

Inflation in the Great Recession and New Keynesian Models

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Have NK DSGE Models Failed?

- Great Recession saw a very large drop in economic activity but only a modest decline in inflation
- Can New Keynesian models explain inflation in the Great Recession?

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 ...*

Have NK DSGE Models Failed?

- Can New Keynesian models explain inflation at all?

King and Watson (2012): ... *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.*

- Conclude that SW model can explain the behavior of inflation only when assuming large exogenous 'markup' shocks, which are difficult to interpret

This Paper

- ① Uses a standard DSGE model available *prior* to recent crisis
 - Model: Smets and Wouters (2007) extended to include financial frictions as in Bernanke, Gertler and Gilchrist (1999) and Christiano, Motto and Rostagno (2003+10)
 - ... estimated with data up to 2008-Q3 (pre-Lehman)
- ② Shows out-of-sample forecasts after 2008
- ③ Attempts to explain the joint behavior of inflation and output

Key Findings

- ① As soon as financial stress (credit spreads) jumps in fall of 2008, the model successfully predicts the broad contours of Great Recession, out of sample:
 - Sharp contraction in activity
 - Modest and protracted decline in inflation
- ② Why is the decline in inflation so small given the large output gap?
 - Prices are sticky \Rightarrow Inflation depends more on expected future mc than current mc
 - Even if current activity is sharply reduced, monetary policy stimulus raises expected future mc , so that inflation expectations remain anchored
- ③ In contrast to King-Watson: inflation is mainly explained by expected future marginal costs and not by exogenous markup shocks

Outline

- ① DSGE Model
 - Smets-Wouters model
 - Incorporating financial frictions
- ② DSGE Forecasts of the Great Recession
- ③ Inflation and Fundamental Inflation
- ④ Importance of Financial Frictions
- ⑤ Is Policy Irrelevant?
- ⑥ Conclusion

Baseline DSGE Model: SW (2007)

- Stochastic growth model + ...

real rigidities

investment adjustment costs

variable capital utilization

+ habit persistence

nominal rigidities

price stickiness (ζ_p)

wage stickiness (ζ_w)

partial indexation
to lagged inflation

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

Baseline DSGE Model: SW (2007)

- Measurement equation:

$$\begin{aligned} \text{Output growth} &= \Delta \text{LN}((\text{GDPC})/\text{LNSINDEX}) * 100 \\ \text{Consumption growth} &= \Delta \text{LN}((\text{PCEC}/\text{GDPDEF})/\text{LNSINDEX}) * 100 \\ \text{Investment growth} &= \Delta \text{LN}((\text{FPI}/\text{GDPDEF})/\text{LNSINDEX}) * 100 \\ \text{Real Wage growth} &= \Delta \text{LN}(\text{PRS85006103}/\text{GDPDEF}) * 100 \\ \text{Hours} &= \text{LN}((\text{PRS85006023} * \text{CE16OV}/100)/\text{LNSINDEX}) \\ &\quad * 100 \\ \text{Inflation} &= \text{LN}(\text{GDPDEF}/\text{GDPDEF}(-1)) * 100 \\ \text{FFR} &= \text{FEDERAL FUNDS RATE}/4 \end{aligned}$$

Sample starts in 1964:Q1

- Bayesian estimation
- Same prior on θ as SW

Incorporating 10-yr Inflation Expectations from Surveys

- SW forecasts inflation well but impose tight prior on π^*
- We use a loose prior on π^* and survey data:

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

- ... and change the model to be able to explain it:

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

where $\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \sigma_{\pi^*} \epsilon_{\pi^*,t}$.

Incorporating Financial Frictions (SW-FF)

- **SW**: arbitrage condition between return on capital and return on nominal bond:

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

where b_t is a shock (“spread” / “discount”).

- **SW-FF**: arbitrage condition is

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

where $\tilde{\sigma}_{\omega,t}$ is an additional shock, and n_t is an additional endogenous variable. and $\tilde{R}_t^k - R_t$ is treated as observed:

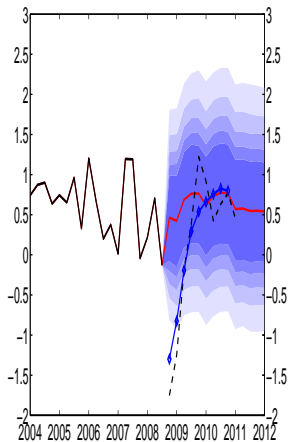
$$E_t[\tilde{R}_{t+1}^k - R_t] = (\text{Baa Corp. rate} - 10\text{y Treas. yield})/4$$

Outline

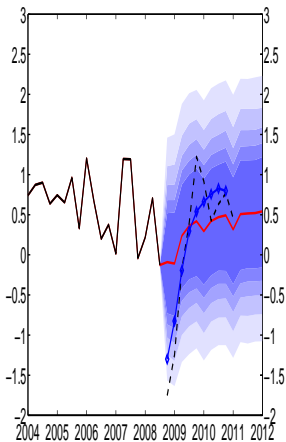
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Forecasting the Great Recession: 2008Q3 Data

