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**

(a) Core PPI

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

(b) Industrial Production

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

THE MECHANISM

Customer markets → firms view customer base as an asset, in which they can invest by lowering prices.

Financial frictions → 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

3-month moving average, annualized

Low liquidity firms
High liquidity firms

Percentage points

2005 2006 2007 2008 2009 2010 2011 2012

-25 -20 -15 -10 -5 0 5 10
**Price Dynamics and Financial Conditions**

- Multinomial logit:
  \[
  \Pr(\text{sgn}[p_{i,j,t+3} - p_{i,j,t}]) = \begin{cases} 
    - & 0 = \Lambda(\beta'X_{j,t} + \gamma \pi_{t}^{\text{IND}(3m)} + d_t) \\
    + & \end{cases}
  \]

- Linear pricing regression:
  \[
  \pi_{3m,i,j,t+3} = \beta'X_{j,t} + \gamma \pi_{t}^{\text{IND}(3m)} + d_t + u_{i,j,t+3}
  \]

- Firm-specific explanatory variables:
  - Financial positions: LIQ_{j,t} \times 1[\text{CRISIS}_t = 0] and LIQ_{j,t} \times 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

## Table

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

**Note:** Robust standard errors are clustered at the firm level; *** \( p < .01 \), ** \( p < .05 \), * \( p < .10 \).
**Quantitative implication**: two std. deviation reduction in liquidity implies a 33% higher probability of a price increase.
**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

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Core</td>
<td>GIIPS</td>
<td>Core</td>
<td>GIIPS</td>
</tr>
<tr>
<td>Inflation</td>
<td>1.74</td>
<td>4.02</td>
<td>1.49</td>
<td>0.55</td>
</tr>
<tr>
<td>Output gap</td>
<td>−0.07</td>
<td>0.81</td>
<td>−0.73</td>
<td>−2.98</td>
</tr>
<tr>
<td>Unemployment gap</td>
<td>0.46</td>
<td>−0.60</td>
<td>−0.09</td>
<td>1.27</td>
</tr>
</tbody>
</table>

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):
    \[ \pi_{it} = \alpha_i + \beta \pi_{i,t-1} + \lambda_i (u_{it} - \bar{u}_{it}) + \phi \Delta \text{VAT}_{it} + \psi_1 [i \in \mathbb{E}] + \epsilon_{it}; \]
  - Wages (backward looking):
    \[ \pi_{it}^w = \alpha_i + \beta \pi_{i,t-1} + \lambda_i (u_{it} - \bar{u}_{it}) + \phi \Delta \tilde{z}_{it} + \psi_1 [i \in \mathbb{E}] + \epsilon_{it}; \]

- Data
  - Countries: AUT, DEU, BEL, FIN, FRA, NLD, GRC, IRL, ITA, ESP, PRT

- 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

Periphery countries

Percentage points (log scale)

Quarterly

Core countries

Percentage points (log scale)

Quarterly

SOURCE: Markit.
Financial Conditions and PC Prediction Errors
With time fixed effects, 2008–2013

<table>
<thead>
<tr>
<th>PC Prediction Error</th>
<th>Explanatory Variable</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In CDS$_{i,t-1}$</td>
<td>0.419</td>
</tr>
<tr>
<td>(2) Prices</td>
<td></td>
<td>[0.369, 0.999]</td>
</tr>
<tr>
<td></td>
<td>ln CDS$_{i,t-1} \times 1[i \in P]$</td>
<td></td>
</tr>
<tr>
<td>(5) Wages</td>
<td>−2.196</td>
<td>−1.469</td>
</tr>
<tr>
<td></td>
<td>[−2.731, −1.661]</td>
<td>[−2.550, −0.389]</td>
</tr>
</tbody>
</table>

**Note:** Bootstrapped 95% confidence intervals in brackets.
Price Markups
Euro area, 2000–2015

Periphery countries

Core countries

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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Explanatory Variable</th>
<th></th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In CDS_{i,t-1}</td>
<td>In CDS_{i,t-1} × 1_{i ∈ P}</td>
<td></td>
</tr>
<tr>
<td>A. Aggregate markups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With time fixed effects</td>
<td>−0.312</td>
<td>1.148</td>
<td>0.681</td>
</tr>
<tr>
<td></td>
<td>[−0.528, −0.095]</td>
<td>[0.926, 1.372]</td>
<td></td>
</tr>
<tr>
<td>B. Sectoral markups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With time fixed effects</td>
<td>−0.331</td>
<td>1.974</td>
<td>0.152</td>
</tr>
<tr>
<td></td>
<td>[−1.915, 1.254]</td>
<td>[1.244, 2.704]</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Bootstrapped 95% confidence intervals in brackets.
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.
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:

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

- Habit-adjusted consumption bundle:

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

- Law of motion for the external habit:

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

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

Production function (labor input only):

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

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

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

Nominal rigidities:
Rotemberg [1982]

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

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: \( \varphi_t = \bar{\varphi} f_t; \quad \log f_t = 0.90 \log f_{t-1} + \epsilon_{f,t} \)
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**

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

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

- \( \hat{\mu}_t \) = (financially adjusted) markup
- \( \hat{\xi}_t \) = shadow value of internal funds
- \( \hat{\beta}_{t,s+1} \) = capitalized growth of customer base
- \( \omega, \tilde{\delta}, \) and \( \chi \) 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”

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

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

\[ \hat{\pi}_t = \frac{-\omega(\eta - 1)}{\gamma_p} \left[ \hat{\mu}_t + \mathbb{E}_t \sum_{s=t}^{\infty} \chi \delta^{s-t+1} \hat{\mu}_{s+1} \right] + \beta \mathbb{E}_t [\hat{\pi}_{t+1}] 
+ \frac{1}{\gamma_p} [\eta - \omega(\eta - 1)] \mathbb{E}_t \sum_{s=t}^{\infty} \chi \delta^{s-t+1} \left[ (\hat{\xi}_t - \hat{\xi}_{s+1}) - \hat{\beta}_{t,s+1} \right] \]
DEMAND SHOCK DURING THE FINANCIAL CRISIS
Homogeneous firms with nominal rigidities

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

Homogeneous firms without 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)
**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

(a) Relative prices
(b) Inflation
(c) Output
(d) Hours worked
(e) Relative market share
(f) Markup
(g) Value of internal funds
(h) Value of marginal sales

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: $\phi_t = 0.3 \rightarrow 0.375$ (AR(1) dynamics)
“Price War” in Response to a Financial Shock

Heterogeneous firms with nominal rigidities

(a) Relative prices

(b) Output

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

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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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

Heterogeneous firms with nominal rigidities

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