Inflation Dynamics During the Financial Crisis

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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]
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) ⇒ financial frictions
    Campello et al. [2011]
  - SG&A expense ratio (SGAX) ⇒ customer markets
    Goriou & Rudanko [2011]
INDUSTRY-ADJUSTED PRODUCER PRICE INFLATION
By financial characteristics

- Low liquidity firms
- High liquidity firms

3-month moving average

Note: Weighted-average inflation relative to industry (2-digit NAICS) inflation (seasonally adjusted monthly rate).
INDUSTRY-ADJUSTED PRODUCER PRICE INFLATION
By product market characteristics

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

\[
\Pr \left( \text{sgn}(\Delta_3 p_{i,j,t+3}) \right) = \begin{cases} 
+ & \text{if } \Lambda(\text{LIQ}_{j,t}, \text{SGAX}_{j,t}, X_{j,t}; \beta_1, \beta_2, \theta) > 0 \\
0 & \text{if } \Lambda(\text{LIQ}_{j,t}, \text{SGAX}_{j,t}, X_{j,t}; \beta_1, \beta_2, \theta) = 0 \\
- & \text{if } \Lambda(\text{LIQ}_{j,t}, \text{SGAX}_{j,t}, X_{j,t}; \beta_1, \beta_2, \theta) < 0
\end{cases}
\]

- Inflation regression (3-month-ahead):

\[
\pi_{i,j,t+3}^{3m} = \beta_1 \text{LIQ}_{j,t} + \beta_2 \text{SGAX}_{j,t} + \theta' X_{j,t} + \eta_j + u_{i,j,t+3},
\]

- Estimation:
  - Coefficients $\beta_1$ and $\beta_2$ 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)

- **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.
**References: “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:
  \[
  x^j_t \equiv \left[ \int_0^1 \left( \frac{c^j_{it}}{s^\theta_{i,t-1}} \right)^{-\frac{1}{\eta}} \frac{1}{1-\eta} \right]^{1-\frac{1}{\eta}} ; \quad \theta < 0 \text{ and } \eta > 0
  \]

  - Law of motion for the external habit:
    \[
    s_{it} = \rho s_{i,t-1} + (1 - \rho) c_{it} ; \quad 0 < \rho < 1
    \]

  - $\psi_t = \text{demand shock}$
Continuum of monopolistically competitive firms producing a variety of differentiated goods indexed by $i \in [0, 1]$.

Production function (labor input only):

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

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

Baseline case: homogeneous firms ($\phi_i = \phi, \forall i$)
Frictions and Monetary Policy

- Frictions:
  - Nominal rigidities:
    Rotemberg [1982]
    \[
    \frac{\gamma_p}{2} \left( \frac{P_{it}}{P_{i,t-1}} - \bar{\pi} \right)^2 c_t = \frac{\gamma_p}{2} \left( \frac{\pi_t}{p_{it}} \frac{P_{it}}{P_{i,t-1}} - \bar{\pi} \right)^2 c_t; \quad p_{it} \equiv \frac{P_{it}}{P_t}
    \]
  - 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”

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

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

The role of 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: $\varphi_t = 0.3 \rightarrow 0.375$ (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: $\phi_1 = 0, \phi_2 = 0.3$
“Price War” in Response to a Financial Shock

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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.