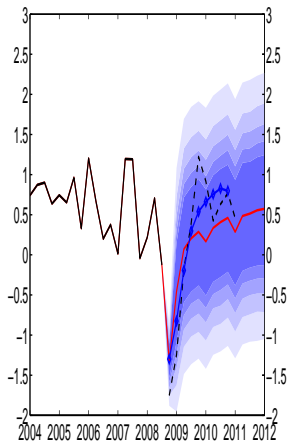
SW



SW-FF

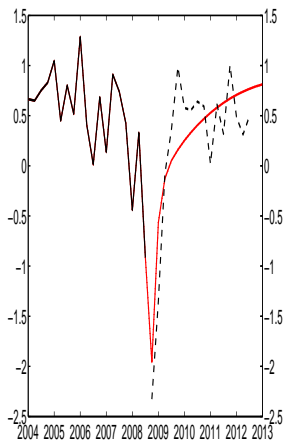


SW-FF + 08Q4 FFR,Spr

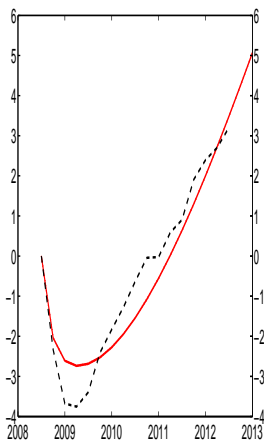


Output Growth, Cumulative Output and Output Gap (SW-FF)

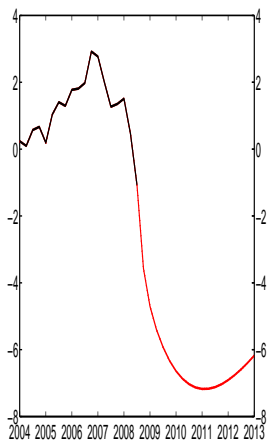
Output



Cumulative



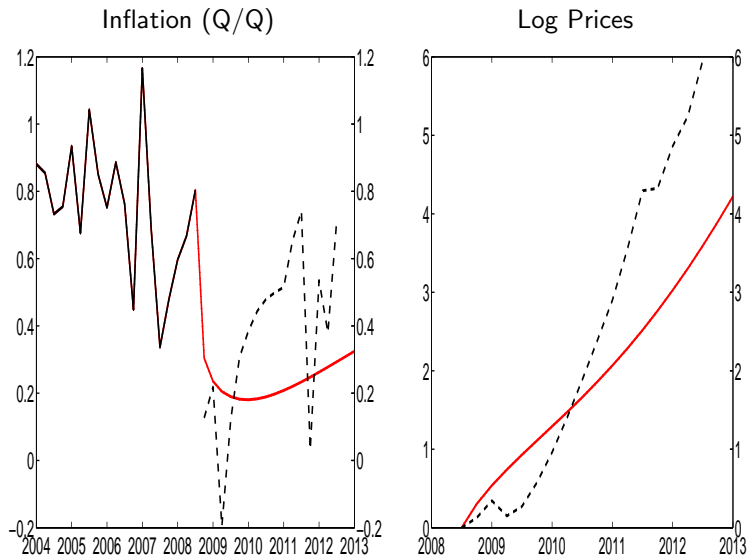
Gap



Forecasting the Great Recession

- 1 As soon as credit spread jump, in October 2008, DSGE (SW π -FF) forecasts severity and persistence of the great recession, and subsequent recovery
- 2 Model roughly captures cumulative output
- 3 Model forecasts a large and persistent output gap (output minus output under flex prices/wages and no mark-up shocks): about -7%
- 4 What happens to inflation?

Inflation



Forecasting the Great Recession and Inflation

- Model captures broad contour of inflation evolution
 - ... misses in 2009-2011 largely affected by energy prices
- Contrary to Hall (2011) and Ball-Mazumder (2011)'s conjecture: Phillips curve in model does not imply large negative inflation forecasts!
- But how can we reconcile large drop in activity and small drop in inflation? What happens to *marginal costs*?
 - Marginal costs = latent variable in the model; related but not equal to labor share

Marginal Costs

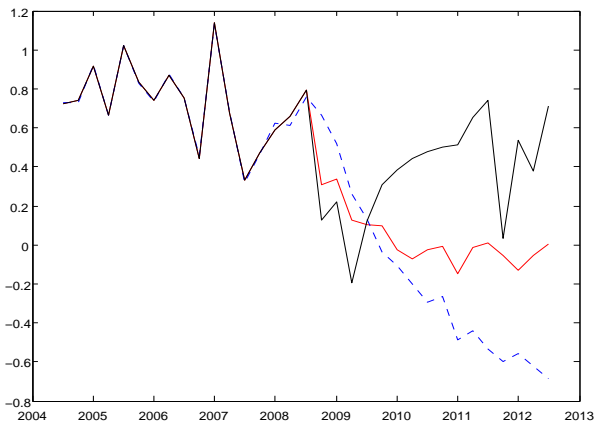


Inflation and Marginal Costs: Bad News?

Model fails to predict realized path of (smoothed) marginal cost, post-2008

- ① Had we correctly forecast the low values of marginal costs, would we have seen a large deflation?
- ② Are the forecasts of future marginal costs unreasonable?

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

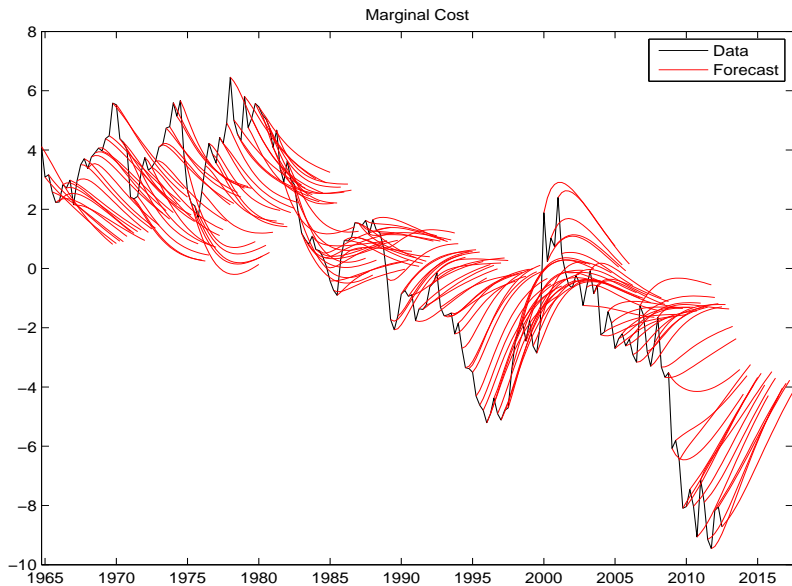


Notes: Forecast conditional on realized marginal cost (red) and Stock-Watson reduced-form Philips curve (blue dash).

