Inflation in the Great Recession and New Keynesian Models

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Can New Keynesian (DSGE) models explain inflation in the Great Recession?

- **Large drop in economic activity**; **modest decline in inflation**.
- Hall (AER 2011): The dominant model of inflation embedded in practical macro models today . . . cannot explain the stabilization of inflation at positive rates in the presence of long-lasting slack.
- Ball and Mazumder (BPEA 2011): A puzzle emerges when Phillips curves estimated over 1960-2007 are used to predict inflation over 2008-10: inflation should have fallen by more than it did . . . the Great Recession provides fresh evidence against the New Keynesian Phillips curve ...
- Coibion and Gorodnichenko (AEJ 2015): The missing disinflation ...

Can New Keynesian models explain inflation at all?

King and Watson (2012):

- Use SW model to decompose inflation into "fundamental inflation" and exogenous component
- "... we find that fundamental inflation behaves very different from actual inflation. This decomposition suggests that inflation control would be more problematic, as inflation is dominated by shocks to the NKPE within the SW model."
- SW model can explain the behavior of inflation only when assuming large exogenous mark-up shocks

This Paper

- Uses a standard DSGE model available prior to recent crisis:
  - Smets and Wouters (2007)
  - \+ Time-varying inflation target
  - \+ **Financial frictions** as in Bernanke, Gertler and Gilchrist (1999) / Christiano, Motto and Rostagno (2003+10).
- Same observables as SW
  - \+ Long-run inflation expectations
  - \+ **Credit spread** (Baa - 10y Treas. yield)
  - = SW-FF
- Estimated with data from 1964:Q1 to **2008:Q3 (pre-Lehman)**

Question/Finding

- **Can the model explain the joint behavior of inflation and output after 2008?**

  Yes – As soon as credit spreads jump in Fall 2008, the model successfully predicts 1) sharp contraction in activity; 2) modest and protracted decline in inflation.

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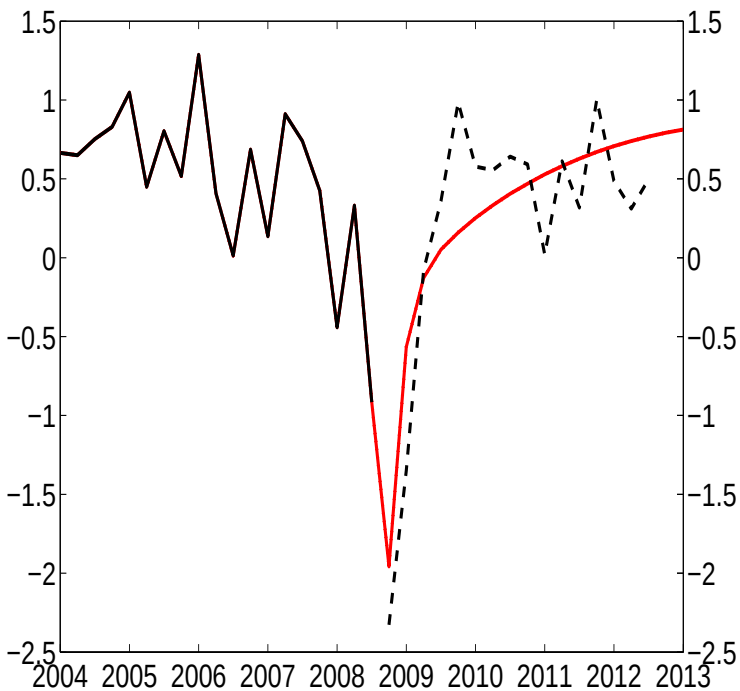
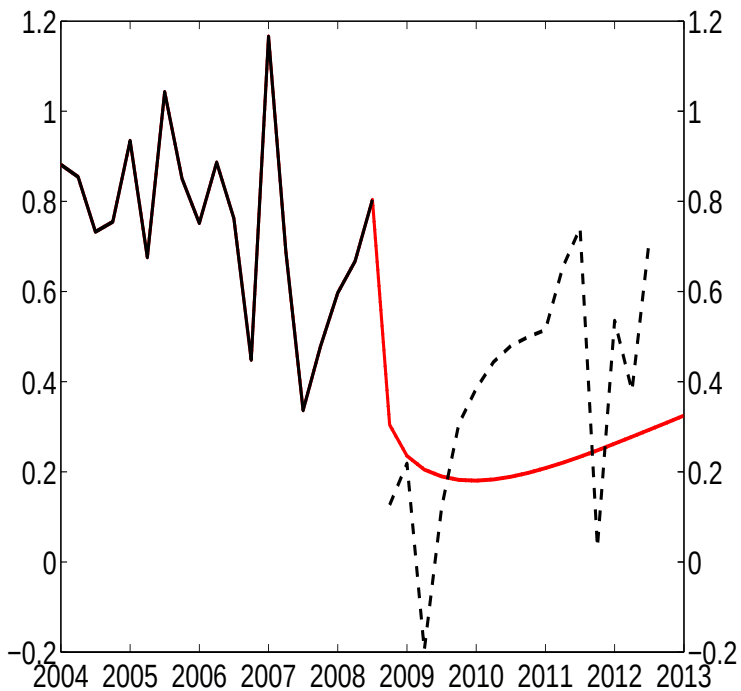
Output Growth (Q/Q)



Inflation (Q/Q)



Why Does Inflation Not Tank?

- **NKPC is forward looking** $\Rightarrow$ the whole path of future gaps matters – as opposed to just the current gap
- Inflation does not tank because **inflation expectations** in the model (and in the data) **remain anchored** – the PDV of expected mc_t does not fall as much as current mc_t

- Why? Because monetary policy is expected to bring inflation back to target (affects the dynamics of marginal costs)
- October 2015 FOMC Minutes:

> *The Committee reiterated its expectation that, even after employment and inflation are near mandate-consistent levels, economic conditions may, for some time, warrant keeping the target federal funds rate below levels the Committee views as normal in the longer run.*

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- We also show that in the FF model **fundamental inflation tracks** well medium/low frequency movements in **inflation for the whole sample**

Why the difference with KW? **Price rigidities**.

- KW/SW: Low estimated price rigidities imply that fundamental inflation $\simeq$ *current* marginal costs $\neq$ inflation.
- SW-FF: Higher estimated price rigidities imply that the model can explain inflation using the dynamics of marginal costs.

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Related Literature/Complementary Explanations

- Gilchrist, Schoenle, Sim, and Zakrajsek (AER 2015): credit frictions and pricing decisions

- Christiano, Eichenbaum, Trabandt (AEJ 2015): effect of financial friction on marginal costs (+ productivity)

Outline

1. DSGE Model
2. DSGE Forecasts of the Great Recession
3. Why Didn't Inflation Tank in the Great Recession?
   - Price Rigidities and Marginal Cost Dynamics
   - Fundamental Inflation
   - Financial Frictions Models and Estimates of Price Rigidity
4. What Explains the Ex-post Forecast Errors?
5. *Forecasting with NK DSGE: Real real-time experience with FRBNY DSGE model*
6. Conclusion

Baseline DSGE Model: SW (2007)

- Stochastic growth model $+ \ldots$

rigidites	**nominal rigidites**
investment adjustment costs	price stickiness (ζ_p)
variable capital utilization	wage stickiness (ζ_w)
	partial indexation to lagged inflation
$+$ habit persistence	

- 7 shocks: Neutral technology, investment specific technology, price and wage mark-up, discount rate, government spending, monetary policy.

Incorporating 10-yrs Inflation Expectations from Surveys

- SW forecasts inflation relatively well but imposes tight prior on π^*.
- We allow for time varying π^* to capture low frequency movements in inflation target and use a looser prior on steady-state π^*
  - Policy rule:

$$\begin{aligned} R_t &= \rho_R R_{t-1} + (1-\rho_R)\left(\psi_1(\pi_t - \pi_t^*) + \psi_2(y_t - y_t^f)\right) \\ &\quad + \psi_3\left((y_t - y_t^f) - (y_{t-1} - y_{t-1}^f)\right) + r_t^m, \end{aligned}$$

  - Inflation target: $\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + \sigma_{\pi^*}\epsilon_{\pi^*,t}$.
- We use **survey** data as an **observable**:

$$\pi_t^{O,40} = \pi^* + \boldsymbol{E}_t\left[\frac{1}{40}\sum_{k=1}^{40}\pi_{t+k}\right]$$

Incorporating Financial Frictions (SW-FF)

- We incorporate into SW model financial frictions along the lines of BGG (1999), Christiano, Motto, and Rostagno (2003, 2014).
- No arbitrage condition is

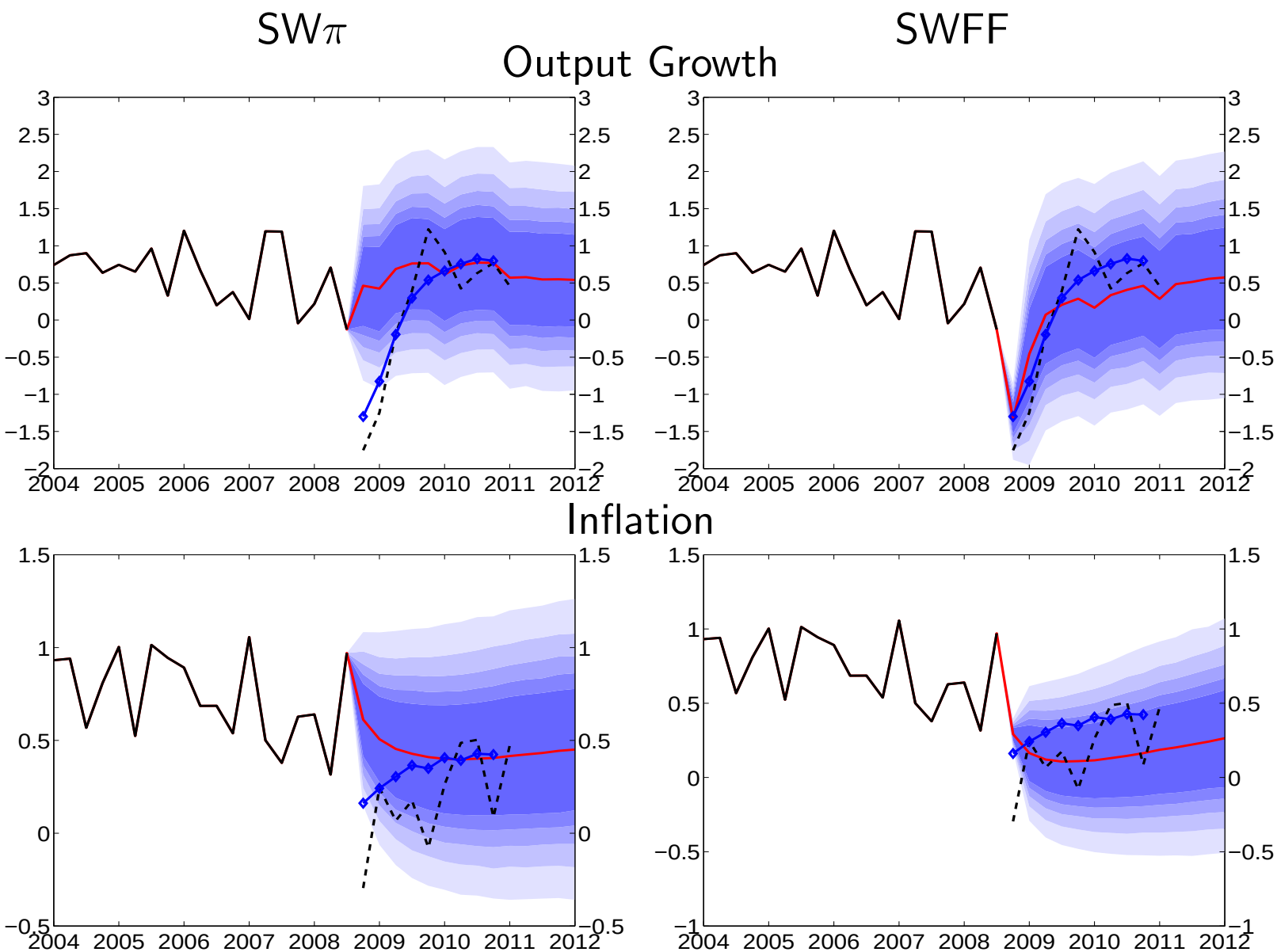
$$\mathbb{E}_t[\tilde{R}^k_{t+1}] = R_t + b_t + \zeta_{sp,b} \underbrace{\left(q^k_t + \bar{k}_t - n_t\right)}_{\text{leverage}} + \tilde{\sigma}_{\omega,t}$$

  where $\tilde{\sigma}_{\omega,t}$ is an additional shock, and entrepreneurs' net worth n_t is an additional endogenous variable

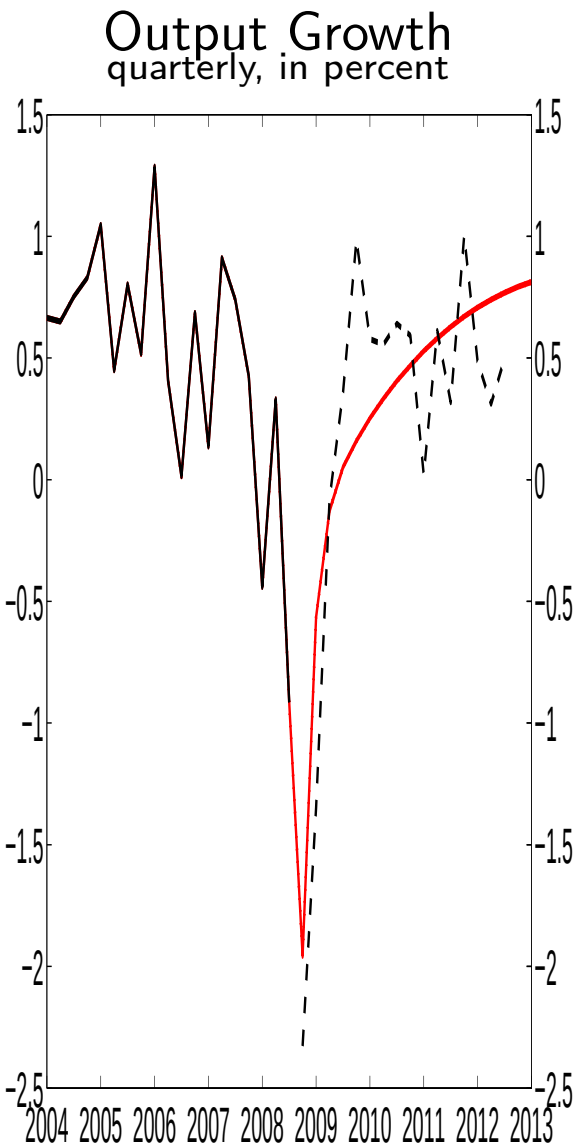
- Spread $\mathbb{E}_t[\tilde{R}^k_{t+1} - R_t]$ is treated as observed:

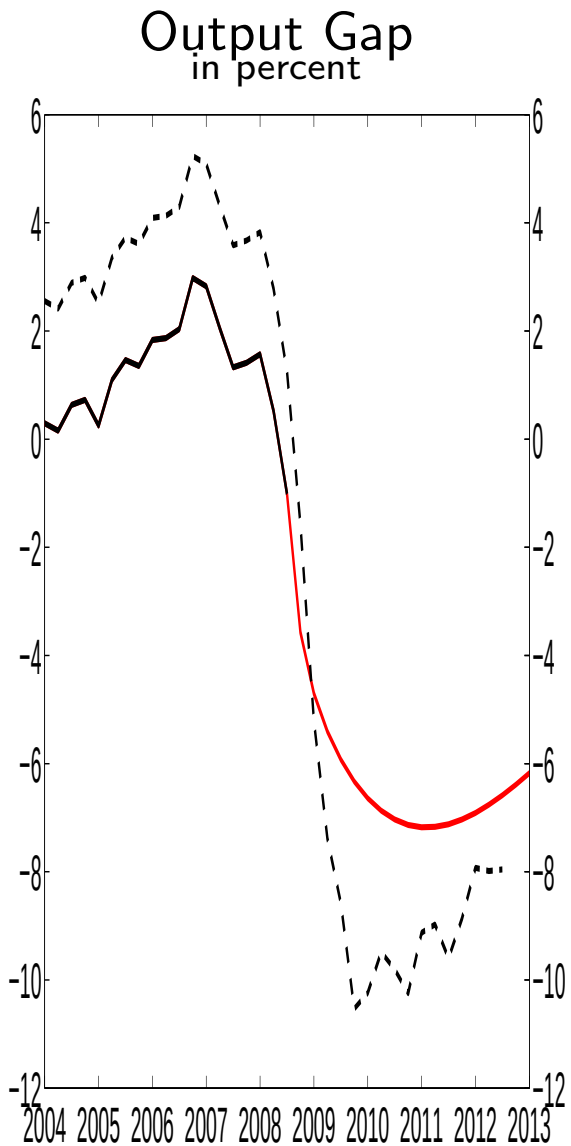
$$\mathbb{E}_t[\tilde{R}^k_{t+1} - R_t] = \text{ (Baa Corp. rate - 10y Treas. yield)/4}$$

