What Helps Forecast U.S. Inflation? — Mind the Gap!

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September 18, 2015 Workshop on Macroeconomics - Koç University

The views are those of the authors and not the Federal Reserve Bank of Dallas or the Federal Reserve System.

Introduction

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  - An open economy Phillips curve can be more relavant in forecasting US inflation

- This paper tests the global slack hypothesis theoretically and empirically—and finds support for the global slack hypothesis
- Weak empirical results may be explained by imperfect measures of slack, it is important to find alternative measures for forecasting

Literature

- There is evidence that it has become increasingly difficult to beat naïve forecasts with a traditional (closed-economy) Phillips curve-based forecast
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  - Atkeson and Ohanian (2001), Stock and Watson (2007, 2008)
- Does global slack help forecast US inflation? The evidence on 'global slack hypothesis' is mixed
  - Borio and Filardo (2007), Binyamini and Razin (2007), Martínez-García and Wynne (2010), Ihrig et al. (2007), Milani (2010, 1012)
- In theory, the open economy Phillips curve might still be valid. It is hard to find reliable measures of output gap

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- Consider an open-economy Phillips curve-based forecasting model with (i) domestic and foreign slack (ii) domestic slack and TOT/RER gap (iii) world money supply growth

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- Open-economy Phillips curve-based model for forecasting is able to generate more accurate forecasts than naïve models (under simulated forecasts)

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- Consider an open-economy Phillips curve-based forecasting model with (i) domestic and foreign slack (ii) domestic slack and TOT/RER gap (iii) world money supply growth
- Open-economy Phillips curve-based model for forecasting is able to generate more accurate forecasts than naïve models (under simulated forecasts)
- The model captures the effects of three channels that might be important for forecasting outcomes as suggested by the literature
  - Evaluate good luck, changes in the conduct of monetary policy, and globalization
  - Good luck and monetary policy remain important channels in a model that accounts explicitly for the role of globalization

Introduction

Empirical findings

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Empirical findings

- Empirical results with various global slack measures are mixed—consistent with the empirical literature
  - We suggest this is largely due to measurement problems of global slack
  - We circumvent these measurement problems and bring the theoretical and empirical results closer using proxies for global slack
    - TOT, REER, global money supply growth, global credit growth

Outline

- Introduction and motivation
- One possible interpretation through the lens of the open-economy NK model
  - Key theoretical results on forecasting
  - Structural changes and time-variation in forecasting accuracy (will skip this today)
- Empirical findings on forecasting accuracy (with Phillips curve-based forecasts)
- Concluding remarks

Outline of the model

- 2-country NK model: Home and Foreign
- The model consists of three basic structural equations for each country and two fundamental exogenous shocks
- The model is based on Martínez-García and Wynne (2010)—a variant of Clarida, Galí, and Gertler (2002) model
    - Augmented to allow for a time-varying inflation target around the zero inflation steady state
    - Price stickiness as in Calvo (1983)
    - Producer currency pricing

Outline of the model

- Aggregate demand

$$\gamma\left(1-2\xi\right)\left(\mathbb{E}_t\left[\widehat{x}_{t+1}\right]-\widehat{x}_t\right)\approx\left(\left(1-2\xi\right)+\Gamma\right)\left[\widehat{r}_t-\widehat{\bar{r}}_t\right]-\Gamma\left[\widehat{r}_t^*-\widehat{\bar{r}}_t^*\right]$$

where

$$\widehat{r}_t\equiv\hat{\imath}_t-\mathbb{E}_t\left[\hat{\pi}_{t+1}\right]$$

- Aggregate supply (Phillips curve)

$$\begin{aligned}\hat{\pi}_t-\bar{\pi}_t \quad &\approx \quad \beta\mathbb{E}_t[\hat{\pi}_{t+1}-\bar{\pi}_{t+1}]+\ldots\\ &\Phi\left[(\varphi\xi+\gamma\Theta)\hat{x}_t+((1-\xi)\varphi+(1-\Theta)\gamma)\hat{x}_t^*\right]\end{aligned}$$

Outline of the model

- Monetary policy rule in the spirit of Taylor (1993)

$$\hat{\imath}_t \approx \tilde{\pi}_t + \left[\Psi_\pi(\hat{\pi}_t - \tilde{\pi}_t) + \Psi_x \hat{x}_t\right] + v_t^m$$

where

$$\tilde{\pi}_t = \tilde{\pi}_{t-1} + \widetilde{\varepsilon}_t$$

- Domestic money growth

$$\Delta\hat{m}_t \approx \Delta\hat{y}_t - \eta\Delta\hat{\imath}_t + \hat{\pi}_t$$

