setting behavior during the "Great Recession."

Overview

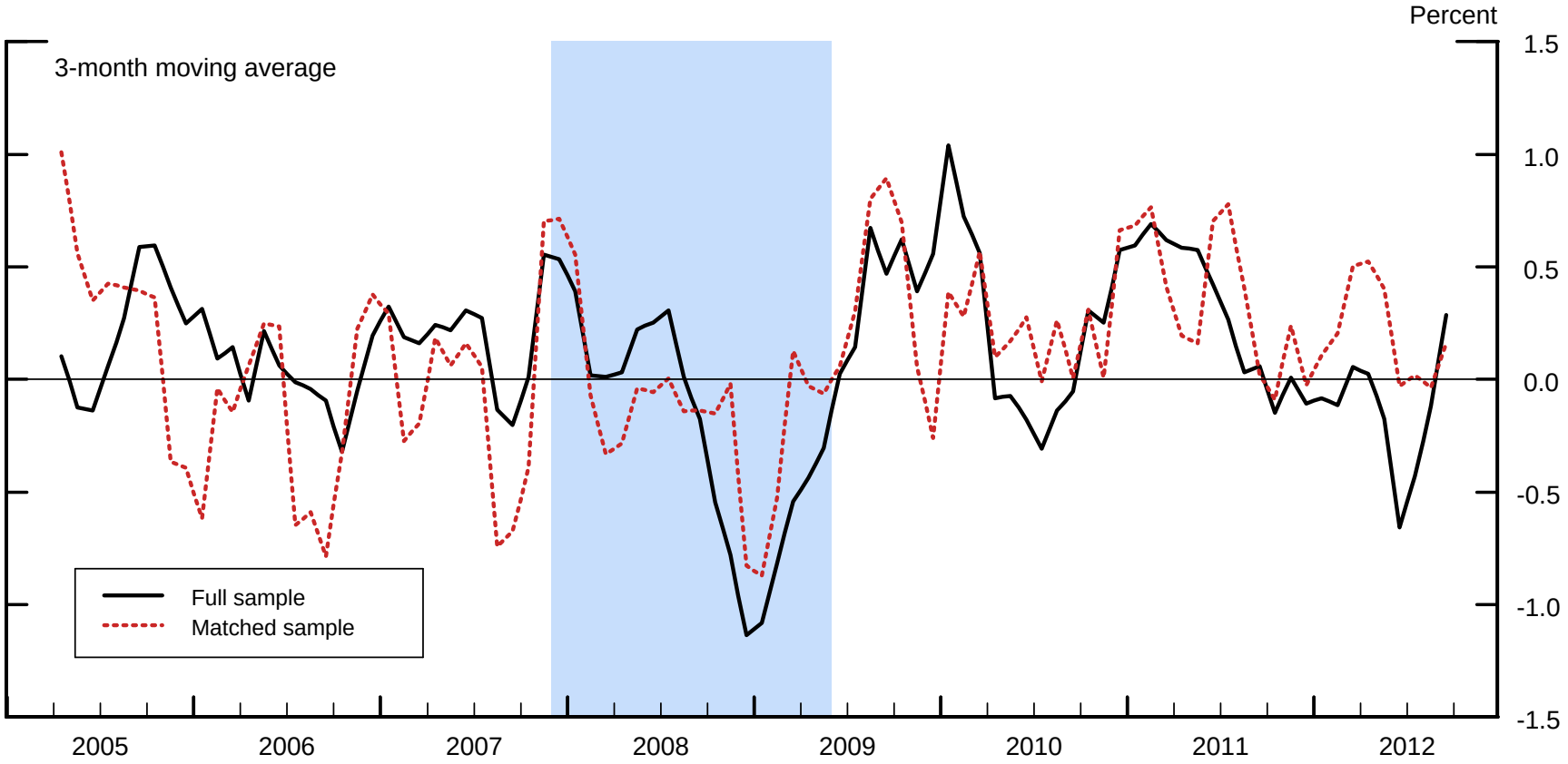
- Merge item-level prices of individual producers included in the Bureau of Labor Statistics' Producer Price Index (PPI) to their income and balance sheet data from Compustat.
- Analyze how balance sheet conditions influence firm-level price-setting behavior:
  - Investment into customer base $\Rightarrow$ price cut (Rotemberg & Woodford [1991]; Chevalier & Scharfstein [1996])
- Build a DSGE model that embeds financial frictions in a customer-markets framework:
  - Explore output and inflation dynamics in response to demand and financial shocks.
  - What happens at the ZLB?