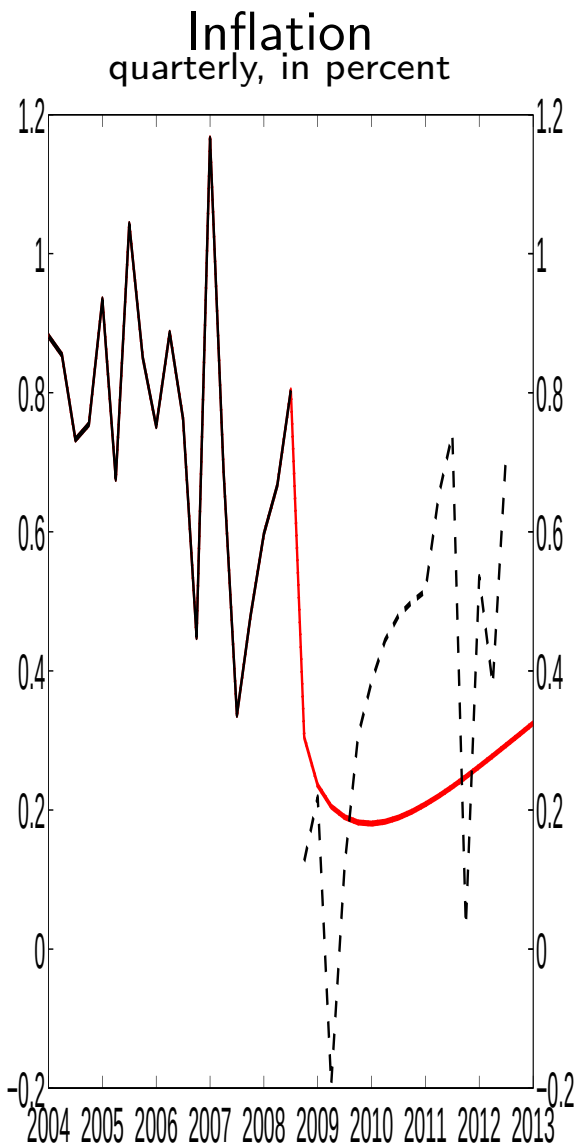
Forecasts of the Great Recession: 2008Q3 Data



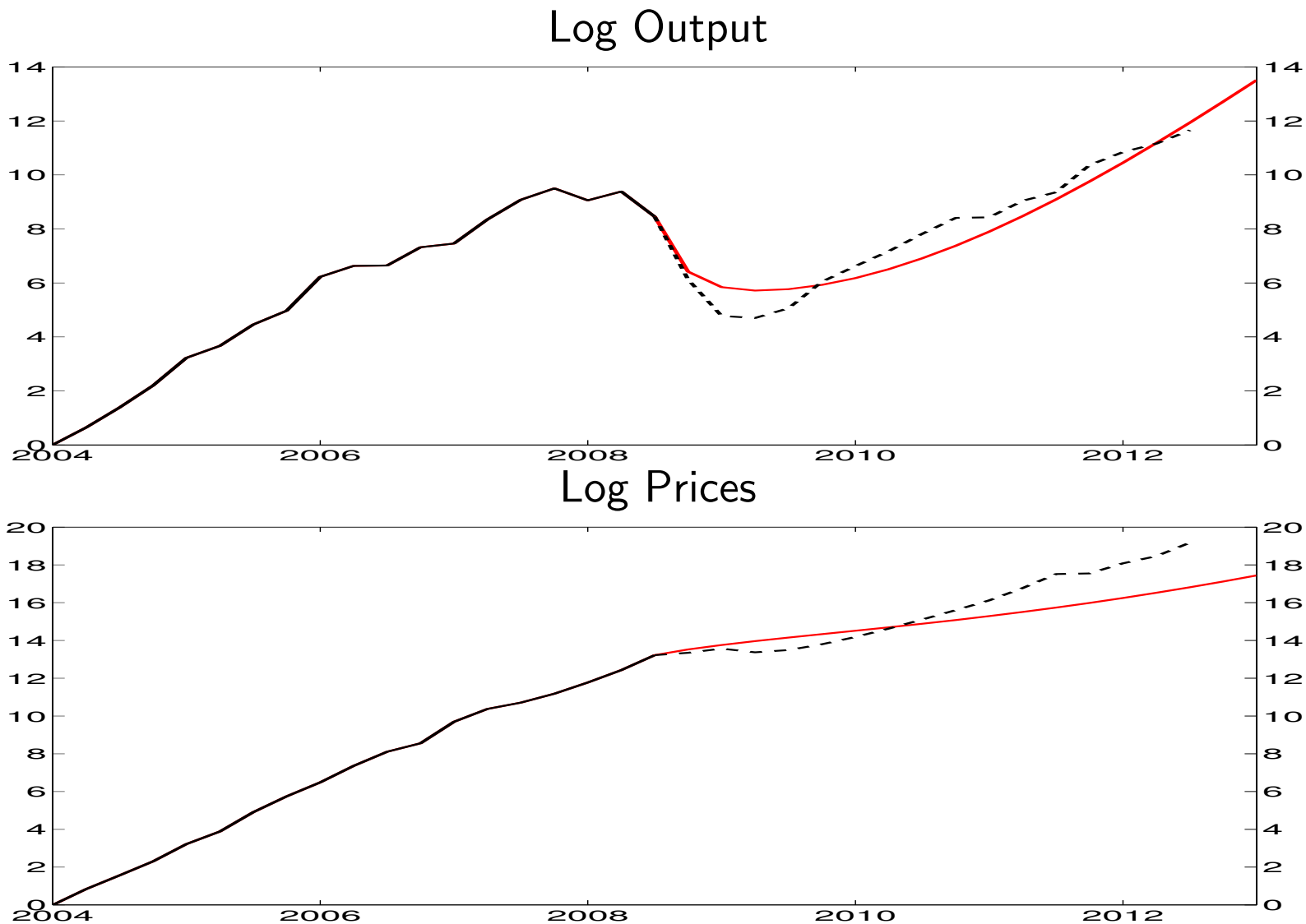
Forecasting the Great Recession







Forecasting the Great Recession – Levels



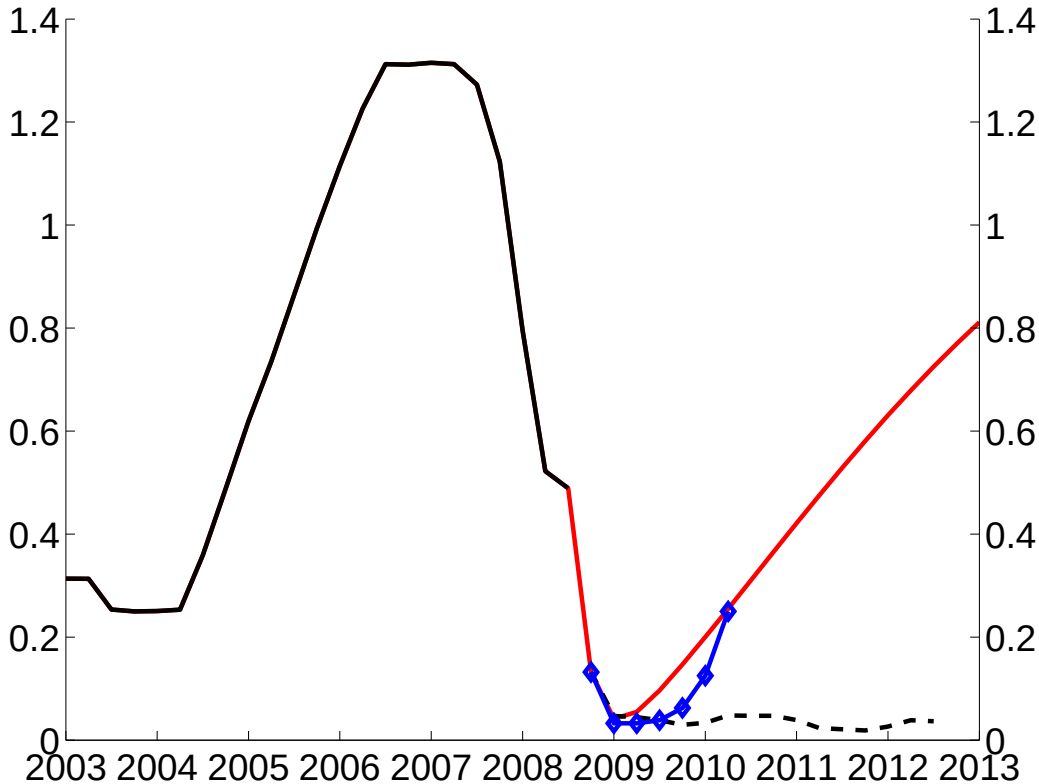
Forecasting the Great Recession

- As soon as credit spread jump, in October 2008, SW-FF **model forecasts severity and persistence of the great recession**, and subsequent recovery
    - Large and persistent output gap (output minus output under flex prices/wages and no mark-up shocks): about -7%
- . . . **yet it does not forecast deflation**
    - Model captures broad contour of inflation evolution... though it misses high frequency movements due to energy prices (Arab Spring, etc.)

- Questions:

  1. What about interest rate forecasts?
  2. What happens to *marginal costs*?
  3. How can we reconcile large drop in activity and small drop in inflation?

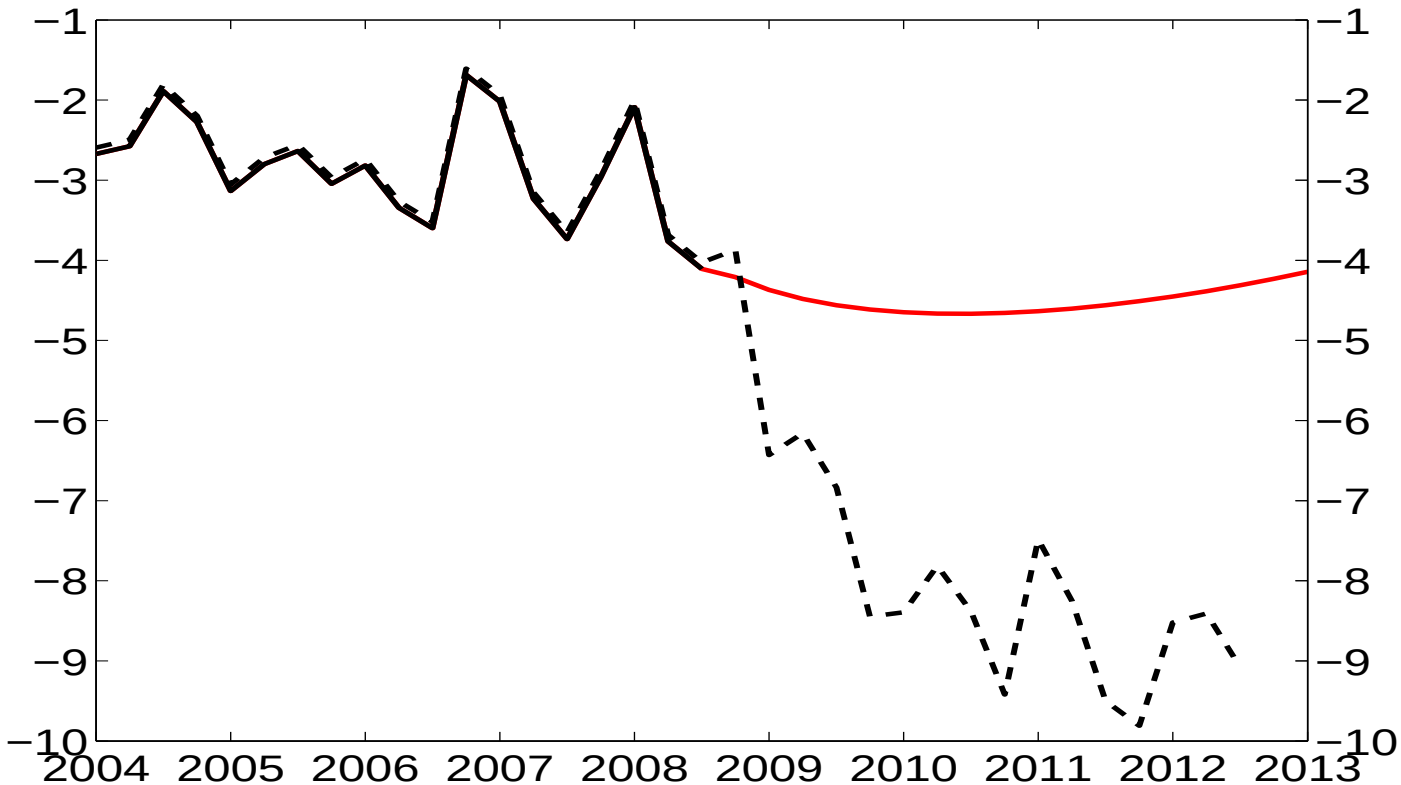
Interest Rate Forecasts



- i) FFR forecasts do not violate ZLB, ii) in line with Blue Chip
- Ex-post FFR turned out very different.

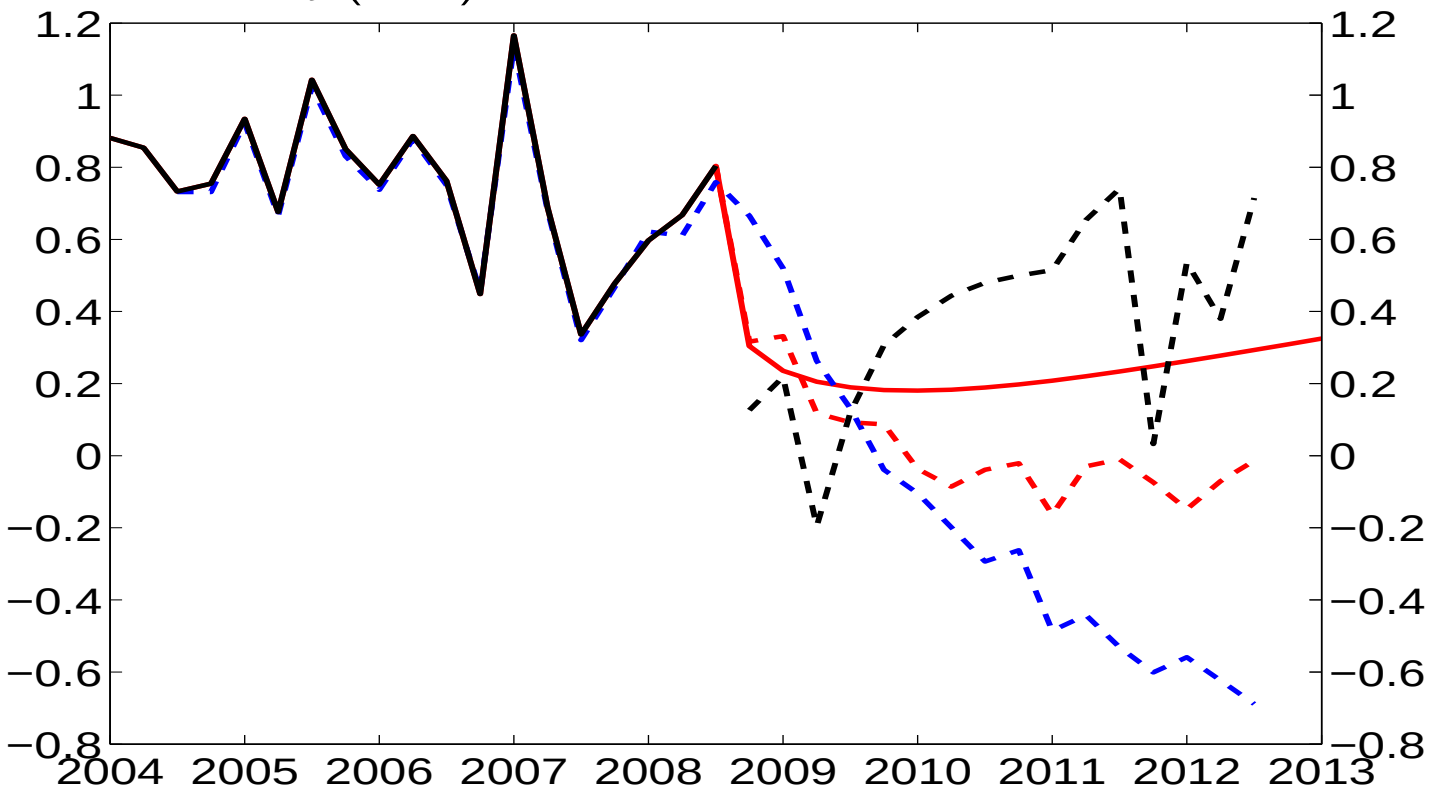
Marginal Costs

- Model fails to predict ex-post marginal cost



Inflation and Marginal Costs: Bad News?

Inflation Forecast Conditional on *ex post* mc_t (red) vs. Backward-looking PC conditional on u_t (blue)



- In forward-looking PC (conditional on *ex post* mc_t): inflation $\simeq 0\%$
- In a backward-looking PC (conditional on *ex post* unemployment): inflation $\simeq -3\%$ annualized.

Inflation and Marginal Costs: Bad News?