What is going on?

- It is **not the current slack** in the economy, i.e., the current value of mc_t that matters for inflation, but the projected path for slack
 - The more marginal costs differ from steady state, the faster the projections revert to steady state \Rightarrow definition of “anchoring inflation expectations”
- In a backward-looking (e.g., Stock-Watson’s) Phillips curve that uses **current and lagged** unemployment rate, inflation would have been much lower.

Current and Expected Future mc_t



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- In a backward-looking (e.g., Stock-Watson’s) Phillips curve that uses **current and lagged** unemployment rate, inflation would have been much lower.
- Are the model’s implied mc forecasts bad? Not worse than those from reduced form models!

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Inflation and Fundamental Inflation

- NKPC implies:

$$\pi_t = (1 - \iota_p L)^{-1} \sum_{j=0}^{\infty} \bar{\beta}^j (1 + \iota_p \bar{\beta}) \mathbf{E}_t[\kappa \hat{m} c_{t+j} + \hat{\lambda}_{f,t+j}]$$

or

$$\pi_t = \tilde{\pi}_t + \Lambda_{f,t}$$

- Fundamental inflation:

$$\tilde{\pi}_t = \kappa (1 - \iota_p L)^{-1} (1 + \iota_p \bar{\beta}) \underbrace{\sum_{j=0}^{\infty} \bar{\beta}^j \mathbf{E}_t[m c_{t+j}]}_{\text{PDV marginal costs}}$$

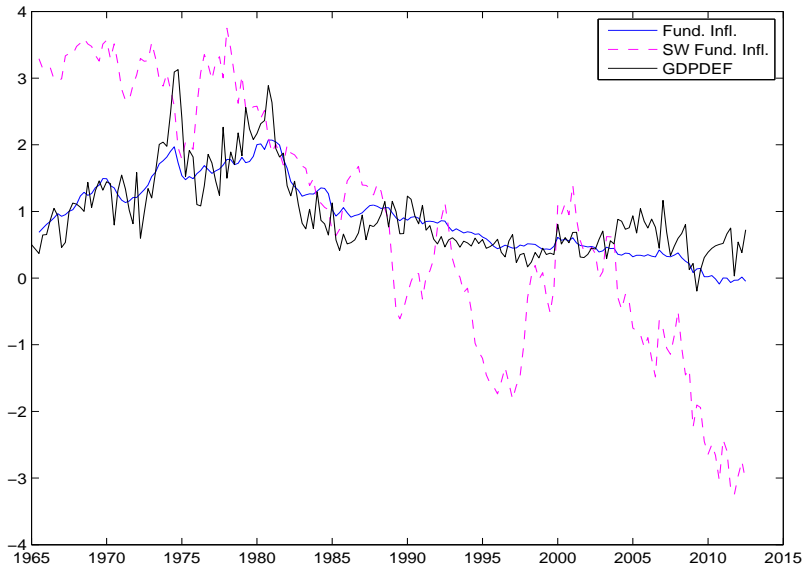
- PDV. markup shocks:

$$\Lambda_{f,t} = (1 - \iota_p L)^{-1} (1 + \iota_p \bar{\beta}) \sum_{j=0}^{\infty} \bar{\beta}^j \mathbf{E}_t[\hat{\lambda}_{f,t+j}]$$

King and Watson (2012)

- Decompose inflation into fundamental inflation and the residual $\Lambda_{f,t}$, using the SW model
 - Find that fundamental inflation behaves very differently from actual inflation; i.e., fluctuations in actual inflation are largely due to “markup” shocks
- ⇒ SW model fails to explain the behavior of inflation!
- KW/SW fundamental inflation falls dramatically since 2007: Based it inflation would be around -12% annualized since 2007, in the absence of markup shocks

Inflation and Fundamental Inflation



Two Questions

- ① Why the difference between $\tilde{\pi}_t$ in SW and SW-FF model?
 - Answer: Relatively low price rigidities in SW model imply that
fundamental inflation \sim current marginal cost \neq inflation
- ② Why does the SW-FF model have higher price rigidities?
 - Answer: Because demand shocks are more important – since **spreads** are observable.

Price Rigidities and Fundamental Inflation

- Key difference: Price rigidities (ζ_p) stronger in SW-FF (0.86) than in SW model (0.65)

$$\tilde{\pi}_t = \kappa (1 - \iota_p L)^{-1} (1 + \iota_p \bar{\beta}) \sum_{j=0}^{\infty} \bar{\beta}^j E_t[mc_{t+j}]$$

- 1 Fundamental inflation responds less to a given movement in expected future mc_t (lower NKPC slope κ)
- 2 With low price rigidities