Data Sources

- Monthly good-level price data underlying the PPI. (Nakamura & Steinsson [2008]; Goldberg & Hellerstein [2009]; Bhattarai & Schoenle [2010])
- Match 700+ PPI respondents to their income and balance sheet data from Compustat.
- Sample period: Jan2005–Sep2012

Aggregate Inflation

All PPI respondents vs. publicly-traded firms



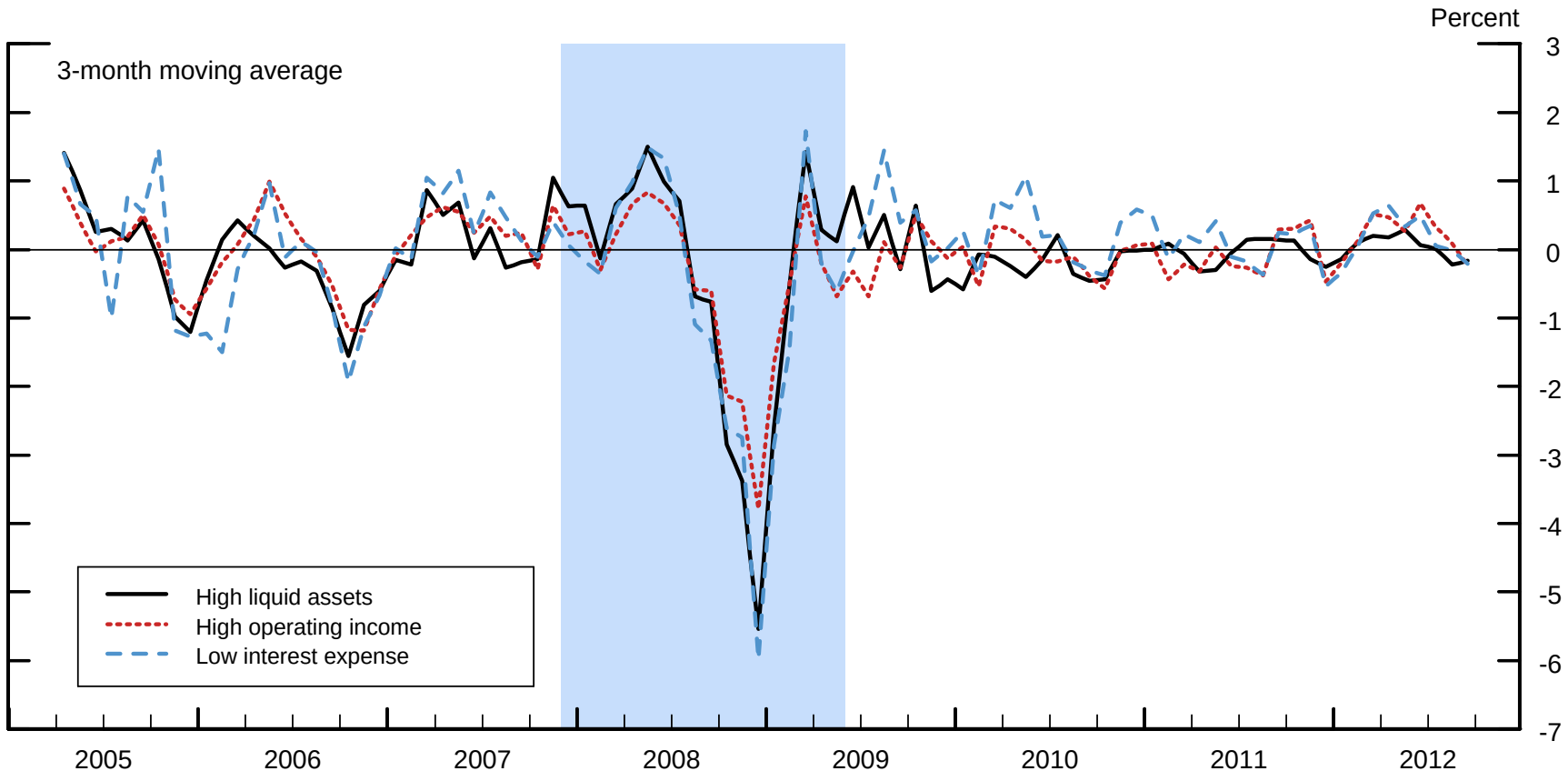
NOTE: Seasonally-adjusted weighted average inflation at a monthly rate.

Relative Inflation by Firm Characteristics

- Relative item-level inflation: $\hat{\pi}_{ijkt} = \pi_{ijkt} - \pi_{kt}$
- Sorting procedure:
  - In period t, sort firms into categories based on observable characteristics in periods $t-1, t-2, \ldots$.
  - Compute aggregate relative inflation rate in period t for the different categories of firms.
- Financial characteristics: liquidity, cashflow, interest expense
- Other characteristics:
  - SG&A expense: customer markets vs. operating efficiency?
  - Durability of output: durable vs. nondurable goods