- Had we correctly forecast the low values of marginal costs, would we have seen a large deflation?
  - **No.** Why?In the NKPC it is **not the** *current* **slack (i.e.,** mc_t**) that matters for inflation, but the** *projected* **path for slack**
    - The often-criticized forward looking nature of the NKPC saves the day.
- This result hinges crucially on the estimated degree of price rigidity

Inflation and Expected PDV of Future mc_t (Fundamental Inflation)

- NKPC implies:

$$\pi_t = (1-\iota_p L)^{-1} \sum_{j=o}^{\infty} \bar{\beta}^j (1+\iota_p \bar{\beta}) \boldsymbol{E}_t [\kappa \underbrace{mc_{t+j}}_{\text{marg. costs}} + \underbrace{\hat{\lambda}_{f,t+j}}_{\text{mark-up shocks}}]$$

- Decomposition

$$\pi_t = \underbrace{\text{fundamental inflation } \tilde{\pi}_t}_{\text{endogenous}} + \underbrace{\text{mark-up shocks}}_{\text{exogenous}}$$

where

- Fundamental inflation:

$$\tilde{\pi}_t = \kappa \, (1-\iota_p L)^{-1}(1+\iota_p \bar{\beta}) \underbrace{\sum_{j=o}^{\infty} \bar{\beta}^j \boldsymbol{E}_t [mc_{t+j}]}_{\text{PDV marginal costs}}$$

Price Rigidities and Fundamental Inflation

$$\tilde{\pi}_t = \kappa \left(1 - \iota_p L\right)^{-1} (1 + \iota_p \bar{\beta}) \sum_{j=o}^{\infty} \bar{\beta}^j \boldsymbol{E}_t[mc_{t+j}]$$

1. Fundamental inflation responds less to a given movement in expected future mc_t (lower NKPC slope κ)
2. Different behavior of $\sum_{j=o}^{\infty} \bar{\beta}^j \boldsymbol{E}_t[mc_{t+j}]$:

Low price rigidities

(i) $mc_t = \frac{MC}{P} \simeq$ markup shocks.

(ii) If markup shocks transitory
$\sum_{j=o}^{\infty} \bar{\beta}^j \boldsymbol{E}_t[mc_{t+j}] \simeq$ current mc_t

(iii) Since current $mc_t \neq$ inflation
$\Rightarrow$ need markup shocks to explain inflation

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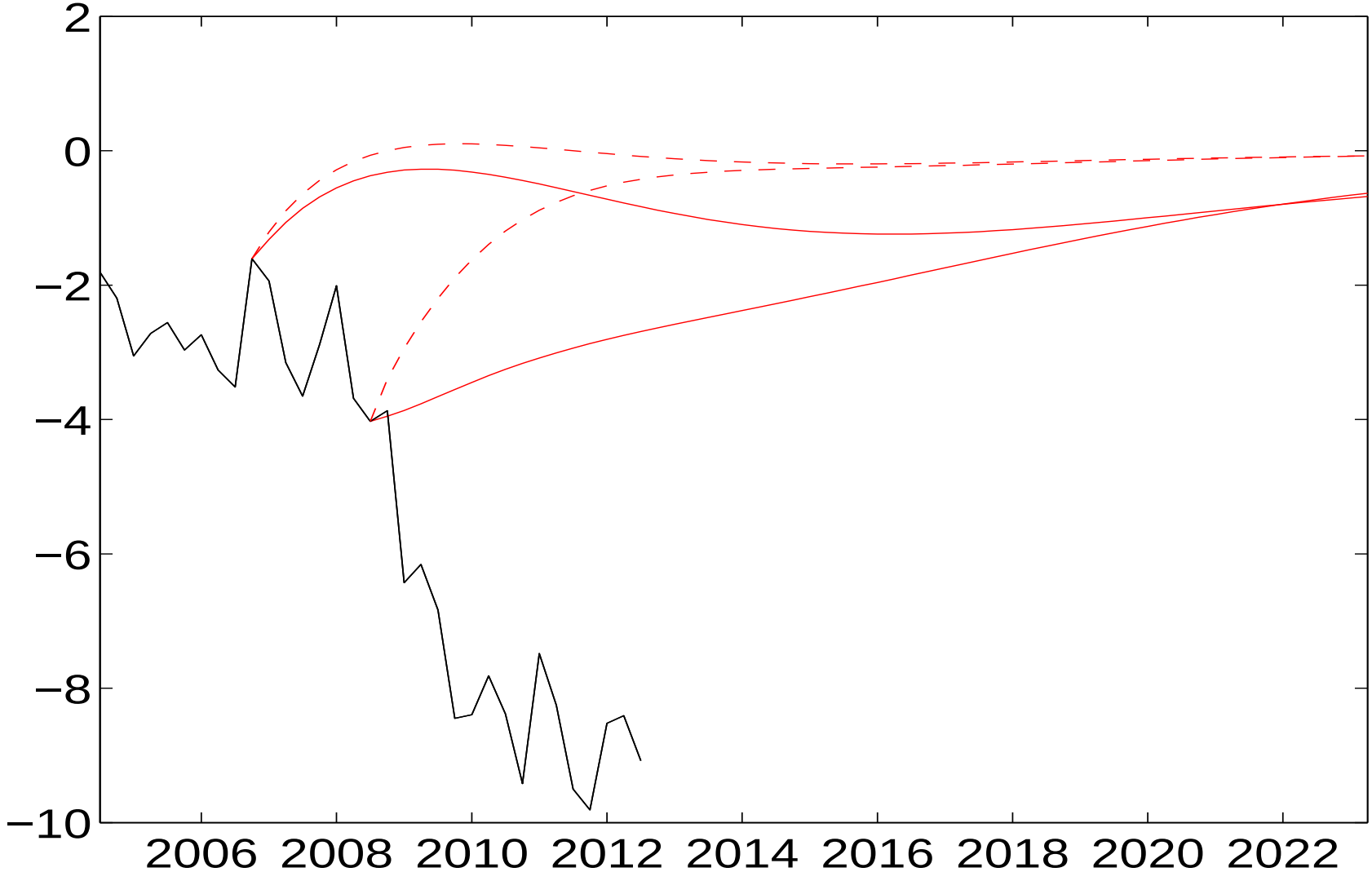
	Low price rigidities	**High price rigidities**
(i)	$mc_t = \frac{MC}{P} \simeq$ markup shocks.	mc_t endogenous
(ii)	If markup shocks transitory $\sum_{j=o}^{\infty} \bar{\beta}^j \boldsymbol{E}_t[mc_{t+j}] \simeq$ current mc_t	persistent changes in activity $\sum_{j=o}^{\infty} \bar{\beta}^j \boldsymbol{E}_t[mc_{t+j}] \neq$ current mc_t
(iii)	Since current $mc_t \neq$ inflation $\Rightarrow$ need markup shocks to explain inflation	fundamental inflation $\simeq$ inflation

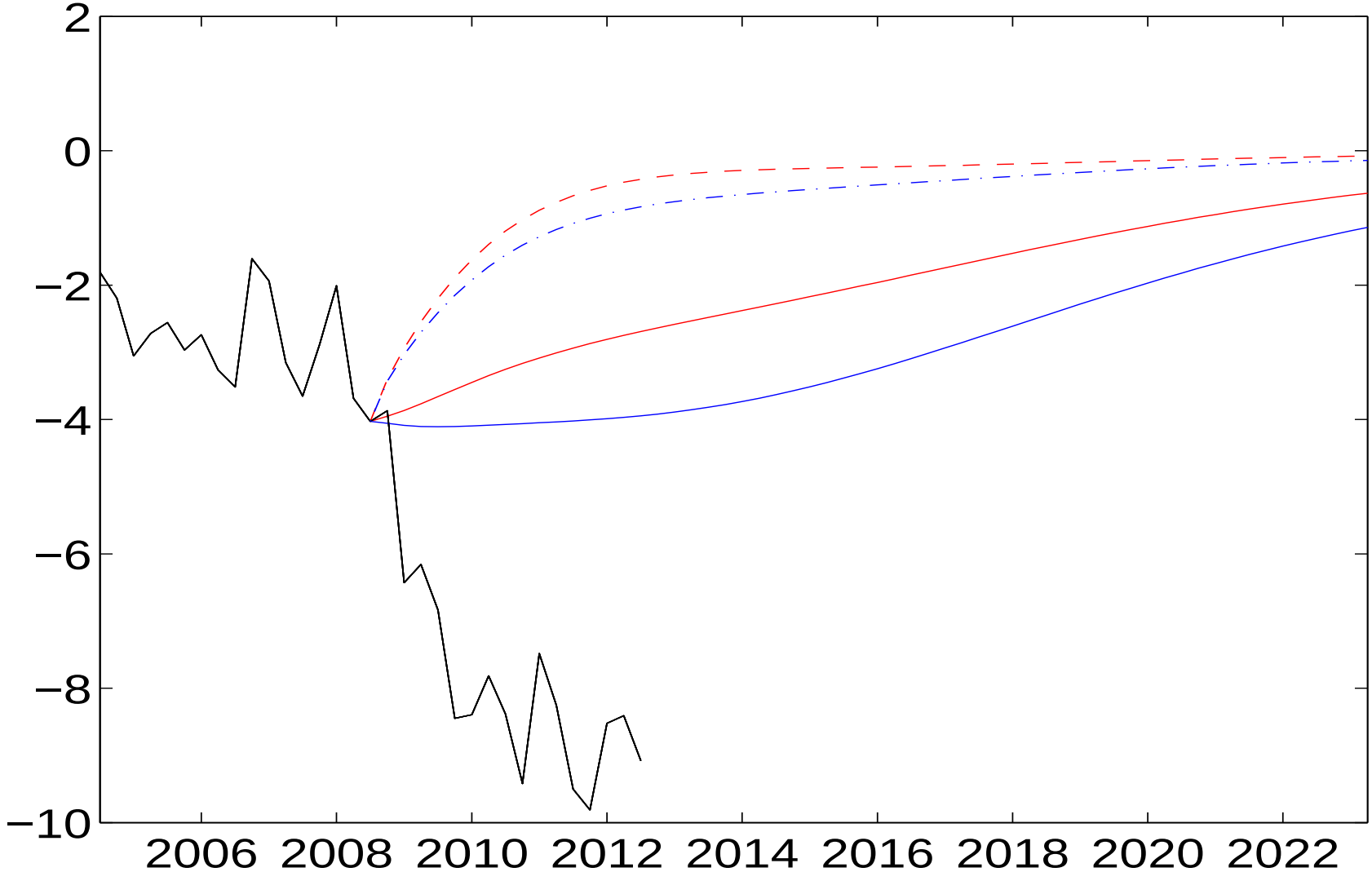
Price Rigidities and Marginal Costs

- Marginal costs forecasts for two estimates of price rigidity: .86 (SW-FF) vs .65 (SW)



Price Rigidities, Marginal Costs, and Monetary Policy

- Marginal costs forecasts for different response to inflation in the policy function (1.3 vs 1.1)



Does a Flat NKPC Make Policy Irrelevant?

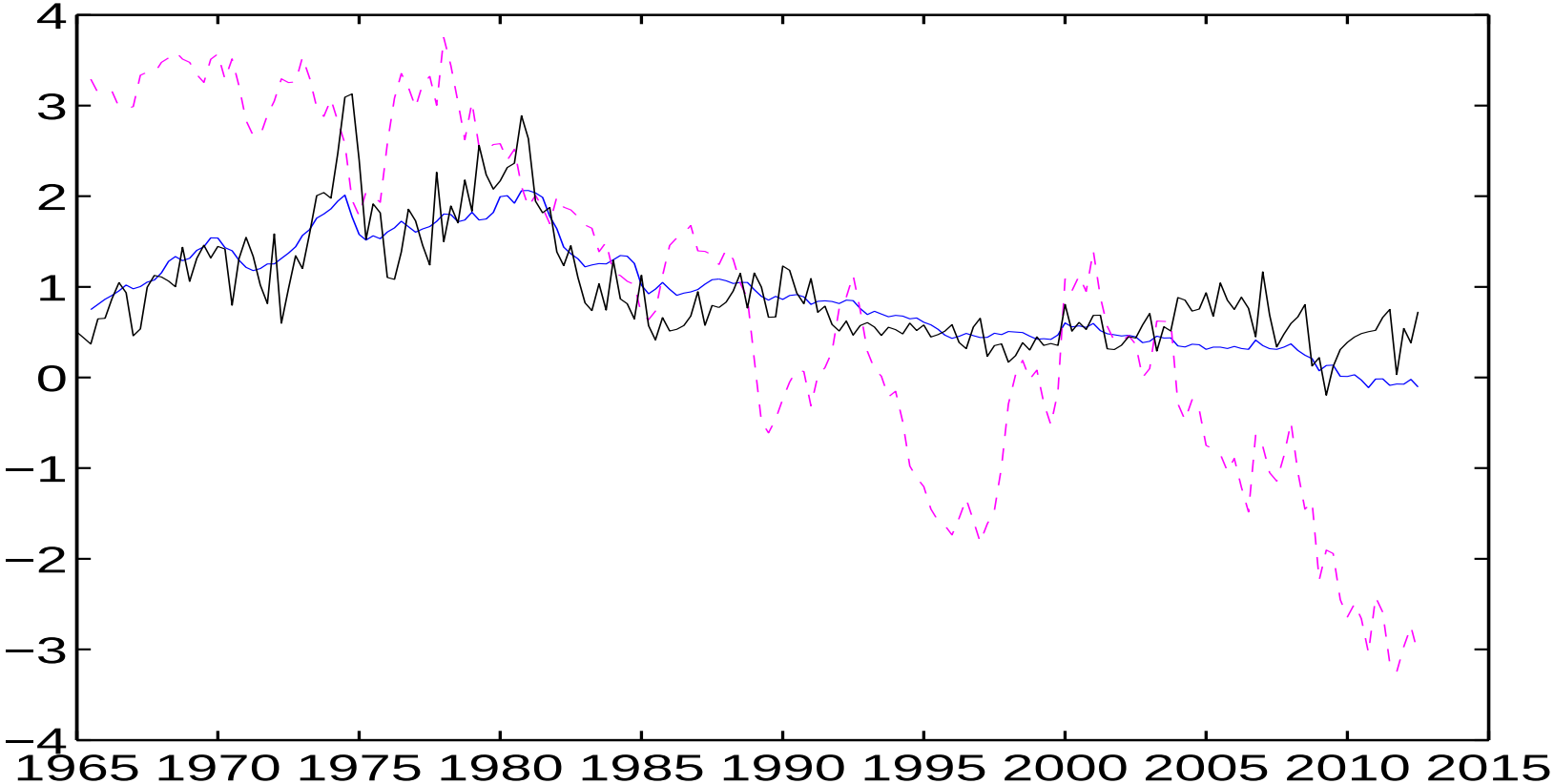
- Does a flatter PC mean that 1) inflation is nearly exogenous (as in Hall, 2011)? And hence that 2) monetary policy looses its ability to stabilize inflation?

- Answer: No and No. Changes in the systematic FFR response to inflation fluctuations has considerable effects on fundamental inflation. The effect works through expected future marginal costs.

- Note that even a standard Taylor rule has an Eggertsson-Woodford flavor: stabilizing inflation means promising stronger economic activity in the future.

Inflation and Fundamental Inflation ($\tilde{\pi}_t$)

- The degree of price rigidity affects the model's ability to describe inflation **for the whole sample**



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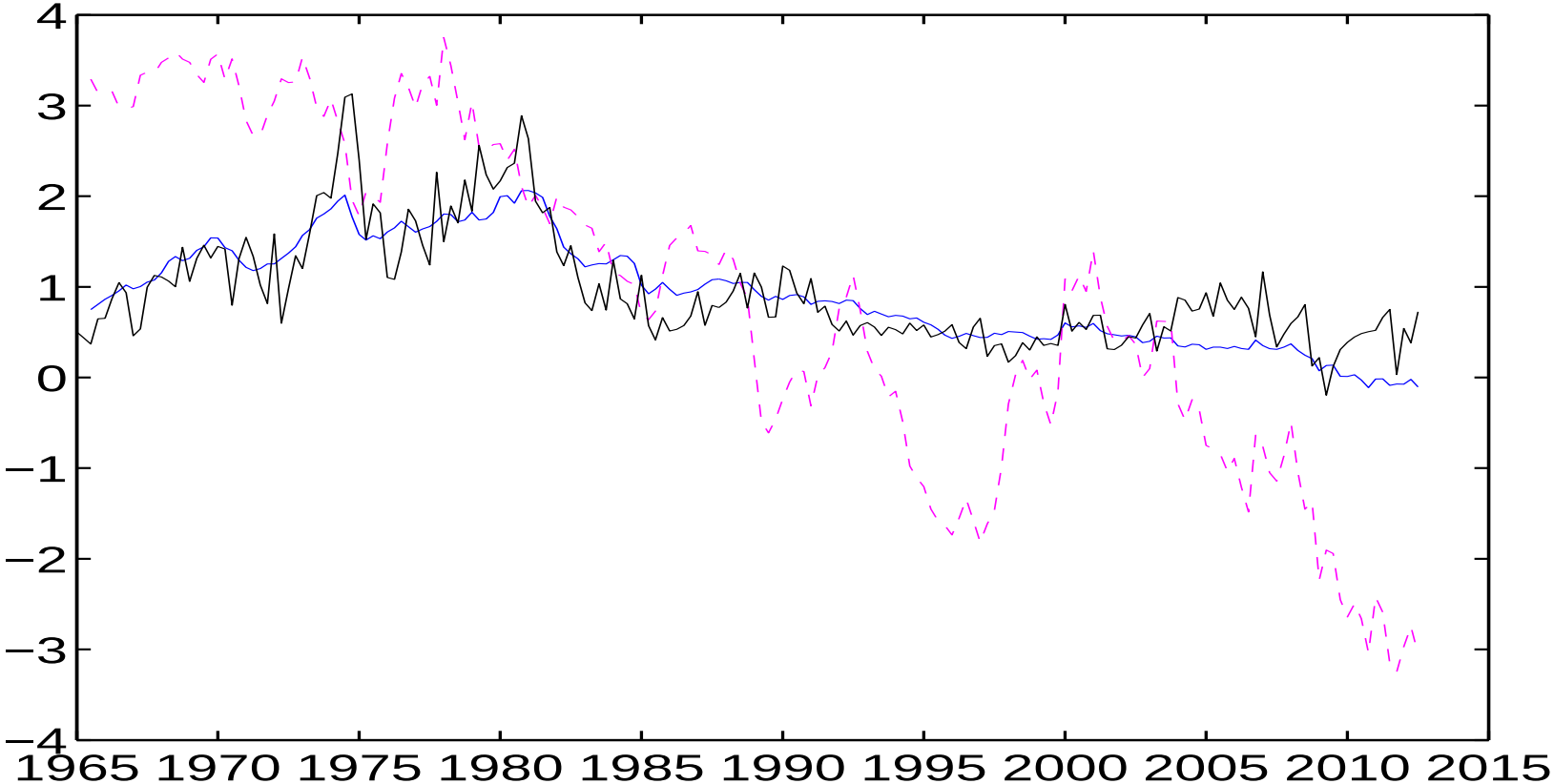