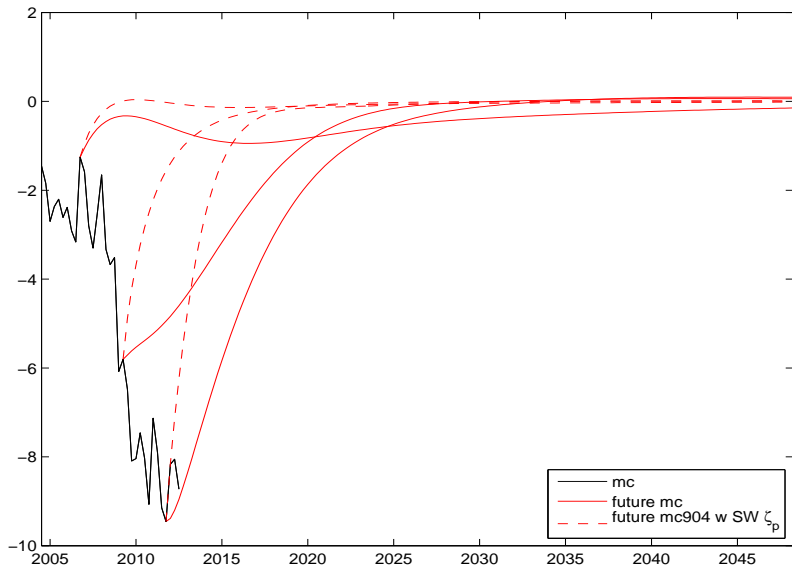
$$\sum_{j=0}^{\infty} \bar{\beta}^j E_t[mc_{t+j}] \sim \text{current } mc_t$$

Since

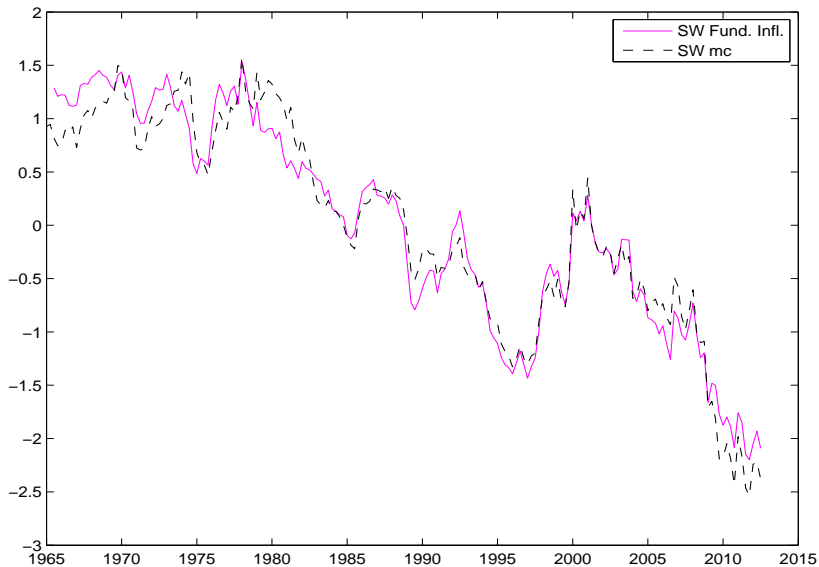
current $mc_t \neq$ inflation

\Rightarrow need markup shocks to explain inflation

Price Rigidities and Forecasts of Marginal Costs



SW Fundamental Inflation vs Marginal Costs



Both SW fundamental inflation and marginal costs are normalized.

Outline

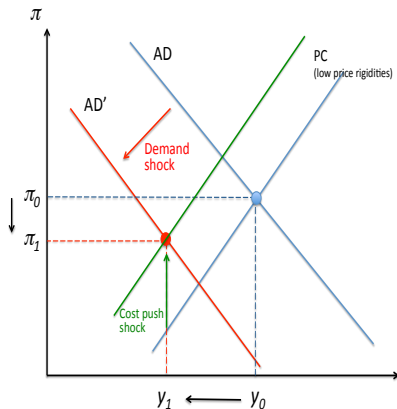
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Why Does the Financial Frictions Model Have Higher Price Rigidities?

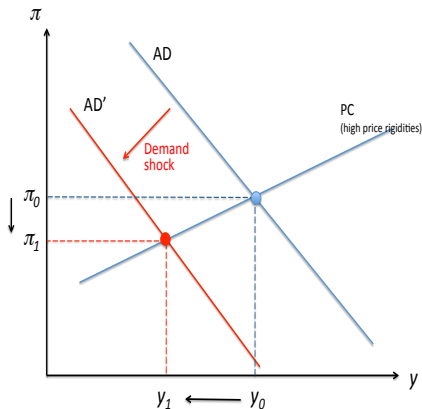
- ① Demand shocks are more important in the SW-FF model relative to SW – because spreads are used as an observable (direct measure of demand shocks)
- ② To explain jointly inflation and output data in presence of demand shocks, must have either:
 - flat NKPC (high ζ_p), or
 - markup shock every time there is a spread shock... but estimation does not like correlated shocks!

Demand Shocks and the Slope of the Phillips Curve

Low rigidities



High rigidities



The Evidence

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

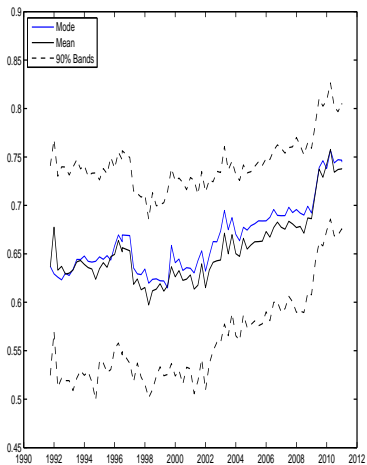
$$\mathbb{E}_t[\tilde{R}_{t+1}^k] - R_t = b_t + \tilde{\sigma}_{\omega,t}$$