Relative Inflation

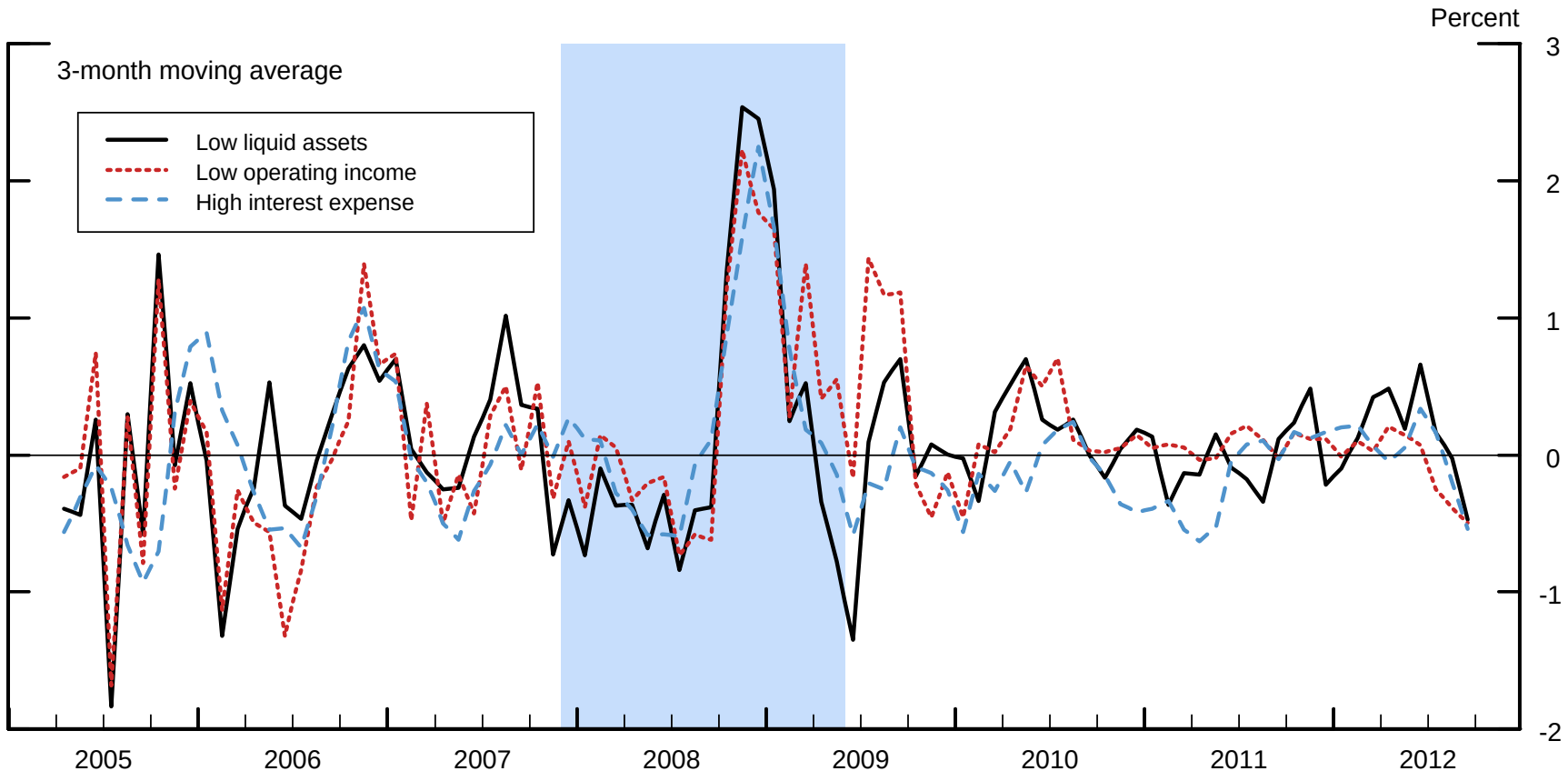
Financially unconstrained firms



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

Relative Inflation

Financially constrained firms



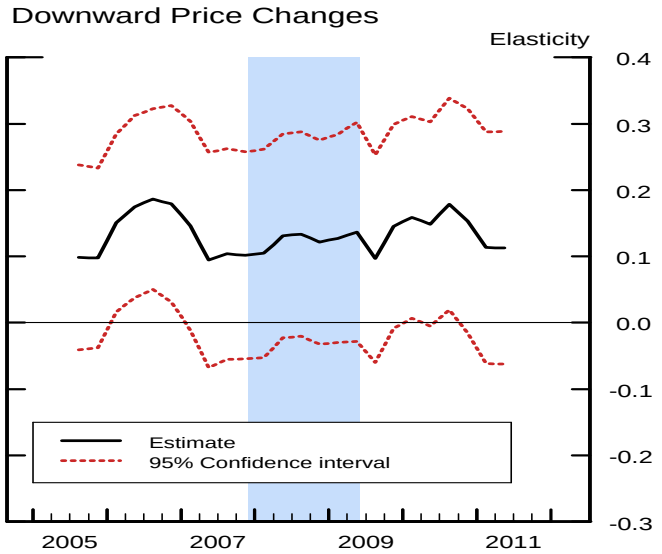
NOTE: Weighted average monthly inflation relative to industry (2-digit NAICS) inflation.