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1. **Why the difference between $\tilde{\pi}_t$ in SW and SW-FF model?**

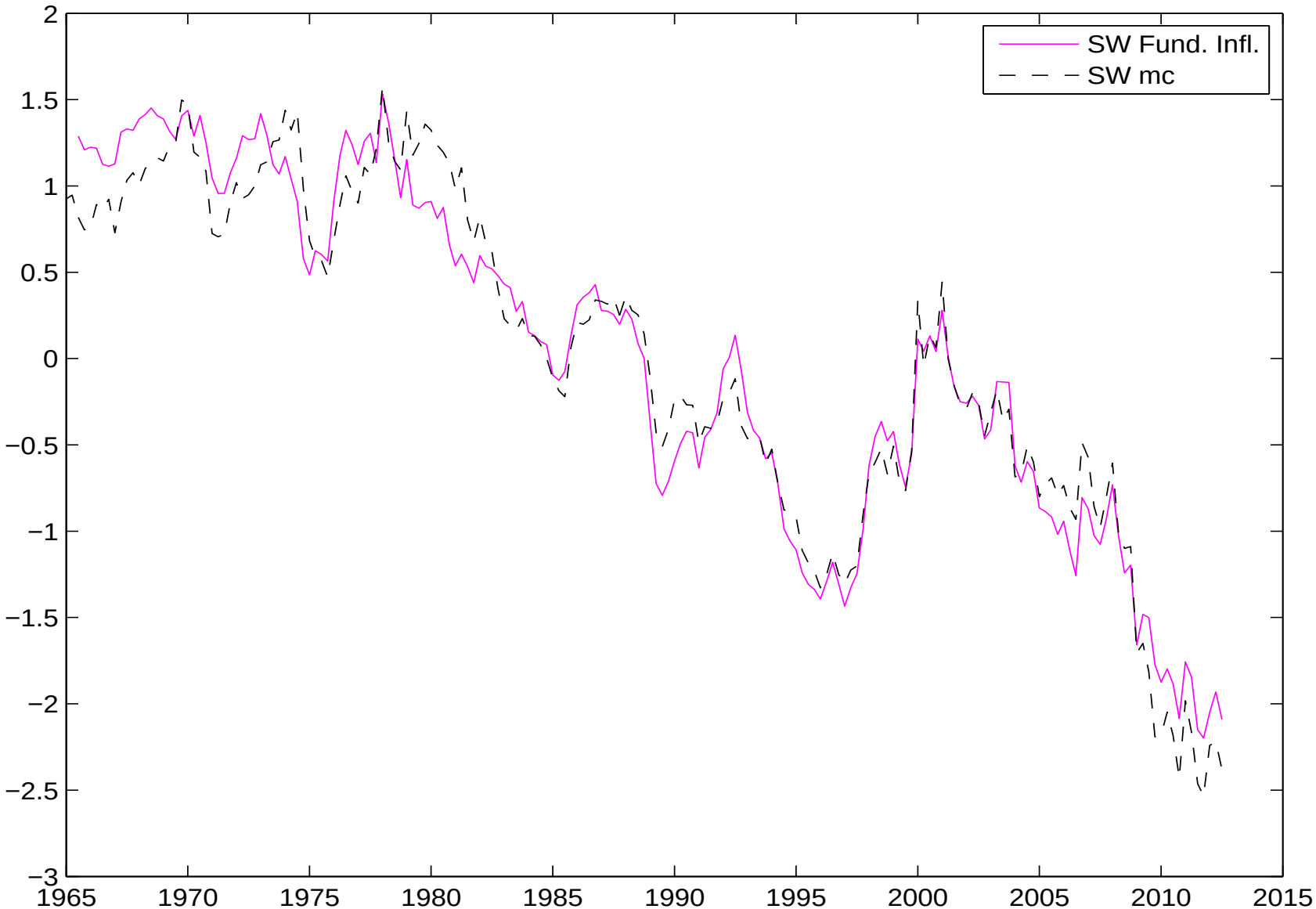
   - *Answer:* Relatively low estimated price rigidities in SW model (.65 in SW vs .86 in SW-FF) imply that

     $$\text{fundamental inflation} \simeq \text{current marginal cost} \neq \text{inflation}$$

2. **Why does the SW-FF model have higher estimated price rigidities?**

   - *Answer:* **credit spreads** treated as **observable** $\rightarrow$ demand shocks appear more important $\rightarrow$ steep NKPC counterfactual

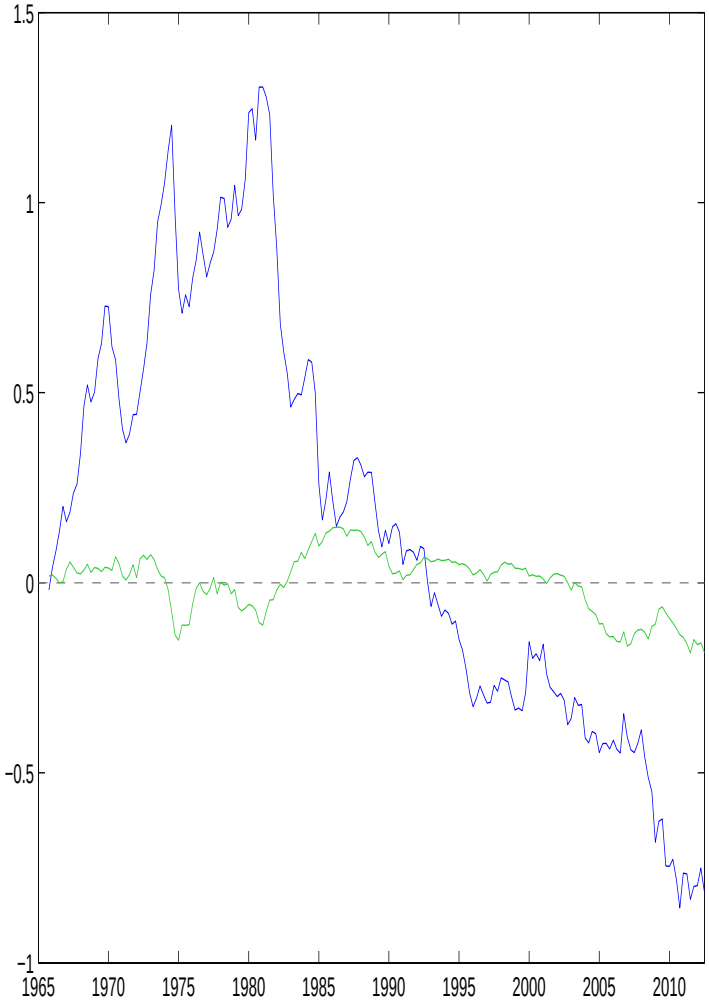
SW Fundamental Inflation vs Marginal Costs



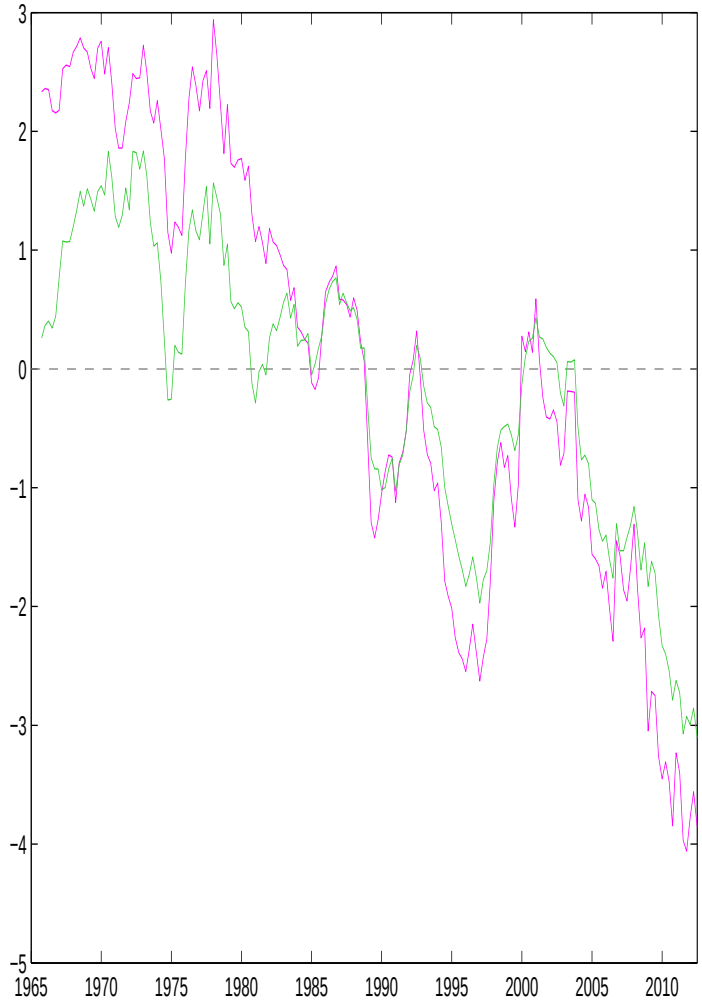
Both SW fundamental inflation and marginal costs are normalized.

Movements in Fundamental Inflation $\tilde{\pi}_t$ Attributable to Mark-up Shocks

SWFF

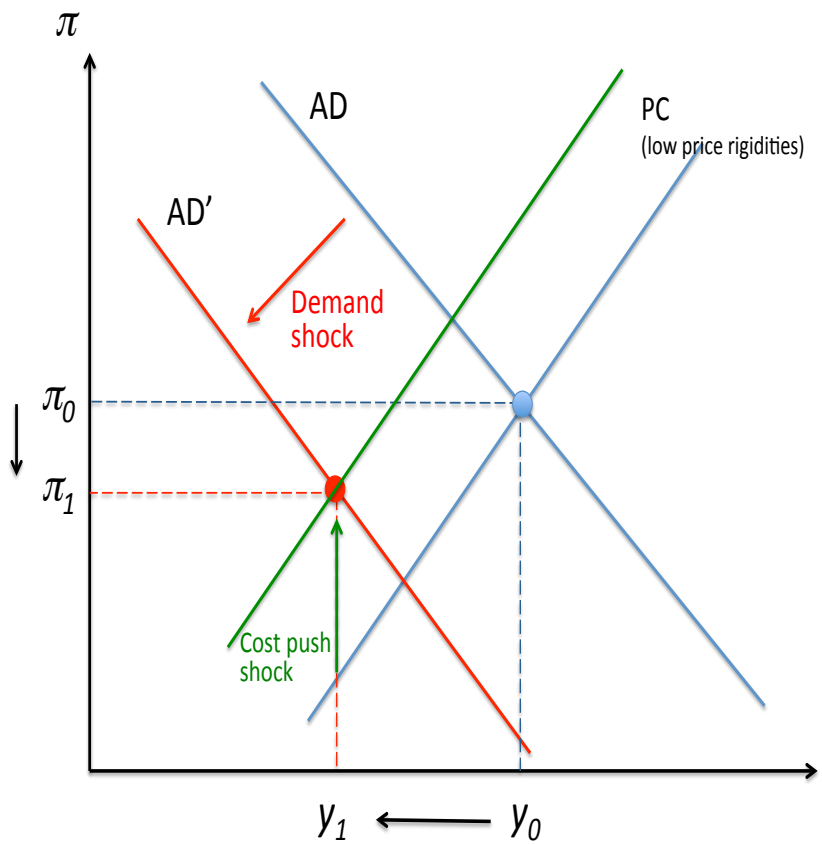


SW

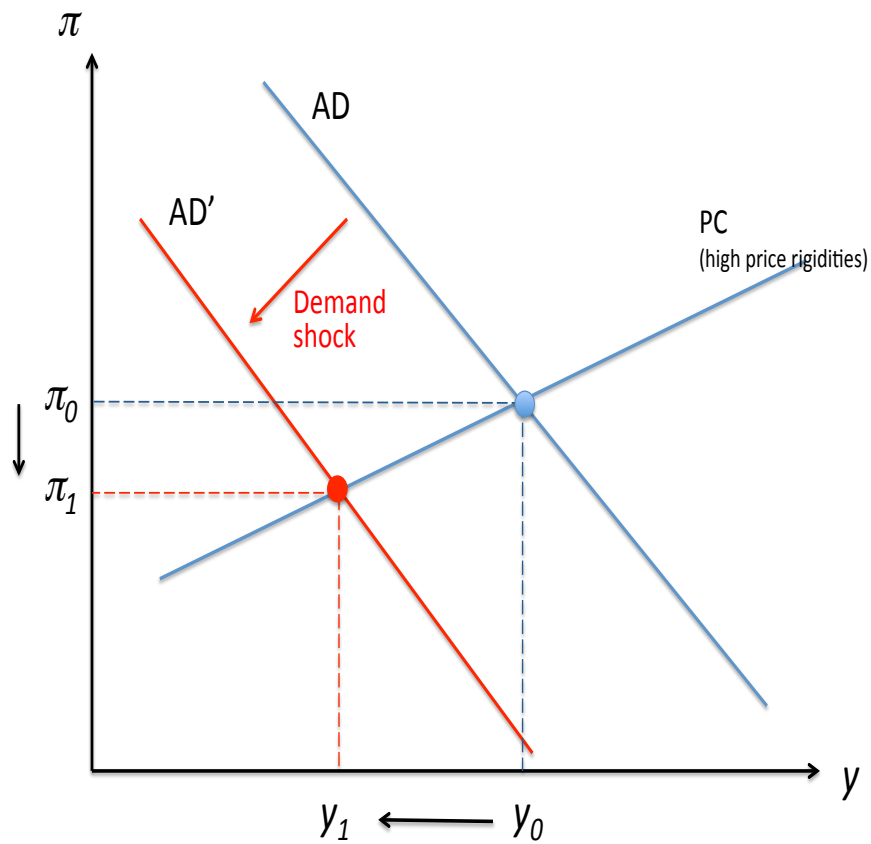


Why Does the Financial Frictions Model Have Higher Price Rigidities?

Low rigidities



High rigidities



Why Does the Financial Frictions Model Have Higher Price Rigidities?

1. Demand shocks are more important in the SW-FF model relative to SW – because spreads are used as an observable (fairly direct effect on investment demand)

2. To explain jointly inflation and output data in presence of demand shocks, must have either:

   - Flat NKPC (high ζ_p), or
   - Markup shock every time there is a spread shock

The Evidence

1. Estimating the SW model (up to 2008Q3), using in addition spread data and add a spread shock in arbitrage condition:

$$\mathbb{E}_t[\tilde{R}^k_{t+1}] - R_t = b_t + \tilde{\sigma}_{\omega,t}$$

results in higher estimated price rigidity: $\zeta_p = 0.81$

   - SW model: $\zeta_p = 0.65$
   - SW-FF model: $\zeta_p = 0.86$

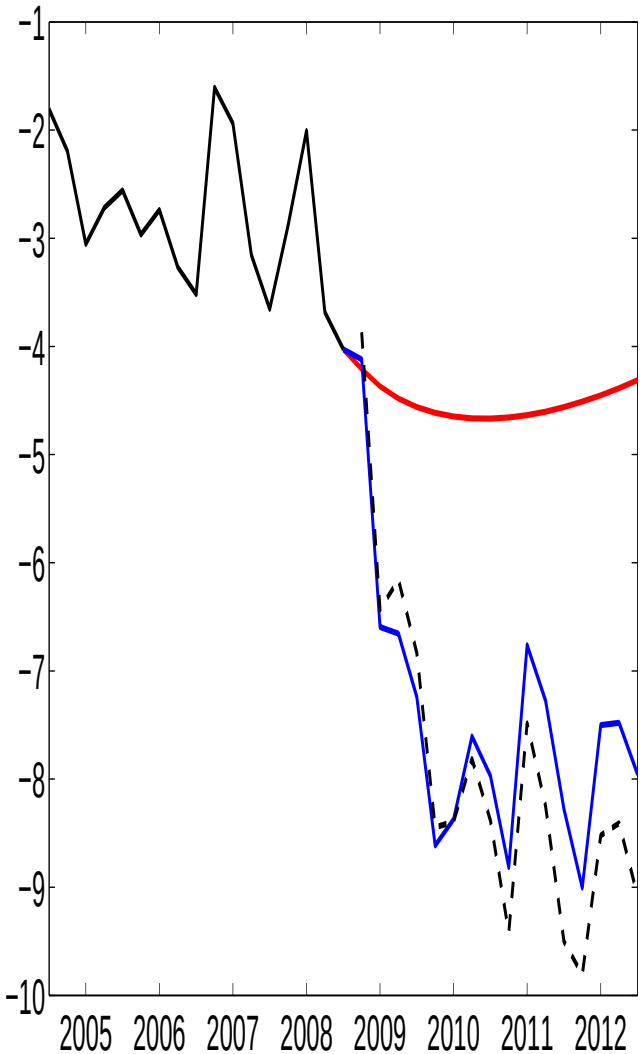
2. If we decompose inflation into 1) a component due to mark-up shocks and 2) a component due to demand shocks (discount rate and MEI shocks) we find that the correlation is -.37 for SW, and .18 for SW-FF.