- Natural interest rate

$$\widehat{\bar{r}}_t \approx \gamma\left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\left(\Theta\Lambda + (1-\Theta)(1-\Lambda)\right) E_t\left[\Delta\widehat{a}_{t+1}\right] + \ldots \right.$$
$$\left. \left(\Theta(1-\Lambda) + (1-\Theta)\Lambda\right) E_t\left[\Delta\widehat{a}^*_{t+1}\right]\right].$$

Outline of the model

- The law of motion for productivity shocks and monetary shocks is governed by

$$\begin{pmatrix} \hat{a}_t \\ \hat{a}_t^* \end{pmatrix} \approx \begin{pmatrix} \delta_a & \delta_{a,a^*} \\ \delta_{a,a^*} & \delta_a \end{pmatrix} \begin{pmatrix} \hat{a}_{t-1} \\ \hat{a}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \hat{\varepsilon}_t^a \\ \hat{\varepsilon}_t^{a*} \end{pmatrix}$$

$$\begin{pmatrix} \hat{\varepsilon}_t^a \\ \hat{\varepsilon}_t^{a*} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_a^2 & \rho_{a,a^*} \\ \rho_{a,a^*} & \sigma_a^2 \end{pmatrix} \right)$$

$$\begin{pmatrix} \upsilon_t^m \\ \upsilon_t^{m*} \end{pmatrix} \approx \begin{pmatrix} \delta_m & 0 \\ 0 & \delta_m \end{pmatrix} \begin{pmatrix} \upsilon_{t-1}^m \\ \upsilon_{t-1}^{m*} \end{pmatrix} + \begin{pmatrix} \hat{\varepsilon}_t^m \\ \hat{\varepsilon}_t^{m*} \end{pmatrix}$$

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Key theoretical results

1. Extending the proposition in Woodford (2008): No variables other than domestic and foreign slack should help improve the forecast of changes in inflation. The forecasting relationship for domestic inflation implied by the open economy NK model can be expressed as

$$
\begin{aligned}
\mathbb{E}_t(\hat{\pi}_{t+j}) &= \widehat{\pi}_t + \frac{\lambda^W}{\eta^W}\hat{x}_t^W + \frac{1}{2}\frac{\lambda^R}{\eta^R}\hat{x}_t^R \\
\hat{x}_t^W &\equiv \frac{1}{2}\hat{x}_t + \frac{1}{2}\hat{x}_t^* \\
\hat{x}_t^R &\equiv \hat{x}_t - \hat{x}_t^*
\end{aligned}
$$

Key theoretical results

2. Domestic terms of trade gap $\hat{z}_t$ (and also real exchange rate gap) is proportional to the relative slack (Martínez-García and Wynne(2010)),

$$\hat{z}_t \approx \kappa \hat{x}_t^R$$

3. World real money gap $\hat{m}_t^{g,W}$ is proportional to the global slack,

$$\hat{m}_t^{g,W} \approx \chi \hat{x}_t^W$$

Empirical analysis

We test the predictive ability of

- Global output gap measures
- Proxies suggested by the open-economy NK model (TOT, REER, money, and credit)
- Domestic measures (slack, money, and credit)

Data

- US inflation (annualized log differences of quarterly price series): CPI, Core CPI, PCE deflator, Core PCE, GDP deflator, PPI
- Forecasting variables - Slack:
  - Domestic slack: CBO, FRBD, IMF, OECD, HP-filtered US real GDP
  - Global slack: FRBD G7, FRBD G28, IMF advanced, OECD G7, OECD Total
- Forecasting variables - Terms of trade:
  - Terms of trade gap: Terms of trade (HP-filtered, first differenced), Terms of trade ex. oil (HP-filtered, first differenced)

Data

- Forecasting variables - Real effective exchange rate:
  - RER gap: REER (HP-filtered, first differenced),
- Forecasting variables - Money growth:
  - Domestic money supply growth (%): US (M2)
  - Global money supply growth (%, G7 average): Canada (M3), Germany, Italy and Japan (M2), France (M2 & M3), UK (M4), US (M2)
- Forecasting variables - Credit growth (BIS):
  - Domestic credit growth (%, Non-financial credit from all sectors to the private sector)
  - Global credit growth (%, G7 average)