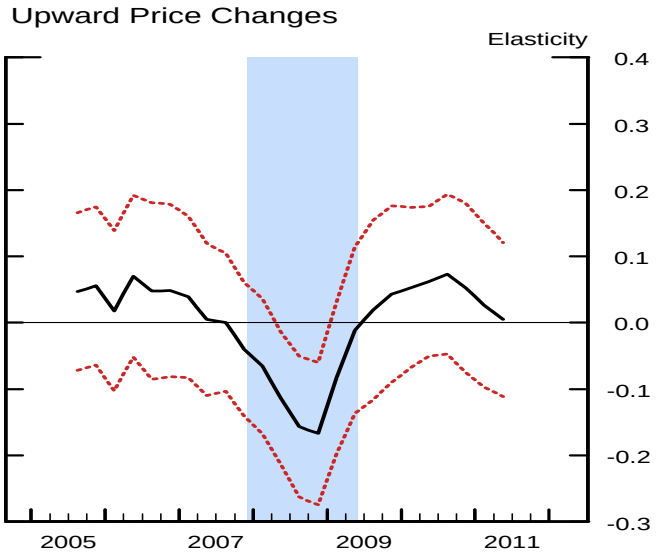
Price Adjustment and Firm Characteristics

- Multinomial logit specification:

$$\Pr(\Delta p_{ij,t+1}) = \begin{cases} + \\ 0 \quad \text{(base)} \\ - \end{cases} = \Lambda(\mathbf{X}_{jt}; \boldsymbol{\beta}_t)$$

  - $\mathbf{X}_{jt}$ = SGAX/sales ratio, liquidity ratio, other controls
- Time-varying elasticity of price changes w.r.t. liquidity ratio:





Preferences

- Household preferences display "Deep Habits." (Ravn, Schmitt-Grohe & Uribe [2006])
- Maximization problem:

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

  - Aggregator: $x^j_t \equiv \left[\int_0^1 \left(\frac{c^j_{it}}{s^{\theta}_{i,t-1}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}; \quad i \in [0,1]$
  - Law of motion: $s_{it} = \rho s_{i,t-1} + (1-\rho) c_{it}; \quad 0 < \rho < 1$
    - **Example**: Video games—the more you play, the more addicted you become!
  - δ_{t+s} = demand shock

Technology

- Production function (labor input, fixed operating costs):

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

  - A_t = persistent aggregate technology shock
  - a_{it} = i.i.d. idiosyncratic technology shock with $\log a_{it} \sim N(-0.5\sigma^2, \sigma^2)$
- Heterogeneous fixed operating costs:
  - $\phi_i \in \mathbf{\Phi} = \{\phi_1, \ldots, \phi_N\}$, with $0 \leq \phi_1 < \phi_2 < \cdots < \phi_N$.
  - Firm measure: $\omega_1, \ldots, \omega_N$, with $\sum_{k=1}^{N} \omega_k = 1$.
- Benchmark model: $\phi_i = \phi$ (homogeneous firms)

Frictions

- Nominal rigidities:
  (Rotemberg [1982])

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

- Financial frictions $\Rightarrow$ costly equity financing
  (Myers & Majluf [1984]; Gomes [2001]; Stein [2003])
  - Dilution cost ($0 < \varphi < 1$): 1\$ of issuance brings in $(1-\varphi)$\$

$$\bar{\varphi}(d_{it}) \equiv -\left[d_{it} - \varphi \min\{0, d_{it}\}\right] = \begin{cases} -d_{it} & \text{if } d_{it} \geq 0 \\ -(1-\varphi)d_{it} & \text{if } d_{it} < 0 \end{cases}$$

Timing

- Within-period sequence of events:
  1. Aggregate information arrives in the morning
  2. Firms post prices based on aggregate information
  3. Take orders, plan production based on expected marginal cost
  4. Idiosyncratic shock realized after orders have been taken
  5. Firms meet demand based on originally posted prices and orders
- Facilitates aggregation and smooth solution.
  (Kiley & Sim [2012])

Firm Problem

- Maximize the expected present value of dividends:

$$\begin{aligned}\mathcal{L} \quad = \quad & \mathbb{E}_0 \sum_{t=0}^{\infty} m_{0,t} \Bigg\{ d_{it} + \kappa_{it} \left[\left(\frac{A_t}{a_{it}} h_{it} \right)^{\alpha} - \phi_k - c_{it} \right] \\ & + \xi_{it} \left[p_{it} c_{it} - w_t h_{it} - \frac{\gamma}{2} \left(\pi_t \frac{p_{it}}{p_{i,t-1}} - \bar{\pi} \right)^2 c_t - \bar{\varphi}(d_{it}) \right] \\ & + \nu_{it} \left[\left(\frac{p_{it}}{\tilde{p}_t} \right)^{-\eta} s_{i,t-1}^{\theta(1-\eta)} x_t - c_{it} \right] + \lambda_{it} [\rho s_{i,t-1} + (1-\rho) c_{it} - s_{it}] \Bigg\}\end{aligned}$$

  - Externality-adjusted composite price index:
    $$\tilde{p}_t \equiv \left[\int_0^1 (p_{it} s_{i,t-1}^{\theta})^{1-\eta} di \right]^{1/(1-\eta)}$$
  - p_{it}, c_{it}, s_{it} chosen before the realization of idiosyncratic shock a_{it}.
  - d_{it}, h_{it} chosen after the realization of idiosyncratic shock a_{it}.