3. Estimates of price rigidities jump up (in both SW-FF and SW) after the crisis.

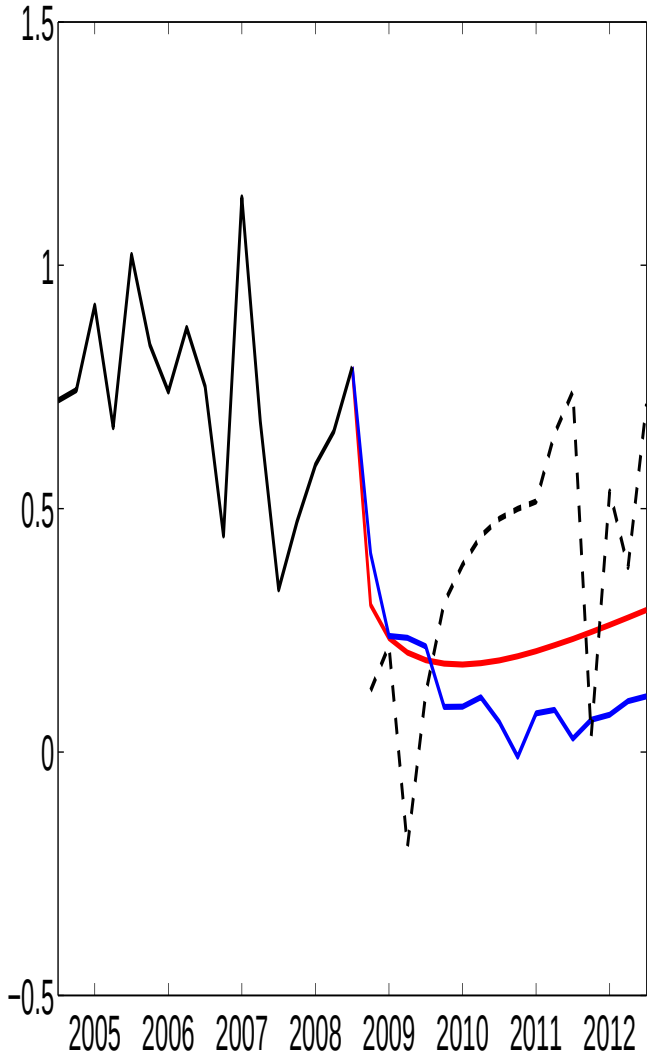
Forecasts Conditional on (Ex-Post) Smoothed Shocks

Non-Markup Shocks

Marginal Cost



Inflation

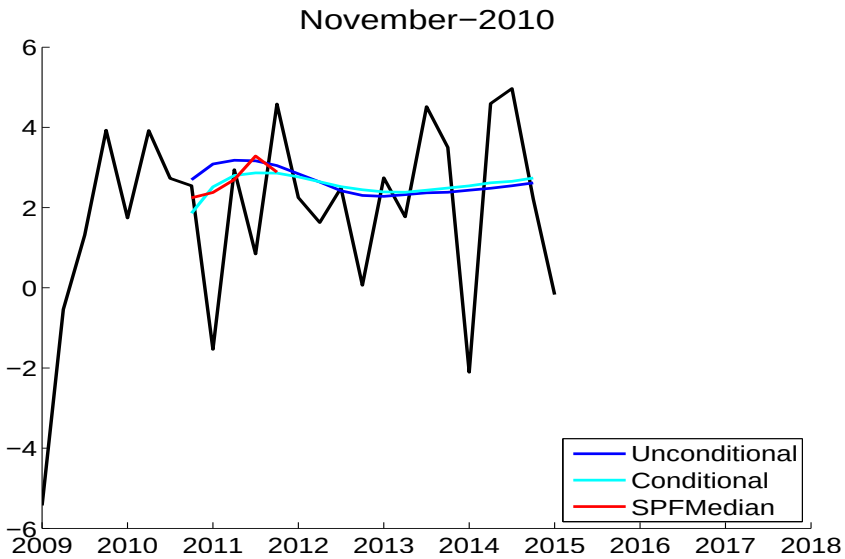


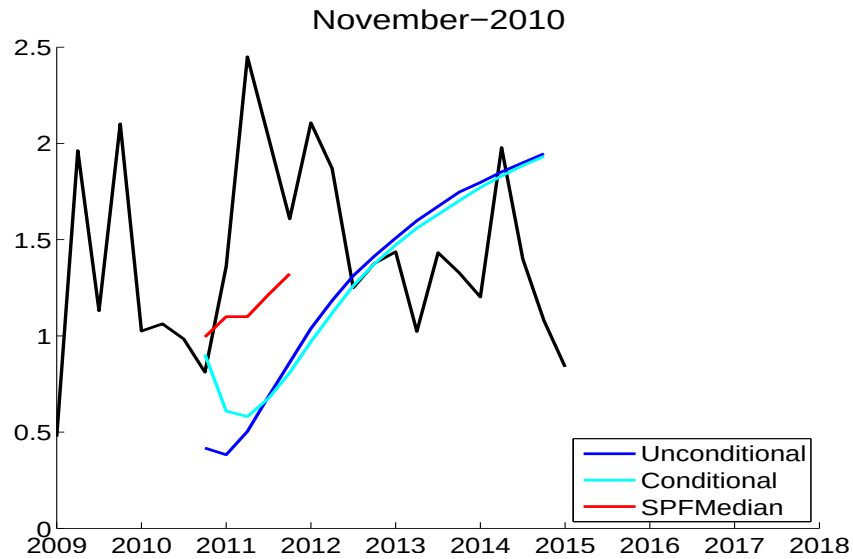
"Real" Real Time Forecasts from FRBNY-DSGE Model

Output Growth

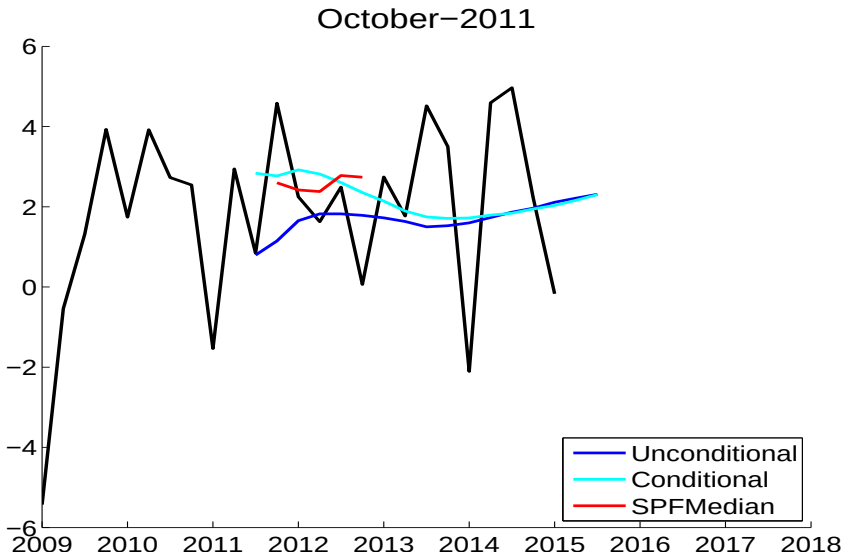
Core PCE Inflation

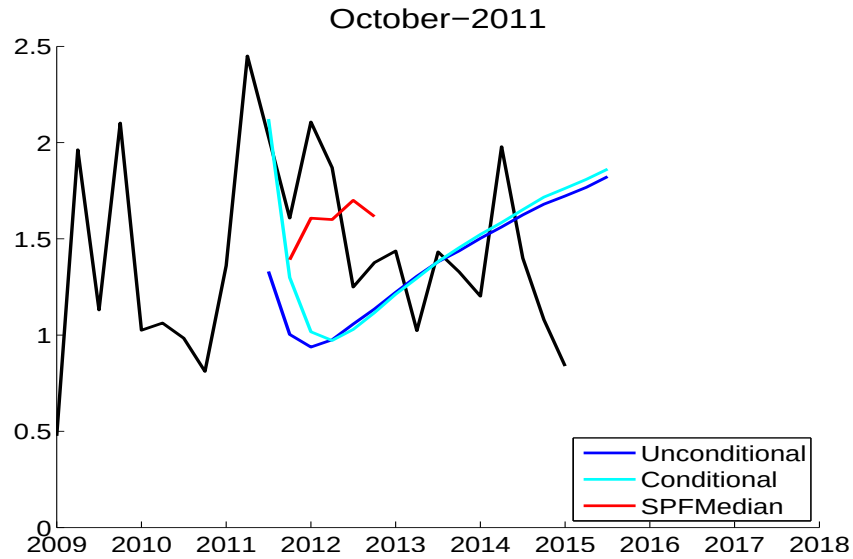
November 2010





October 2011





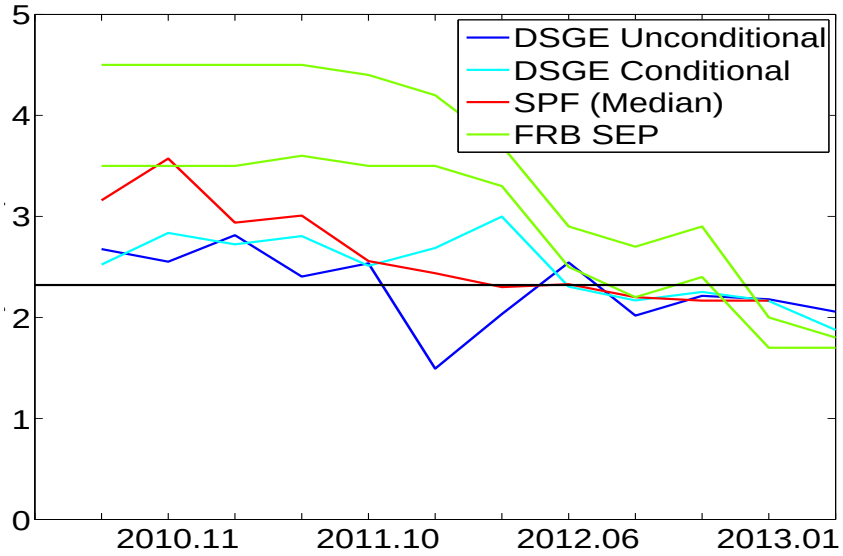
"Real" Real Time Forecasts from FRBNY-DSGE Model

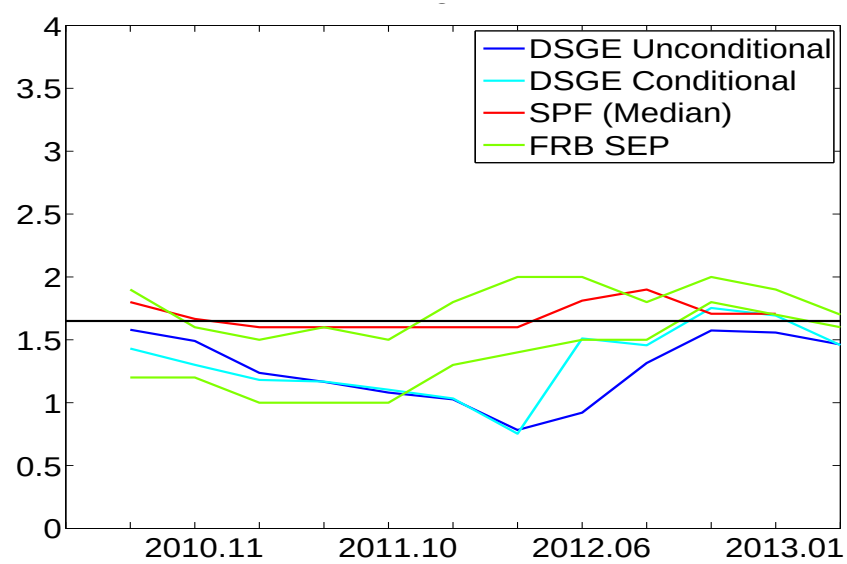
Evolution of year-over-year forecasts

Output Growth (Y-o-Y)

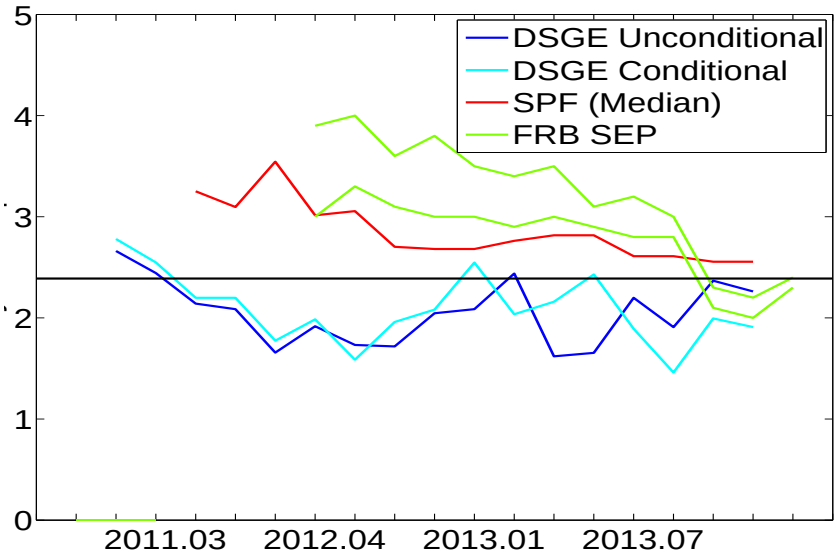
Core PCE Inflation (Q4/Q4)

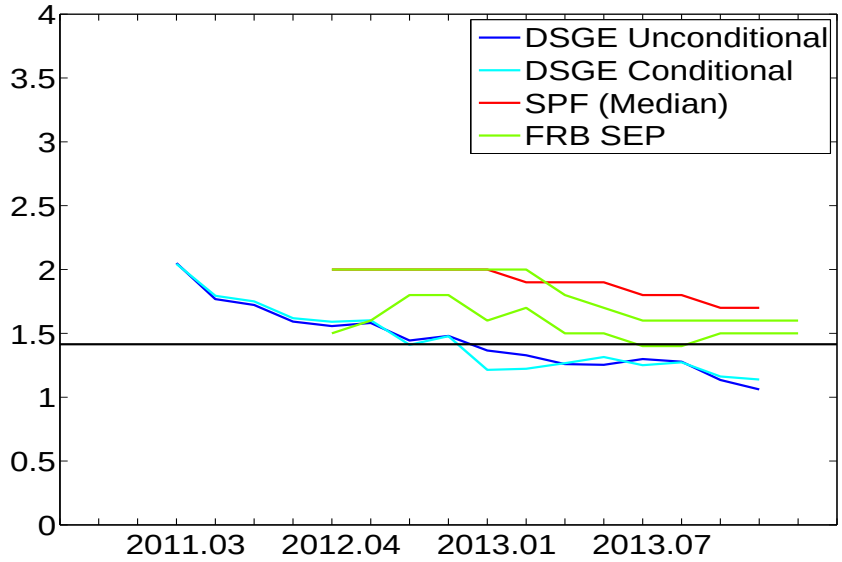
2012





2014





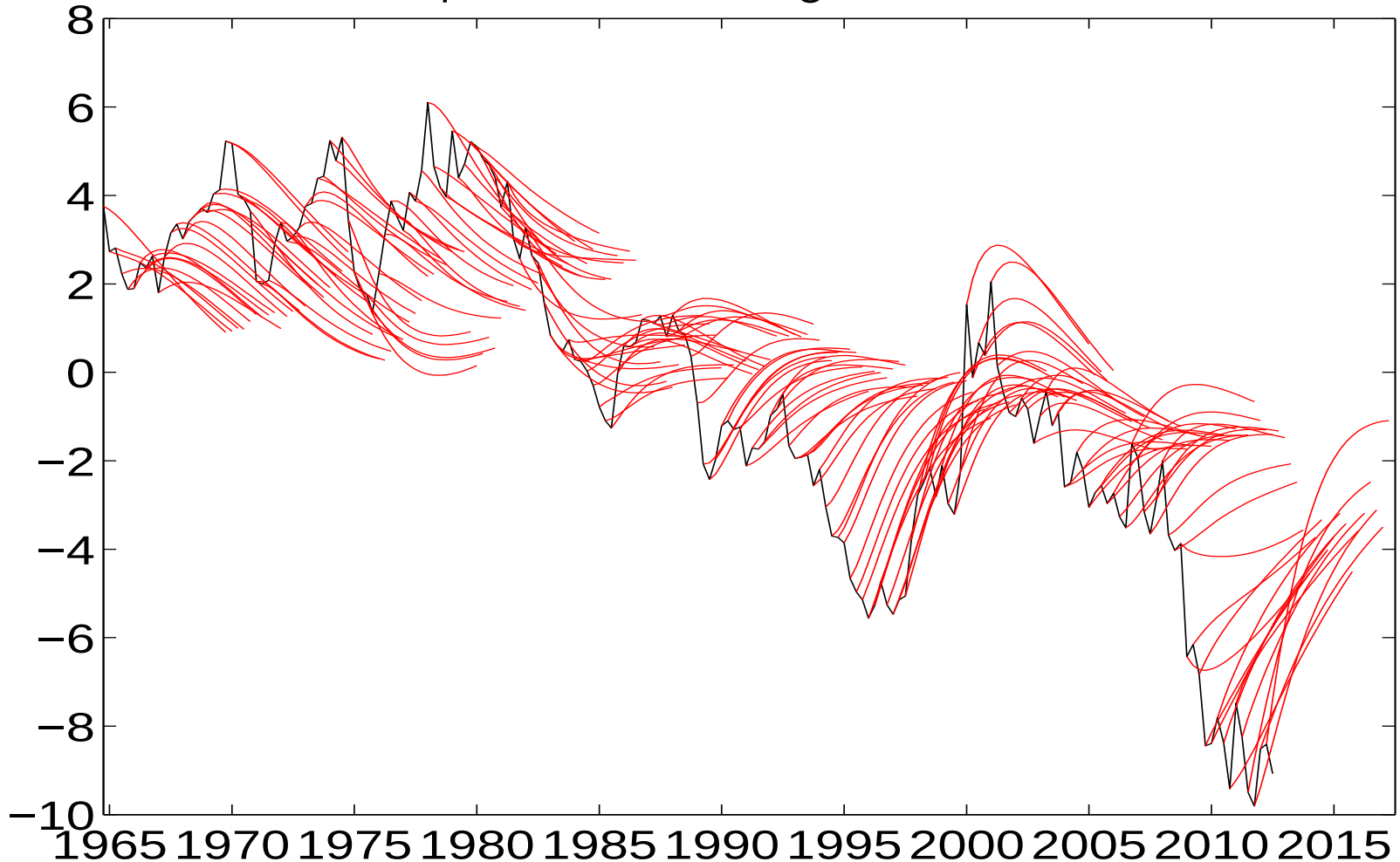
Conclusion

1. As soon as financial stress (credit spreads) jumps in fall of 2008, the model SW-FF successfully predicts the broad contours of Great Recession, out-of-sample:
   - Sharp contraction in activity
   - Modest and protracted decline in inflation