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

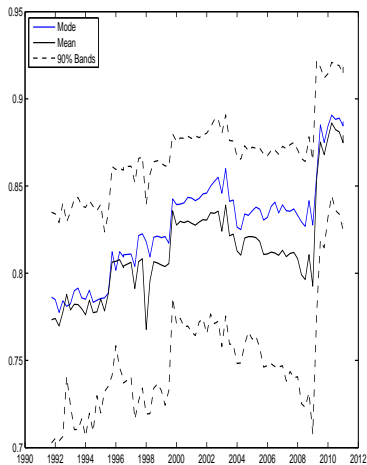
- SW model: $\zeta_p = 0.65$
 - SW-FF model: $\zeta_p = 0.86$
- 2 If we decompose inflation into 1) a component due to mark-up shocks and 2) a component due to demand shocks (discount rate and MEI shocks) we find that the correlation is -0.37 for SW, and 0.18 for SW-FF.
 - 3 Estimates of price rigidities jump up (in both SW-FF and SW) after the crisis.

ζ_p : Recursive Estimation

SW



SW-FF



Outline

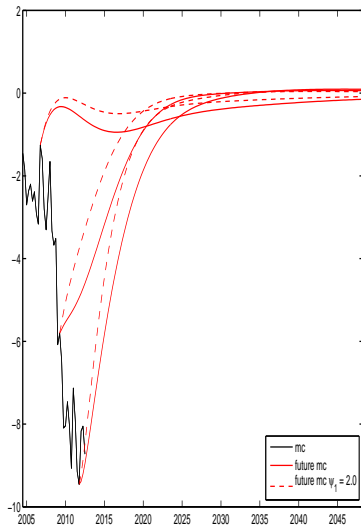
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Is Policy Irrelevant?

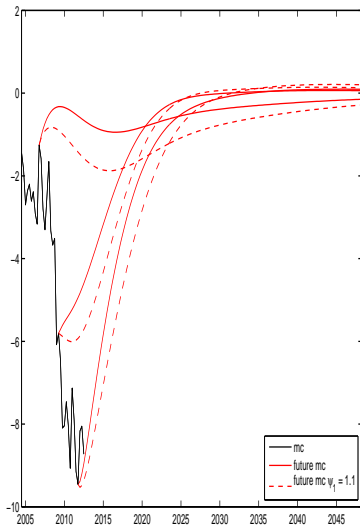
- The slope of the NKPC κ – which determines the extent to which inflation depends on activity – is smaller in SW-FF due to higher estimated price rigidity
 - Does a flatter PC mean that 1) inflation is nearly exogenous (as in Hall, 2011)? And hence that 2) monetary policy loses its ability to stabilize 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.

Forecasts of mc_t with Different Policy Coefficients

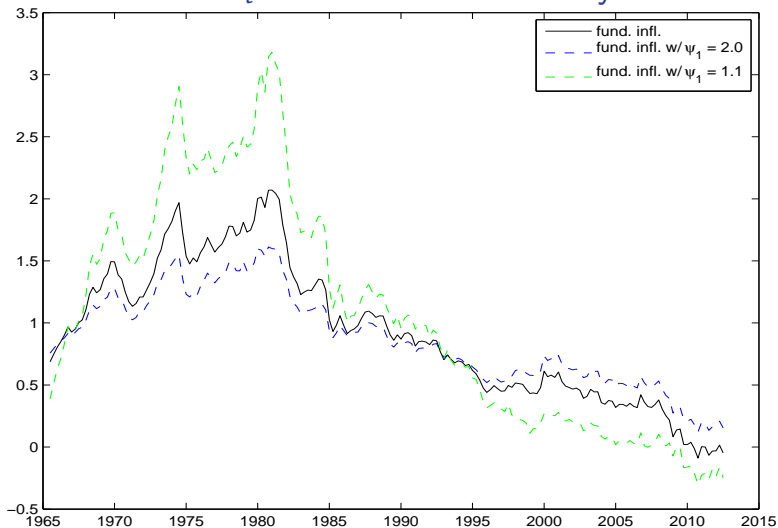
$\psi_1=2$



$\psi_1=1.1$



Counterfactual $\tilde{\pi}_t$'s with Different Policy Coefficients



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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?
 - Evidence that prices are sticky
 - Inflation depends more on expected future mc than current mc
⇒ even if current activity is sharply reduced, monetary policy stimulus raises expected future mc , so that inflation expectations remain anchored

Conclusion (cont.)

- ③ With higher price rigidities (in SW-FF model) inflation is mainly explained by expected future mc and not by exogenous markup shocks
 - Contrasts with King-Watson: with more flexible price (SW model), markup shocks are key drivers of inflation

- ④ Why does the financial frictions model have higher price stickiness?
 - Because observing spreads makes demand shocks more important (spread movements shift the AD curve) → make a steep NKPC curve counterfactual.

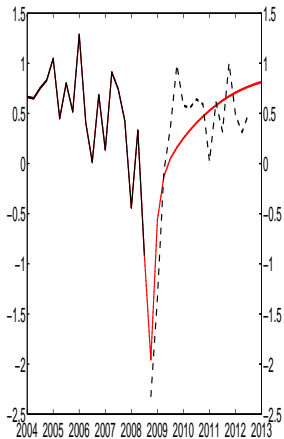
- ⑤ Does a flatter PC mean that monetary policy loses its ability to stabilize inflation?
 - No

EXTRA SLIDES

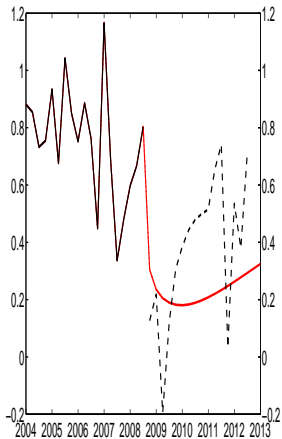
- ...