Shadow Value of Internal Funds

- FOC on dividends:

$$\xi(a_t;\phi_k) = \begin{cases} 1 & \text{if } a_t \leq a_t^E(\phi_k) \\ 1/(1-\varphi) & \text{if } a_t > a_t^E(\phi_k) \end{cases}$$

- External financing trigger:

$$a_t^E(\phi_k) = \frac{A_t}{w_t}\left[\frac{c_{kt}}{(c_{kt}+\phi_k)^{\frac{1}{\alpha}}}\right]\left[p_{kt} - \frac{\gamma}{2}\left(\pi_t \frac{p_{kt}}{p_{k,t-1}} - \bar{\pi}\right)^2 \frac{c_t}{c_{kt}}\right]$$

- Expected shadow value of internal funds:

$$\begin{aligned} \mathbb{E}_t^a[\xi_{it} \mid \phi_k] &= 1 + \frac{\varphi}{1-\varphi}[1 - \Phi(z_t^E(\phi_k))] \geq 1 \\ z_t^E(\phi_k) &\equiv \frac{1}{\sigma}[\log a_t^E(\phi_k) + 0.5\sigma^2] \end{aligned}$$

Markups

- Aggregate markup:

$$\mu(A_t, c_t, w_t; \phi_k) = \alpha(A_t/w_t)(c_t + \phi_k)^{\frac{\alpha-1}{\alpha}}$$

- Financially-adjusted markup:

$$\begin{aligned}
\tilde{\mu}(A_t, c_t, w_t; \phi_k) &\equiv \frac{\mathbb{E}_t^a[\xi_{it}|\phi_k]}{\mathbb{E}_t^a[\xi_{it}a_{it}|\phi_k]}\mu(A_t, c_t, w_t; \phi_k) \\
&\leq \mu(A_t, c_t, w_t; \phi_k) \\
\text{where} & \\
\mathbb{E}_t^a[\xi_{it}a_{it}|\phi_k] &= 1 + \frac{\varphi}{1-\varphi}[1 - \Phi(z_t^E(\phi_k - \sigma))] \\
\mathbb{E}_t^a[\xi_{it}a_{it}] &\geq \mathbb{E}_t^a[\xi_{it}] \geq 1
\end{aligned}$$

- Financial frictions increase marginal costs $\Rightarrow$ lower markups.

Price-Setting Without Nominal Rigidities

- No customer markets:

$$p_{kt} = \eta \left[1 - \frac{1}{\tilde{\mu}_t(\phi_k)} \right]$$

- With customer markets:

$$\begin{aligned} p_{kt} &= \eta \left[1 - \frac{1}{\tilde{\mu}_t(\phi_k)} \right] \\ &\quad + \psi \mathbb{E}_t \left[\sum_{s=t}^{\infty} \tilde{\beta}_{t,s} \frac{\mathbb{E}^a_{s+1}[\xi_{i,s+1} | \phi_k]}{\mathbb{E}^a_t[\xi_{it} | \phi_k]} \left[1 - \frac{1}{\tilde{\mu}_{s+1}(\phi_k)} \right] \right] \end{aligned}$$

Inflation Dynamics

- Phillips curve with financial distortions:

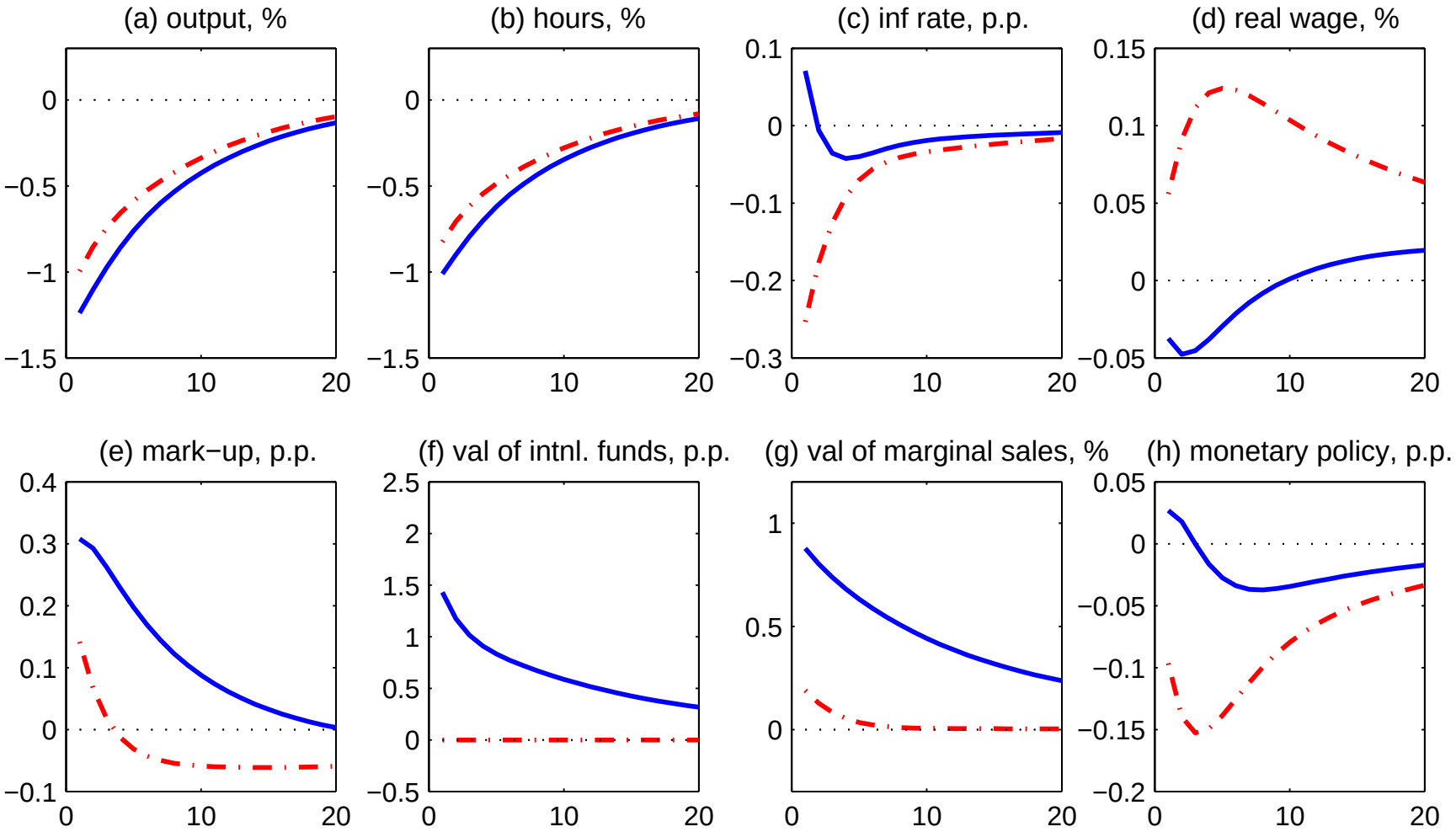
$$
\begin{aligned}
p_{kt} = {} & \gamma \pi_{kt} \pi_t \left(\pi_{kt} \pi_t - 1 \right) + \eta \left[1 - \frac{1}{\tilde{\mu}_t(\phi_k)} \right] \\
& - \gamma \mathbb{E}_t \left[m_{t,t+1} \frac{\mathbb{E}^a_{t+1}[\xi_{i,t+1} | \phi_k]}{\mathbb{E}^a_t[\xi_{it} | \phi_k]} \pi_{k,t+1} \pi_{t+1} \left(\pi_{k,t+1} \pi_{t+1} - 1 \right) \frac{c_{t+1}}{c_{kt}} \right] \\
& + \psi \mathbb{E}_t \left[\sum_{s=t}^{\infty} \tilde{\beta}_{t,s} \frac{\mathbb{E}^a_{s+1}[\xi_{i,s+1} | \phi_k]}{\mathbb{E}^a_t[\xi_{it} | \phi_k]} \left[1 - \frac{1}{\tilde{\mu}_{s+1}(\phi_k)} \right] \right]
\end{aligned}
$$

Calibration

Benchmark model: homogeneous firms

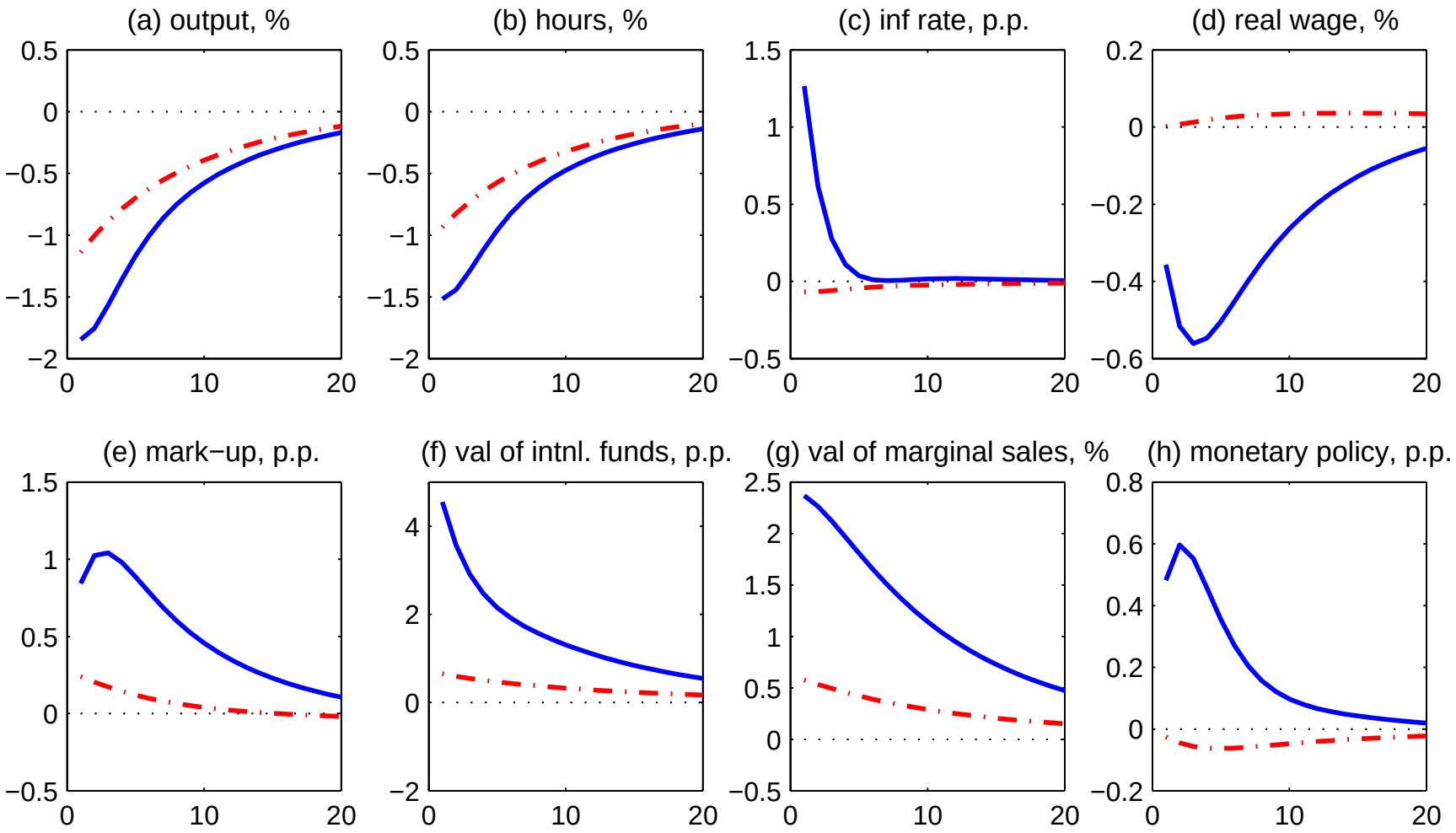
Parameter		**Value**
Preferences and Technology		
Relative risk aversion: γ_x		1.00
Deep habit: θ		-0.95
Persistence of deep habit: ρ		0.95
Elasticity of labor supply: $1/\gamma_h$		5.00
Elasticity of substitution: η		2.00
Fixed operating costs: ϕ		0.21
Idiosyncratic volatility (a.r.): σ		0.20
Financial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