2. Why has inflation declined so little?
   - Inflation depends more on expected future *mc* than current *mc* $\Rightarrow$ even if current activity is sharply reduced, monetary policy stimulus raises expected future *mc*, so that inflation expectations remain anchored

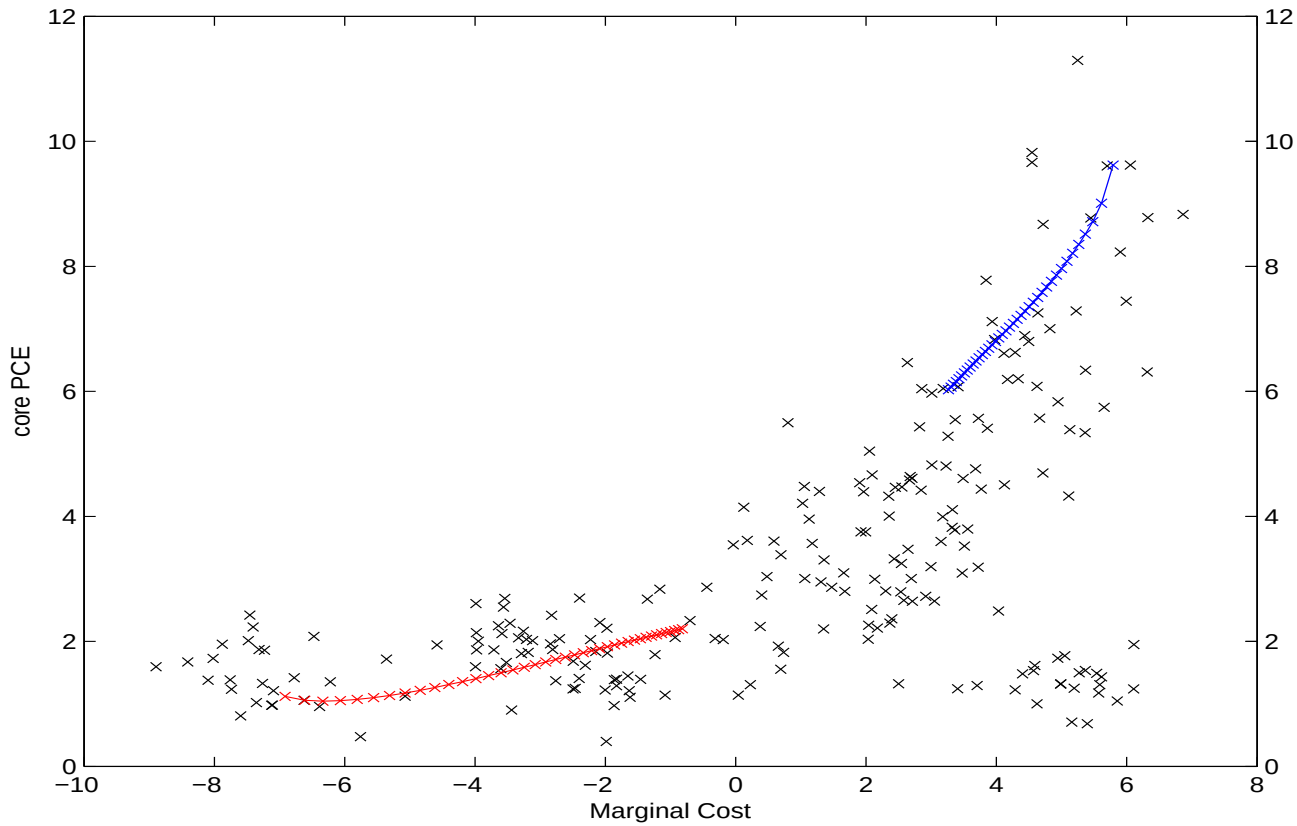
Current and Expected Future mc_t

- $\tilde{\pi}_t$ is the PDV of expected future marginal costs ...
- How do these expected future marginal costs look like?



A Non-linear Phillips Curve

- The relationship between inflation and *current* marginal costs appears to be non-linear – but this is because inflation does not depends on the PDV of future *mc*'s
- The forecasted evolution of inflation and *mc* is not at odds with past data.



Are DSGE forecasts of *mc* unreasonable?

- Downward secular trend does not help the optics in the latest part of the sample ...
  - mc_t is forced to return to steady state (0) ....but in the data there appears to be a long run trend possibly due to factors (demographic...) this DSGE does not have
  - In any case, reduced form models (e.g., recursive AR(2)) do not forecast a lot better

- Our conjecture
  - Incorporating a trend will matter for the forecasts of marginal costs, but will not change the story for inflation
  - Why? As long as the central bank is committed to bring inflation to $\sim 2\%$ (π^*), inflation expectations will not stray too far from π^*.

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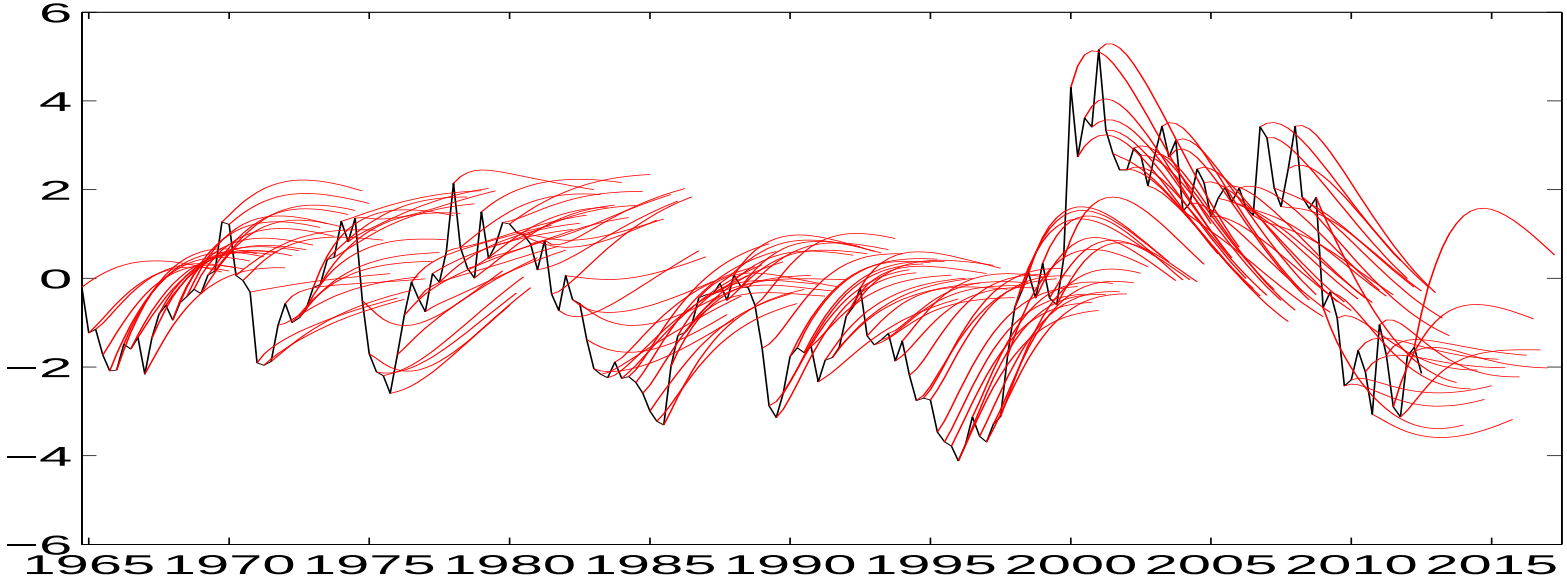
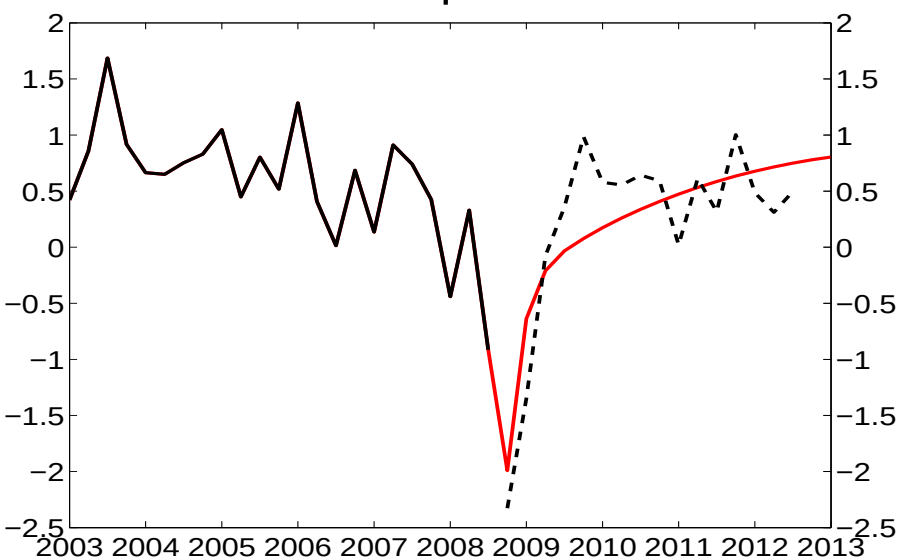
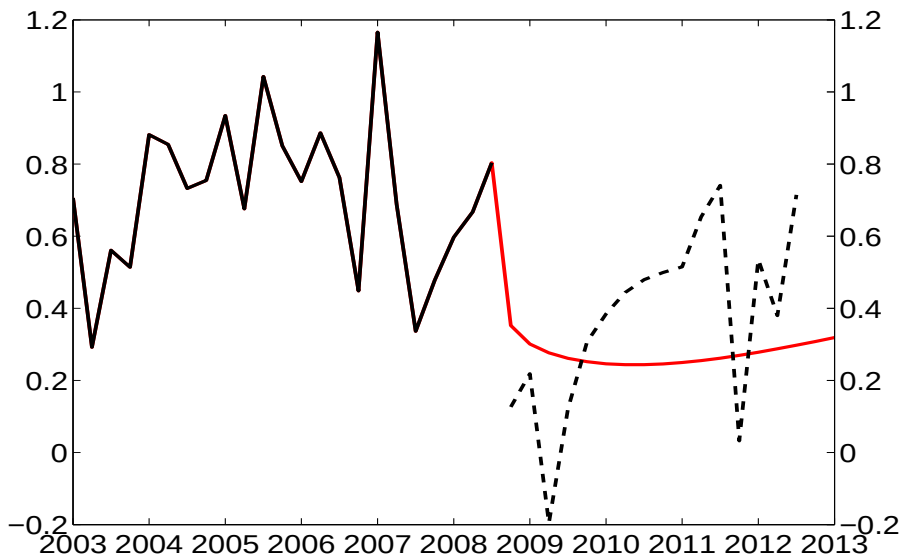
Separately Detrending Wage Growth