DSGE Forecasts of the Great Recession

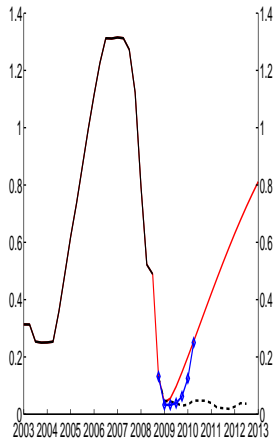
Output



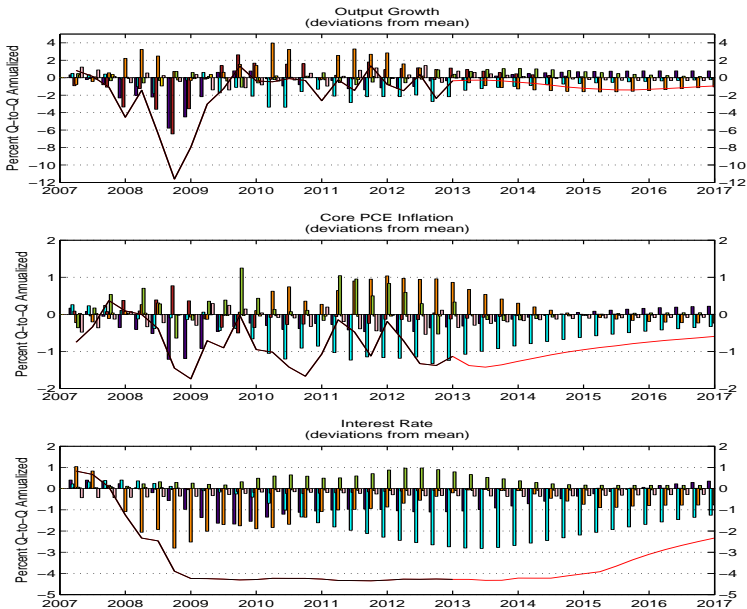
Inflation



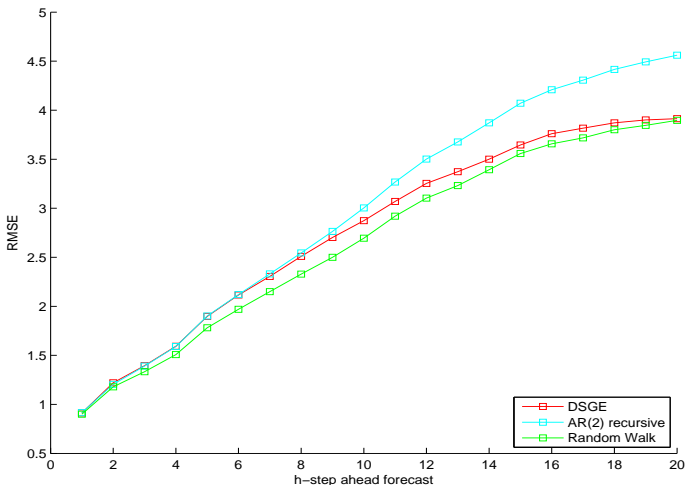
FFR



Contribution of Policy (orange bars); FRBNY-DSGE model

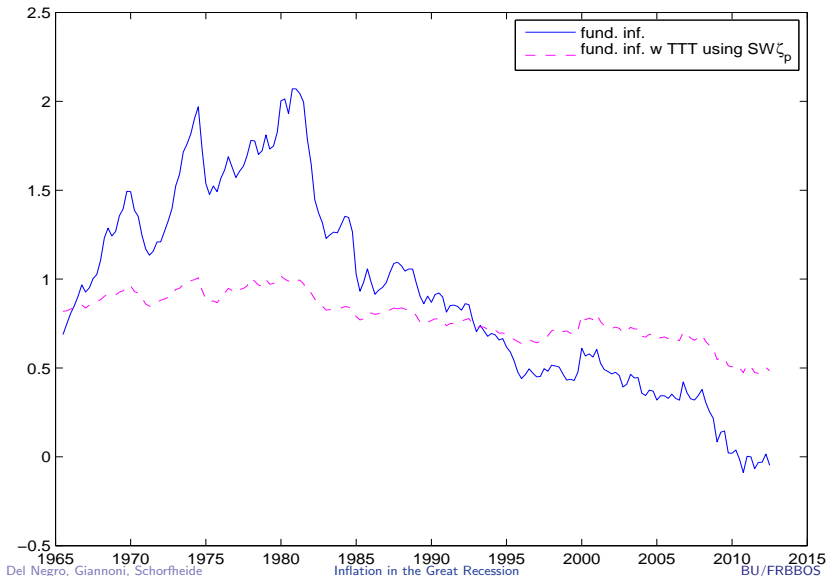


Are DSGE Forecasts of mc Unreasonable?



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.