Crisis Experiment: Demand Shock



NOTE: Blue = model w/ financial frictions; Red = model w/o financial frictions.

Demand and Financial Shock



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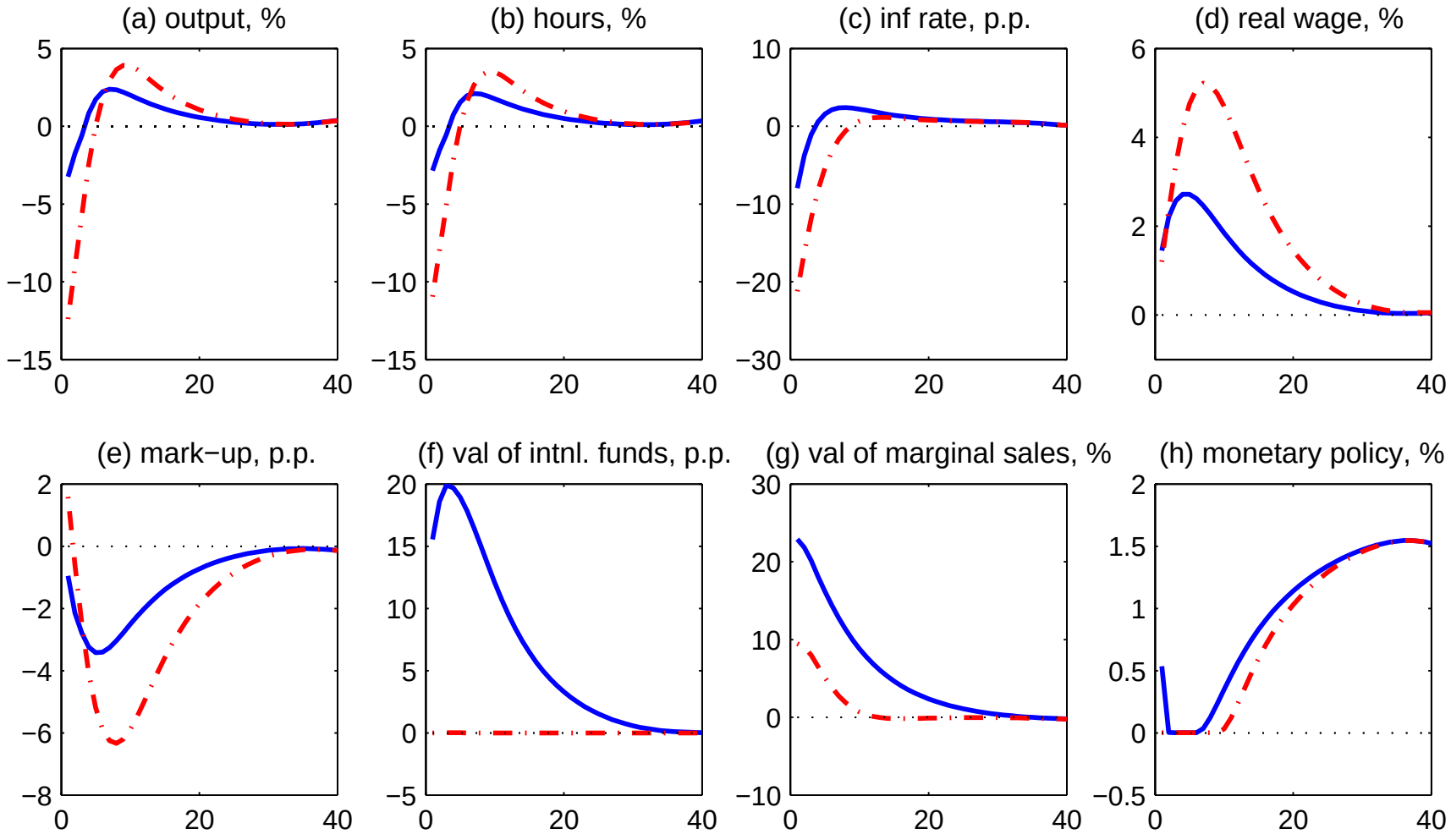
Discount Rate Shock