Forecast models

- We introduce three models to forecast US inflation

Model 1: Reduced-form Phillips curve model. $\hat{x}_t$: domestic slack, domestic money; global slack, global money, global credit growth

$$\hat{\pi}^h_{t+h|t} = a_1 + \lambda_{11}(L)\hat{\pi}_t + \lambda_{12}(L)\hat{x}_t + \hat{\epsilon}_{1,t+h}$$

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Model 2: Reduced-form open-economy Phillips curve model. $\hat{x}_t$ and $\hat{z}_t$: domestic and foreign slack, domestic slack and TOT/RER gap

$$\hat{\pi}^h_{t+h|t} = a_1 + \lambda_{21}(L)\hat{\pi}_t + \lambda_{22}(L)\hat{x}_t + \lambda_{23}(L)\hat{z}_t + \hat{\epsilon}_{2,t+h}$$

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Model 3: Univariate autoregressive (AR) process

$$\hat{\pi}^h_{t+h|t} = a_3 + \lambda_3(L)\hat{\pi}_t + \hat{\epsilon}_{3,t+h}$$

Forecast evaluation

- We use a recursive, pseudo out-of-sample forecasting method
  - i.e. at any given date t, we forecast inflation at date $t+h$ using all available data up to date t
- Let T_0 denote the starting date of the data series and T_1 denote the end. The estimation sample starts at T_0 and ends in t_0.
- *MSFE* of model j at horizon h and from date t_0 to $T_1 - h$

$$MSFE_j(h) = \frac{1}{T_1 - h - t_0 + 1} \sum_{t=t_0}^{T_1-h} \hat{\hat{\epsilon}}^2_{j,t+h}$$

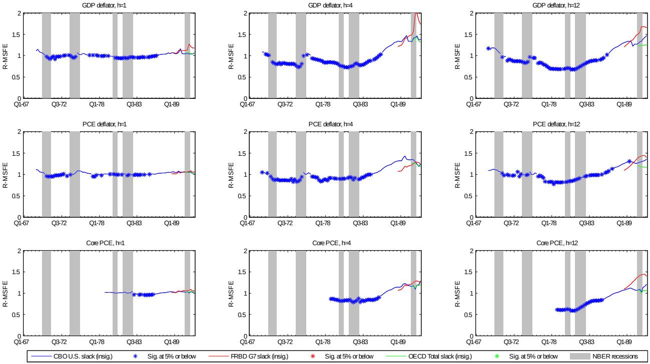
Inference and samples

- We define relative *MSFEs* as $MSFE_{EM}\,/\,MSFE_{AR}$
  - $H_0 : MSFE_{EM}\,/\,MSFE_{AR} \geq 1 \quad H_1 : MSFE_{EM}\,/\,MSFE_{AR} < 1$
- Inference is based on a one-sided F-test against critical values based on a bootstrap algorithm described in Clark and McCracken (2005)
  - We use the procedure described by Clark and McCracken (2005) to test Model 2 (against Model 1)
  - Extend the procedure in Clark and McCracken (2005) to test Model 3 (against Model 1)

Stylized facts: How did forecast accuracy evolve over time?

- We perform rolling forecasts (Model 1, 2, 3) for the following sets of variables:
  - Domestic slack, global slack
  - Terms of trade and terms of trade ex. oil
  - Real effective exchange rate
  - Domestic and global money growth
  - Domestic and global credit growth
- Estimation and forecast samples include 80 quarters each
- We start from the earliest quarter available in the dataset

Stylized facts: US CBO slack vs. Global slack (FRBD G7 and OECD Total)