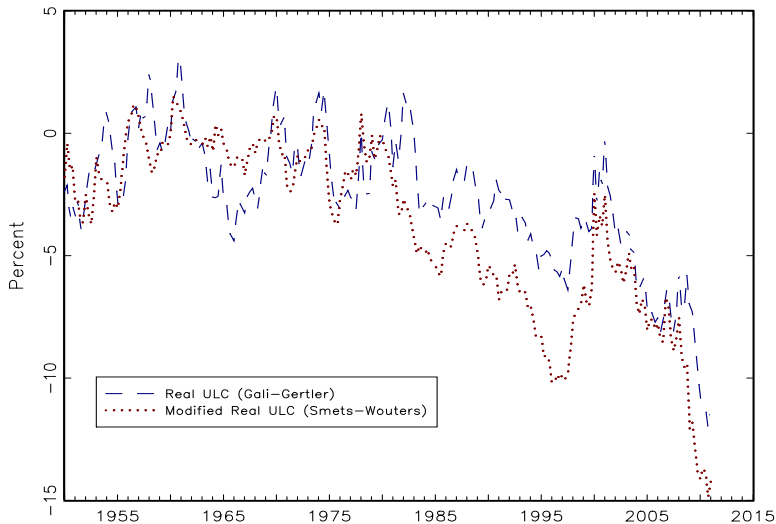
Our Fundamental Inflation vs Fundamental Inflation using SW Price Rigidities in the Evolution of Marginal Costs



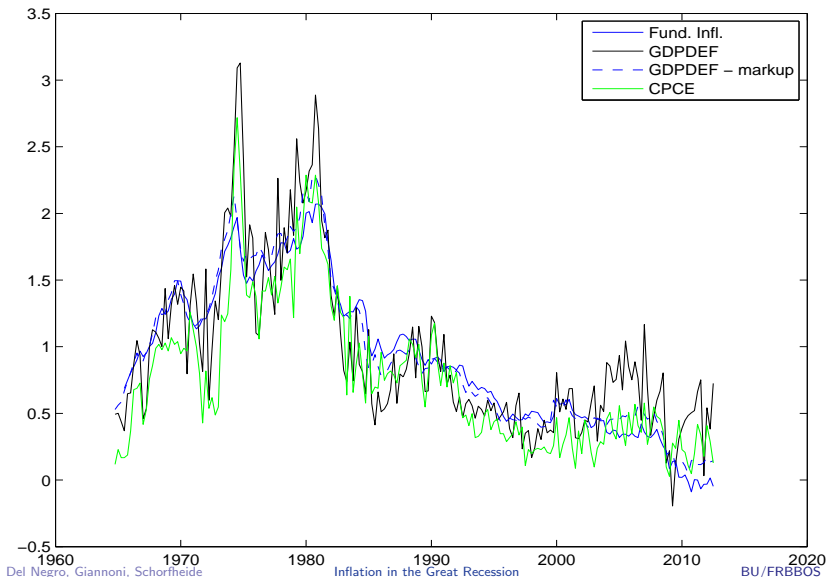
Movements in Fundamental Inflation $\tilde{\pi}_t$ Attributable to Mark-up Shocks



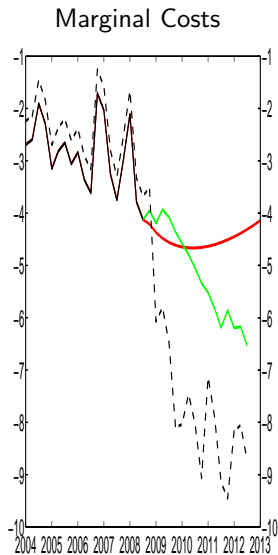
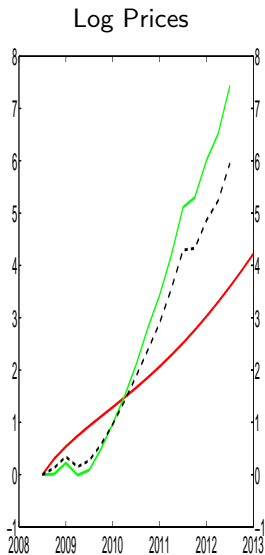
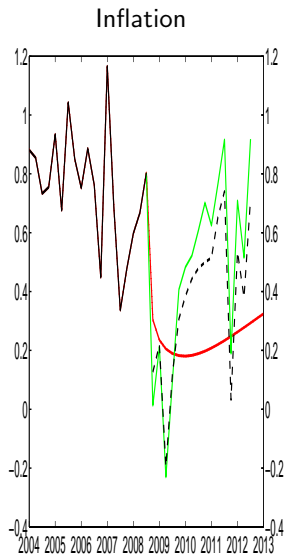
KW: Marginal costs



Inflation, Fundamental Inflation, Counterfactual Inflation without Markup Shocks, and Core Inflation



Effect of Markup Shocks

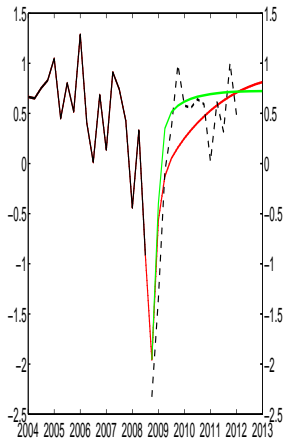


Observables or frictions?

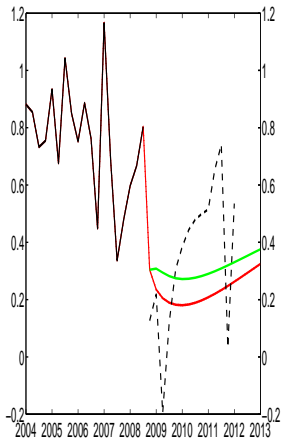
- SW π -FF's forecasts: Do the financial frictions/cross-equation restrictions play any role, or is it all in the new observable (spreads)?
- Two exercises:
 - ① Take states from SW+FF and stick them into plain SW transmission
 - ② Estimate a Minnesota prior VAR using the same variables as SW-FF up to 2008Q3 (level), and condition on 2008Q4 interest rates and spreads