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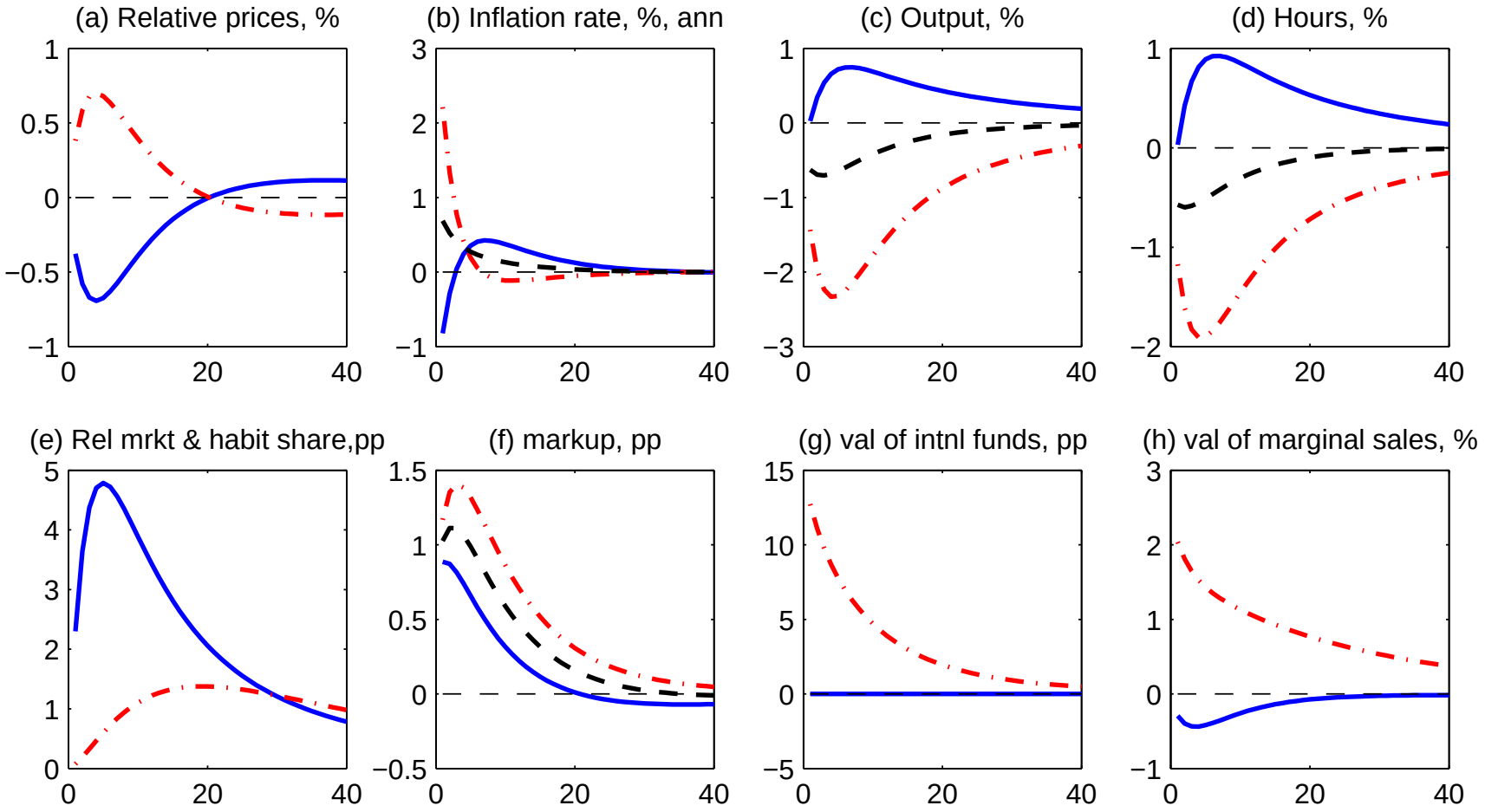
Financial Shock

Heterogeneous fixed operating costs



NOTE: Blue = financially strong firms; Red = financially weak firms; Black = aggregate.

Conclusion

Mr. Marchionne and other auto executives accuse Volkswagen of exploiting the crisis to gain market share by offering aggressive discounts. "It's a bloodbath of pricing and it's a bloodbath on margins," he said.

The New York Times
July 25, 2012