Output

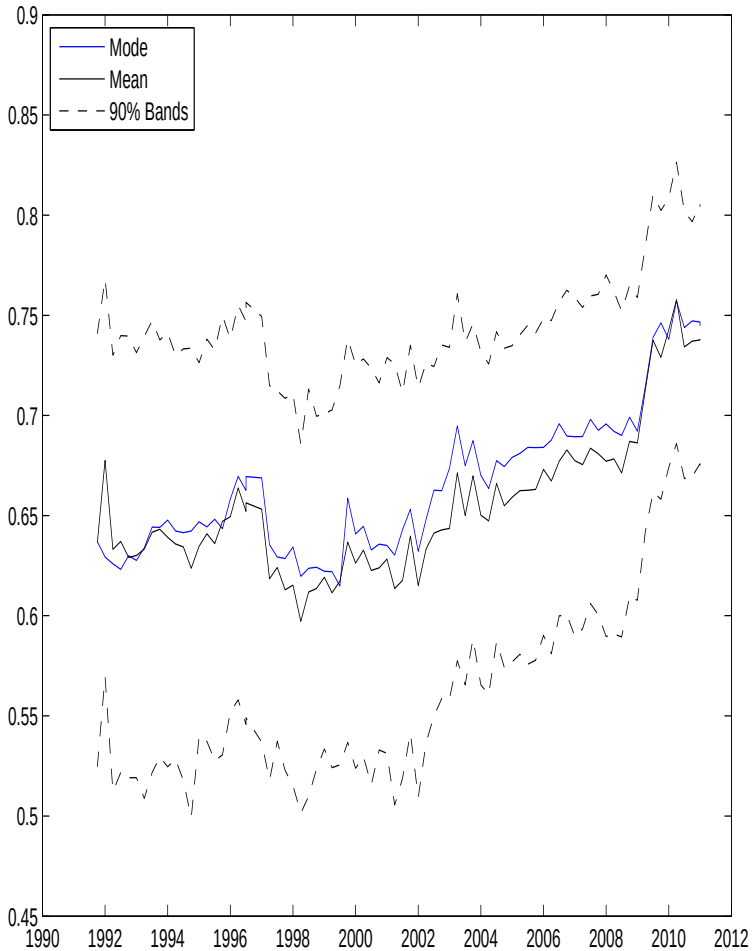


Inflation

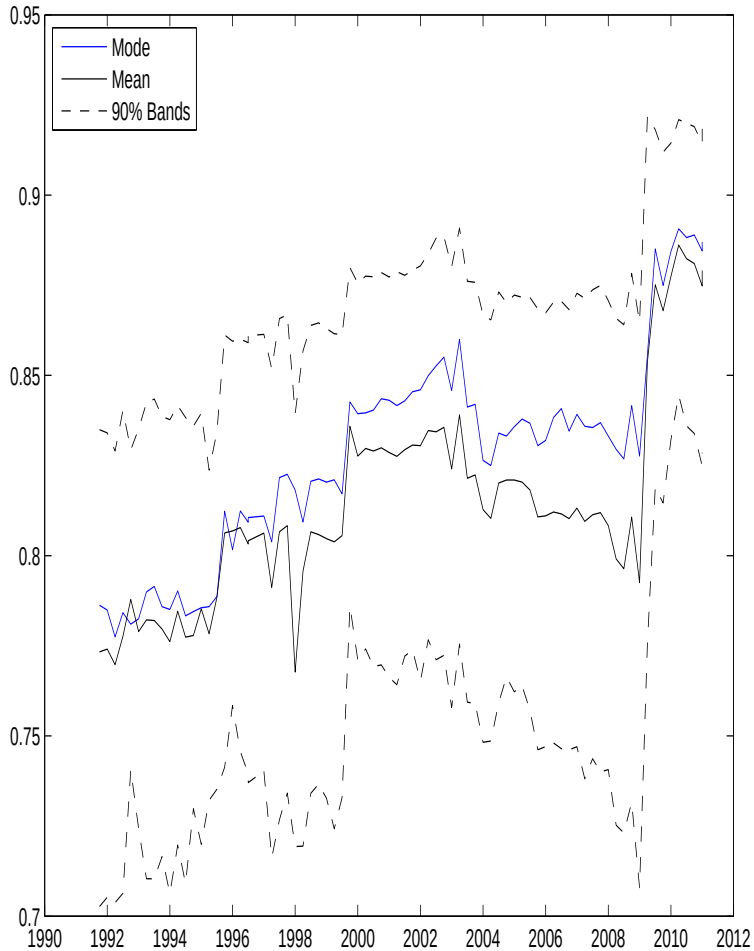


ζ_p: Recursive Estimation

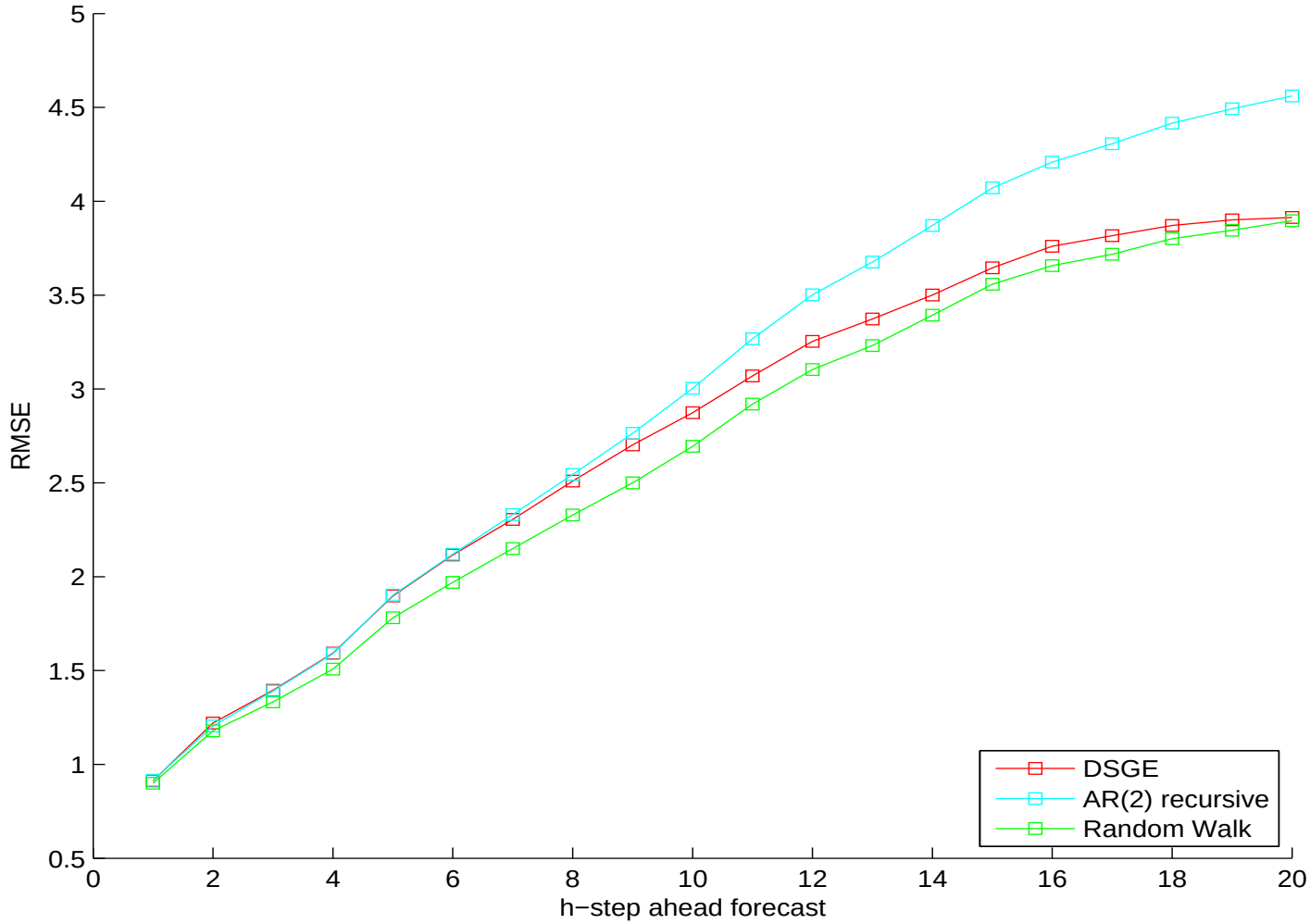
SW



SW-FF



Comparing *mc* Forecasts: DSGE vs. Reduced -Form Models

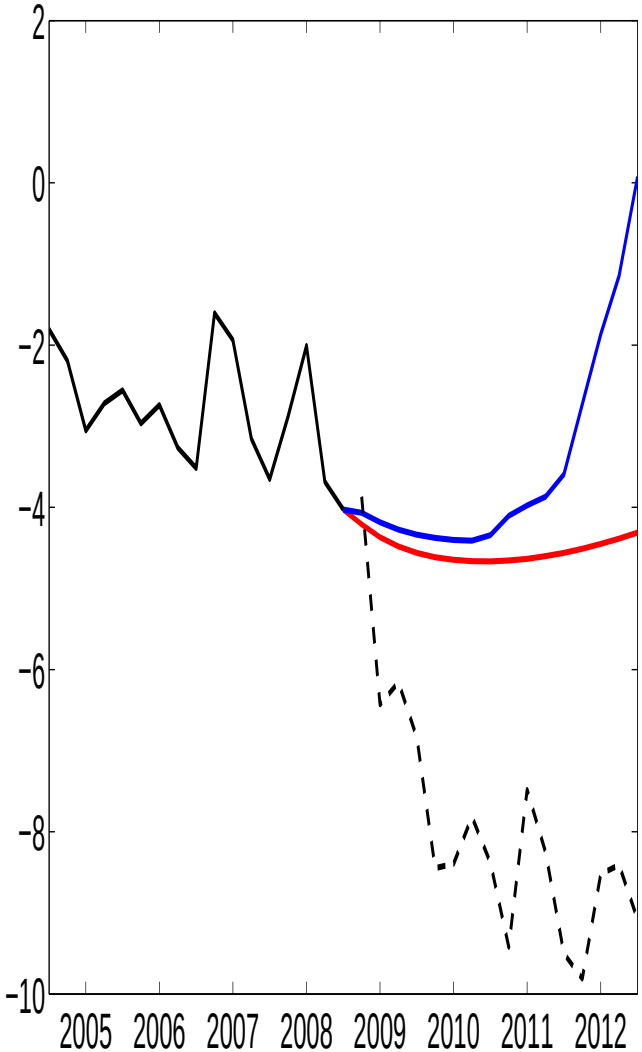


RMSE of forecasts of marginal costs in the SW-FF model (DSGE), an AR(2) model estimated recursively on past marginal cost data, and a random walk model, for the period 1989Q4-2012Q3.

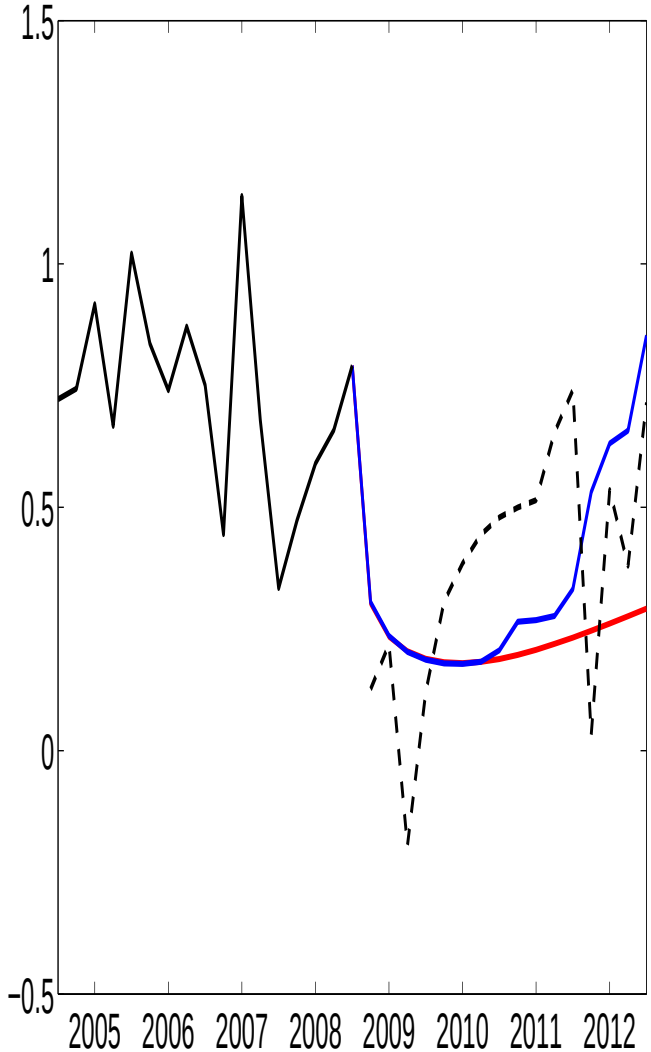
Forecasts Conditional on (Ex-Post) Smoothed Shocks

No Shocks (Policy)

Marginal Cost



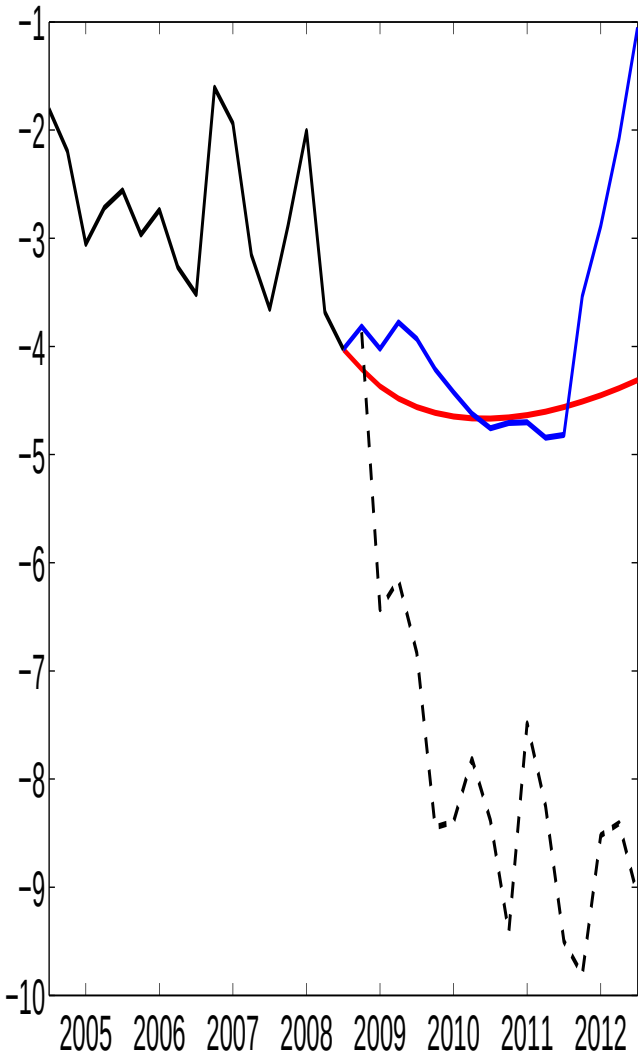
Inflation



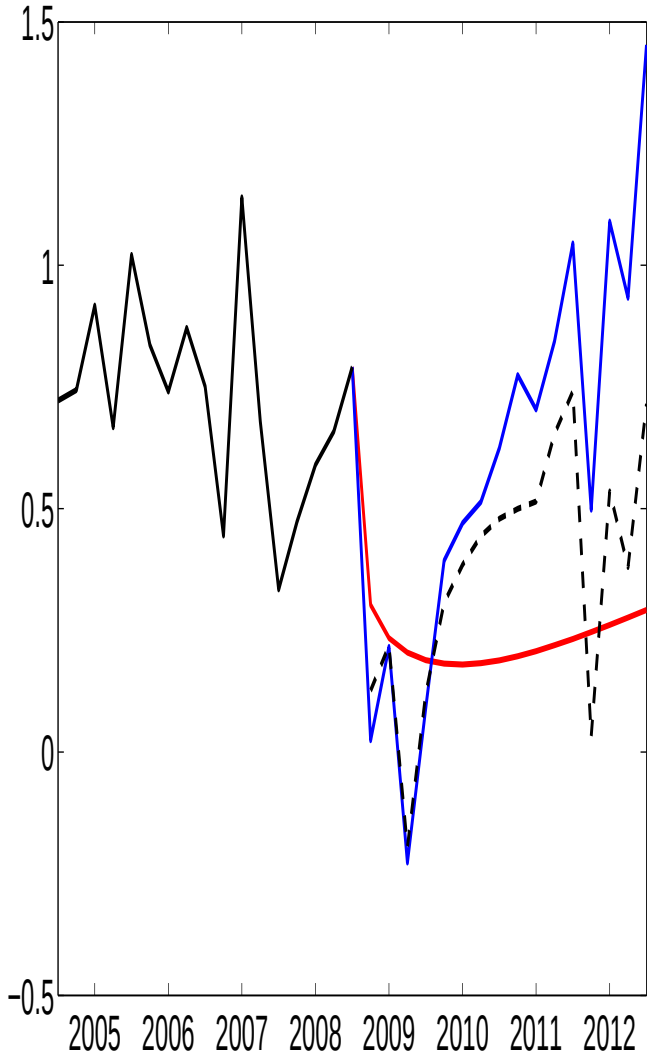
Forecasts Conditional on (Ex-Post) Smoothed Shocks