SW π -FF vs SW π

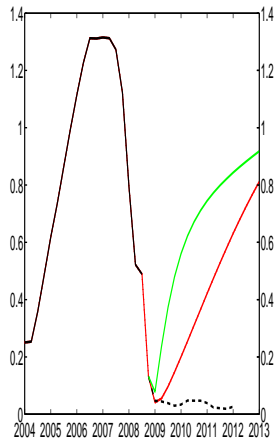
Output



Inflation

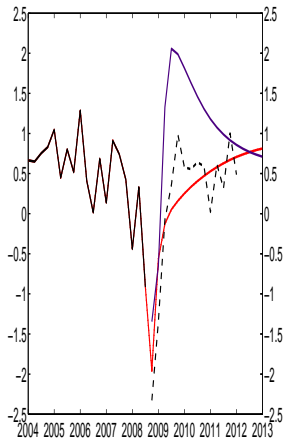


FFR

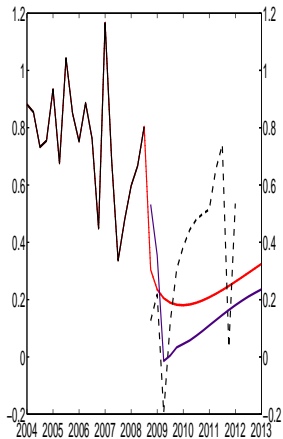


SW π -FF vs VAR

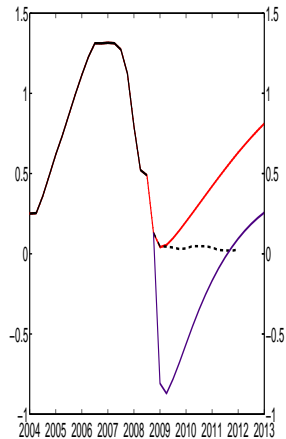
Output



Inflation



FFR



What if the Fed had done something different?

- The estimated rule in SW is:

$$R_t = .675 \times R_{t-1} + (1 - .675)(1.37 \times (\pi_t - \pi_t^*) + .025 \times (y_t - y_t^f)) + .250 \times \Delta(y_t - y_t^f) + r_t^m,$$

This rule places a small weight on the **level** of the output gap.

- What if the Fed had targeted labor market conditions (which is arguably doing now) from the beginning:

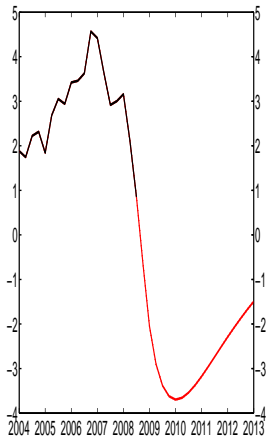
$$R_t = .675 \times R_{t-1} + (1 - .675)(1.37 \times (\pi_t - \pi_t^*) + .1 \times L_t) + r_t^m,$$

where L_t is (per capita) hours in deviation from st. st.

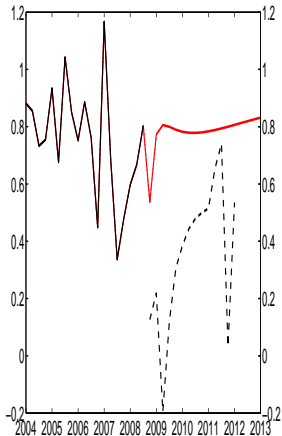
- This model does predict the severity of the recession (and the sluggish recovery) → This puts it in a position to give an interesting answer to this question.

Alternative rule (response to labor market conditions)

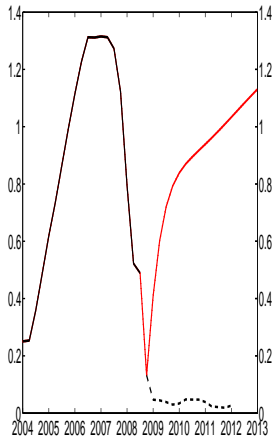
Output Gap



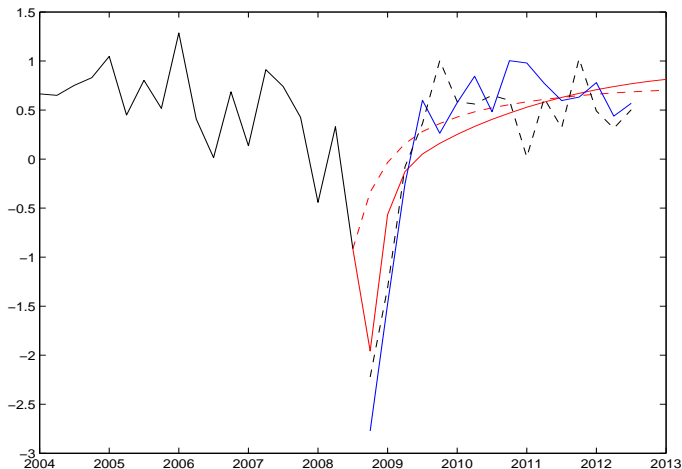
Inflation



FFR

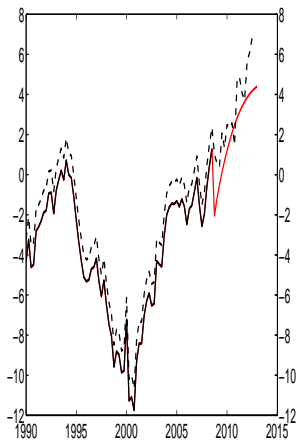


DSGE Output Forecast of the Great Recession: Conditional (*red*), Unconditional (*red dashed*), Unconditional + *ex post* Demand Shocks (*blue*)



Entrepreneurs' Net Worth and Leverage

Entrepreneurs' Net Worth



Leverage