Markup Shocks

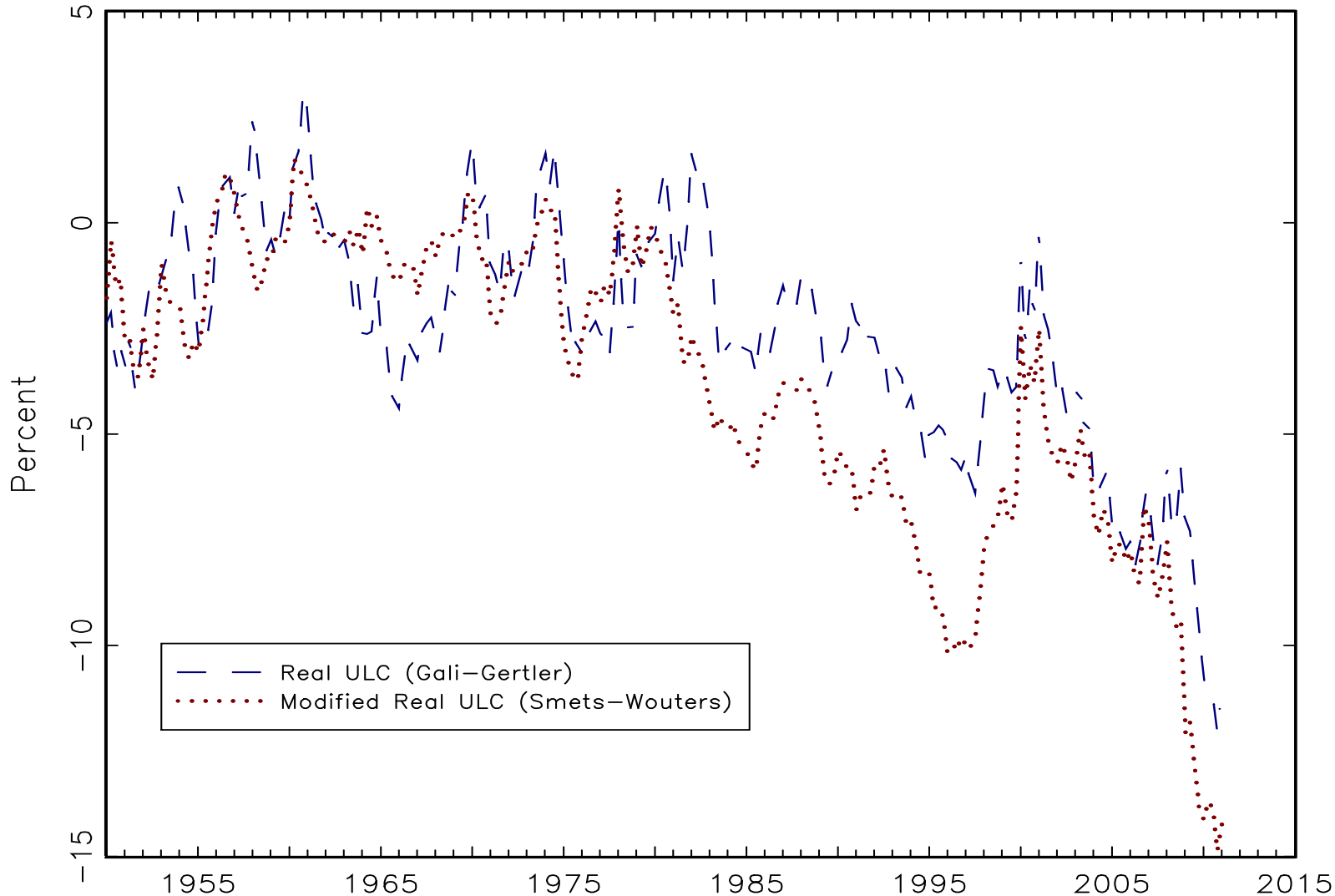
Marginal Cost



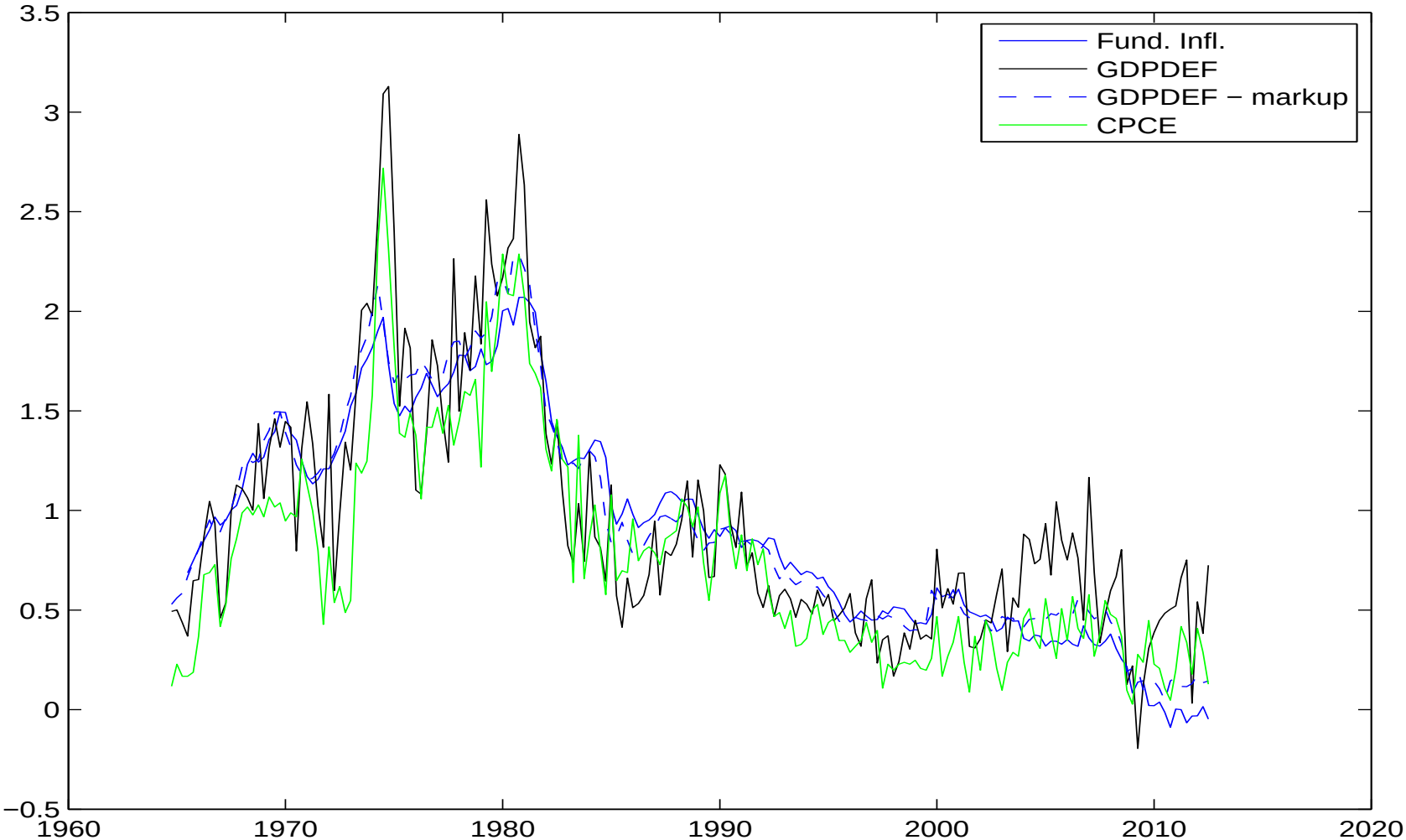
Inflation



KW: Marginal costs



Inflation, Fundamental Inflation, Counterfactual Inflation without Mark-up Shocks, and Core Inflation



Observables or frictions?

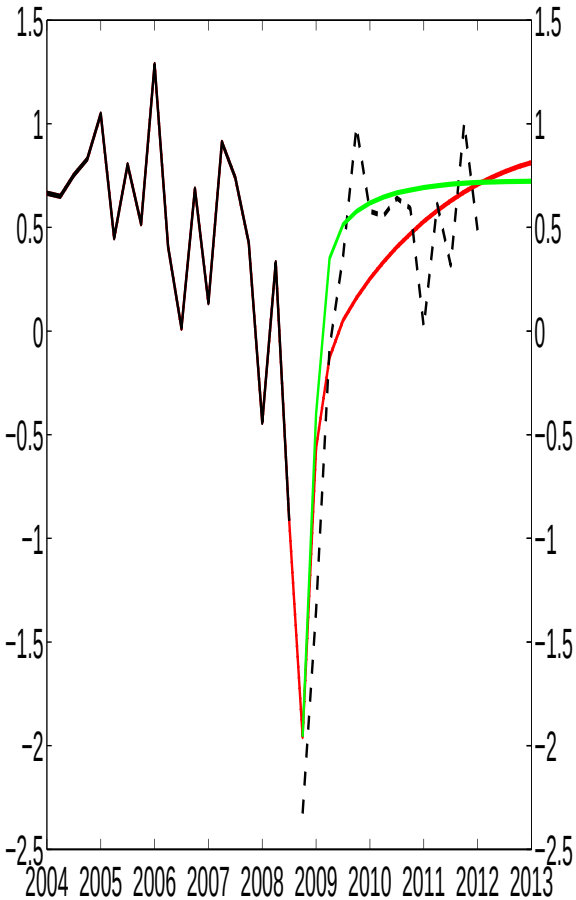
- SW-FF's forecasts: Do the financial frictions/cross-equation restrictions play any role, or is it all in the new observable (spreads)?

- Two exercises:

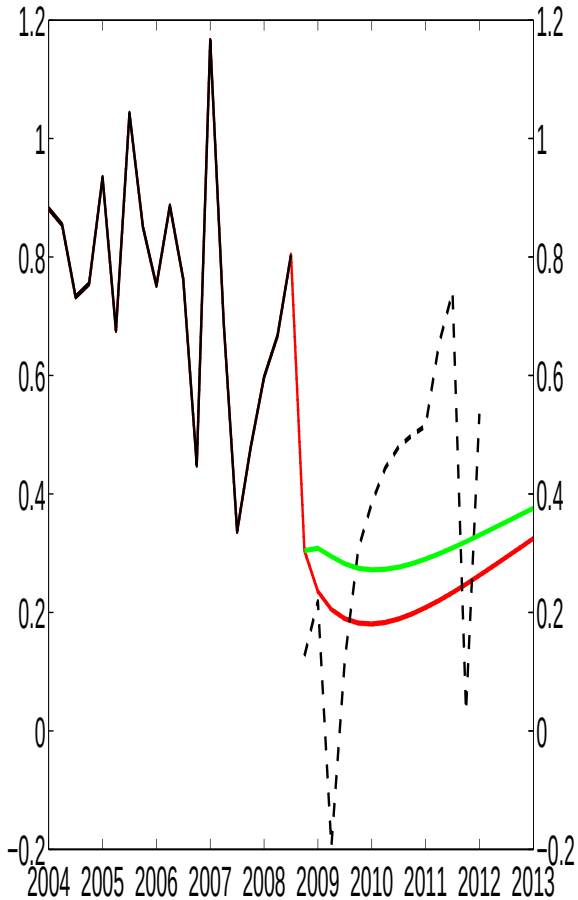
  1. Take states from SW-FF and stick them into plain SW transmission
  2. Estimate a Minnesota prior VAR using the same variables as SW-FF up to 2008Q3 (level), and condition on 2008Q4 interest rates and spreads

SWπ-FF vs SWπ

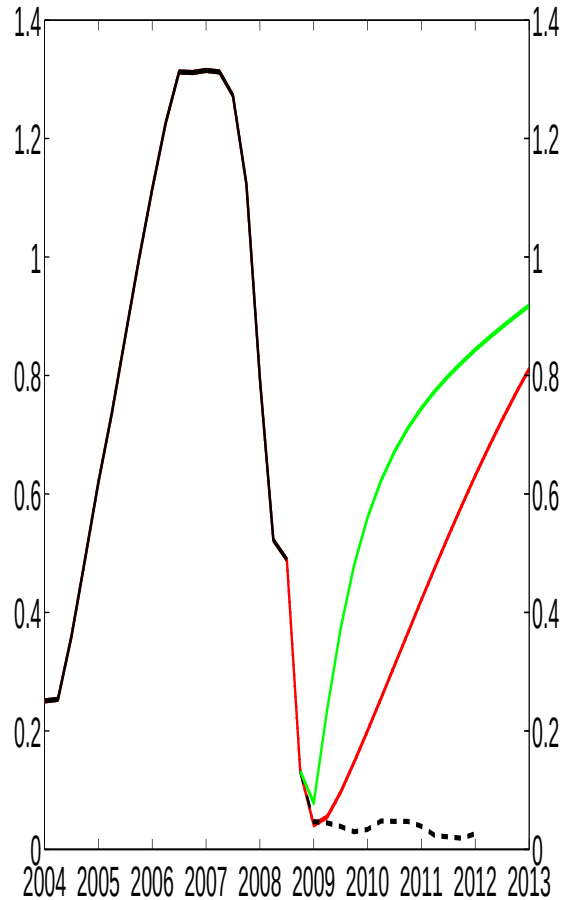
Output



Inflation

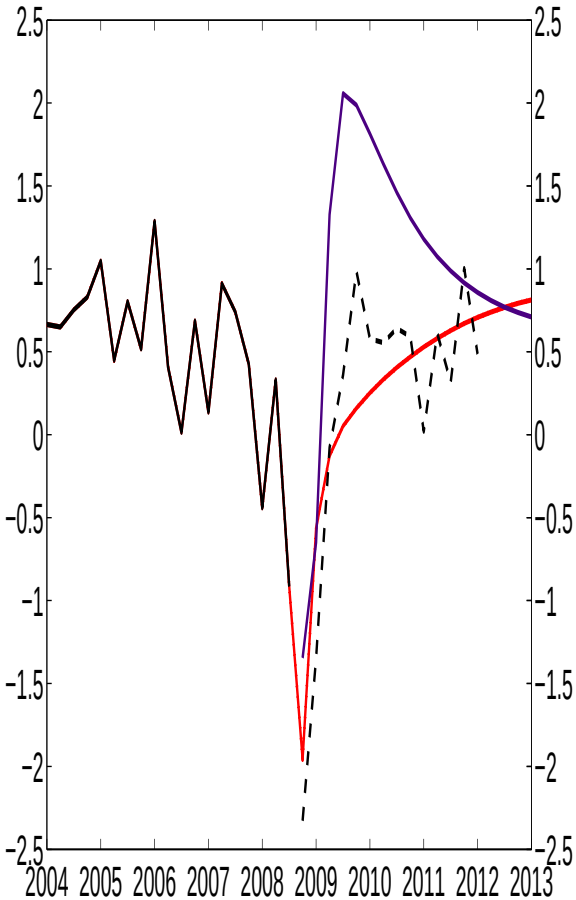


FFR

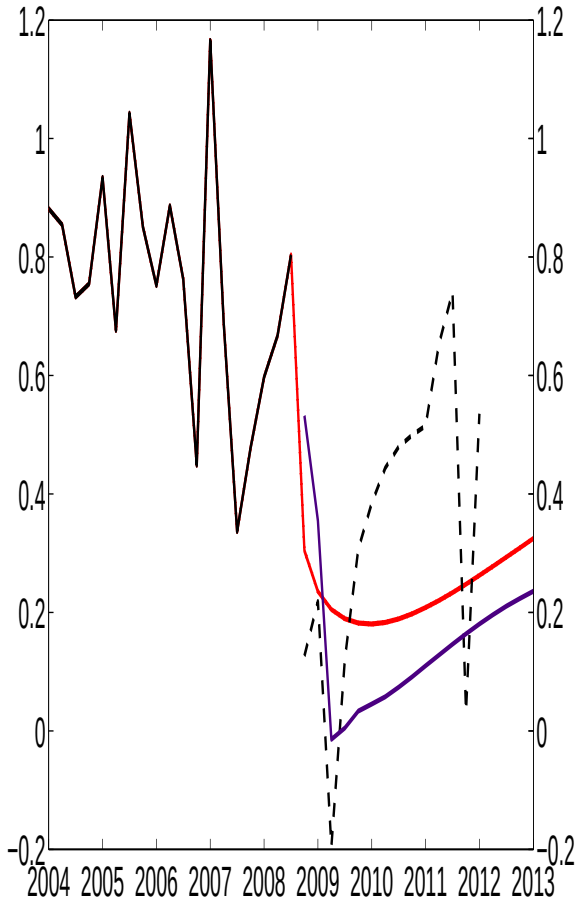


SW-FF vs VAR

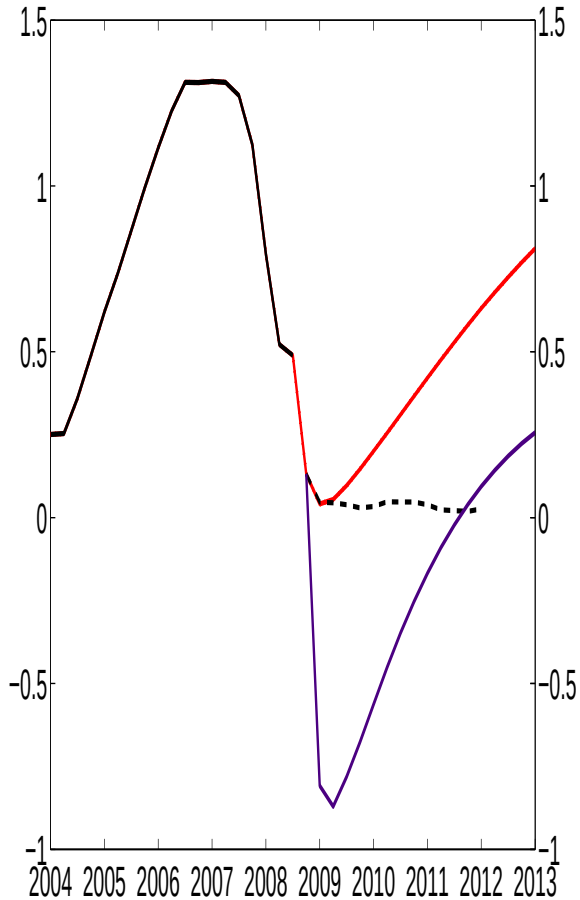
Output



Inflation

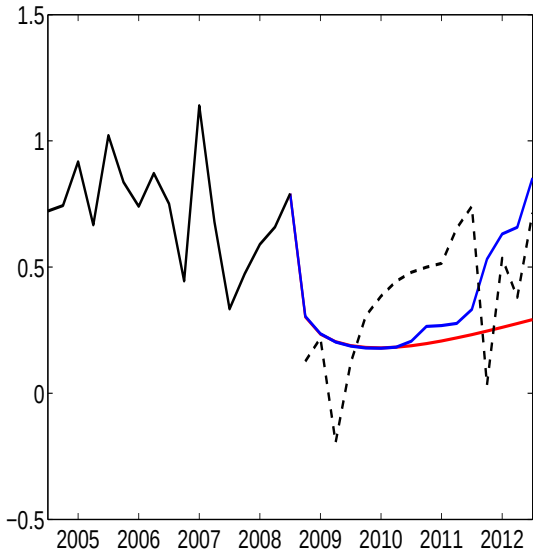


FFR

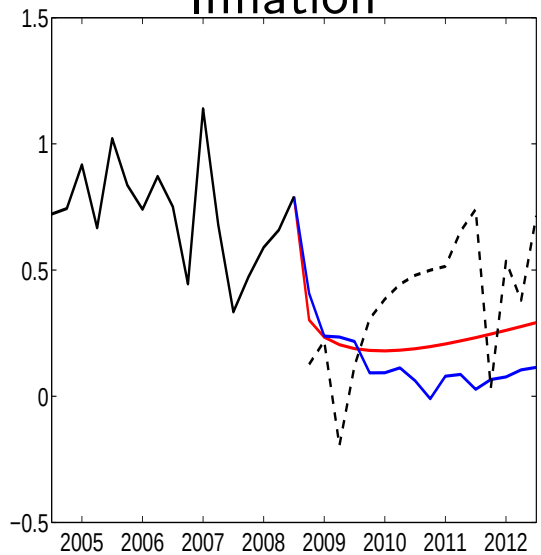


Forecasts Conditional on (Ex-Post) Smoothed Shocks

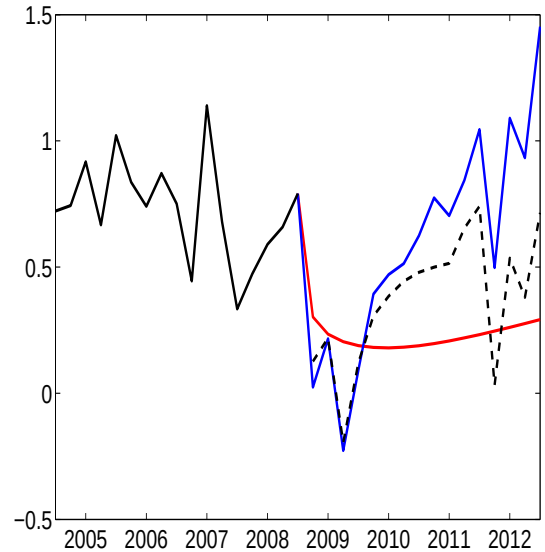
No Shocks



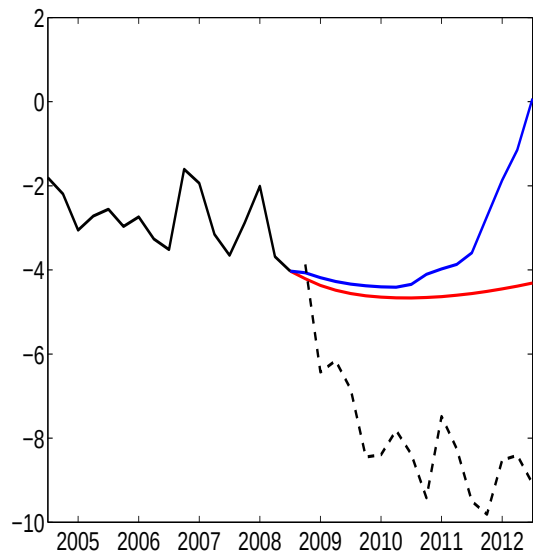
Non-Markup Shocks



Markup Shocks



Inflation



Marginal Cost