Absolute MSFE of AR process

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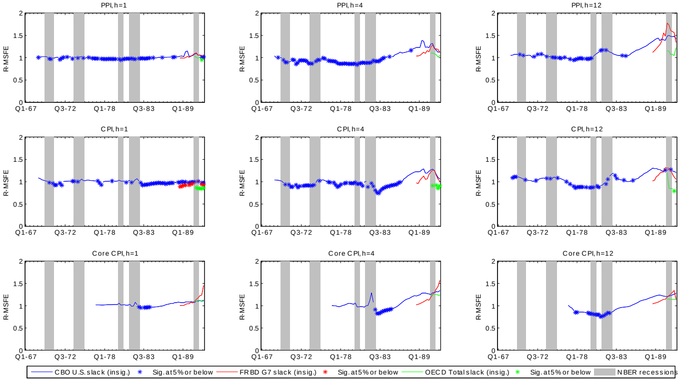
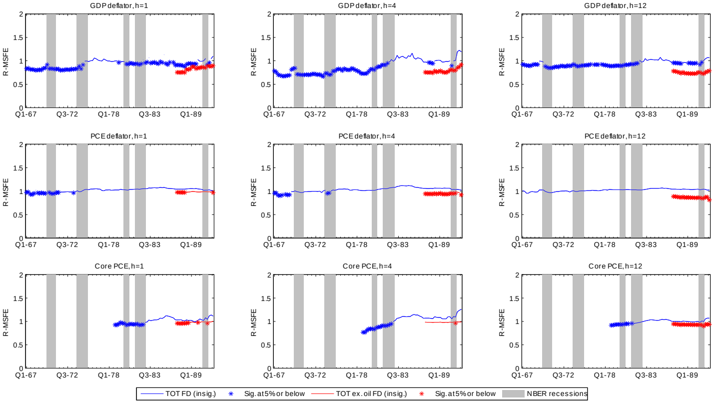


Absolute MSFE of AR process

Stylized facts: ToT vs. ToT ex. oil (FD)



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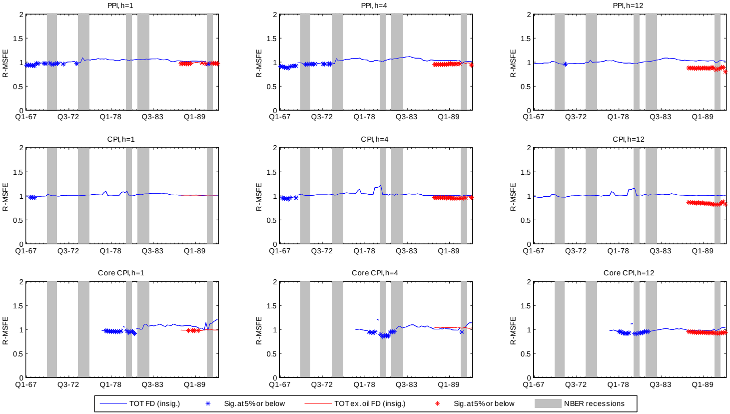
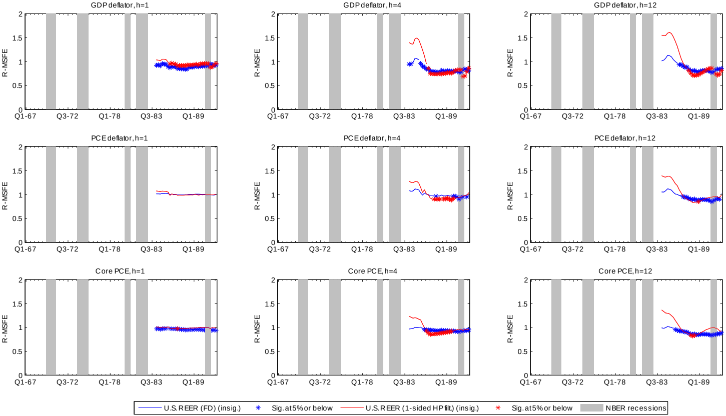
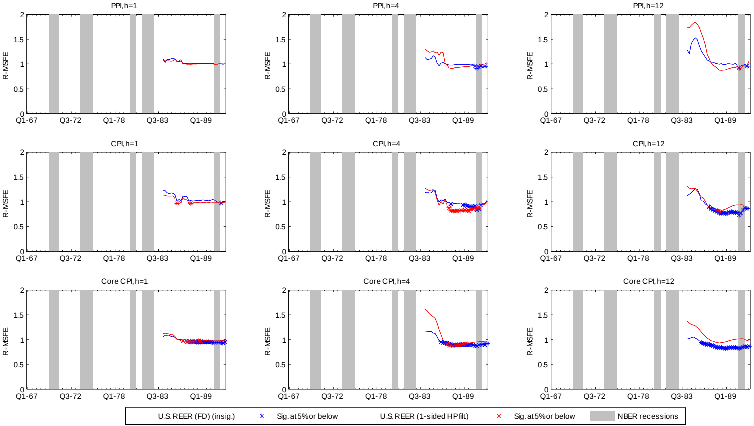


ToT (HP1)

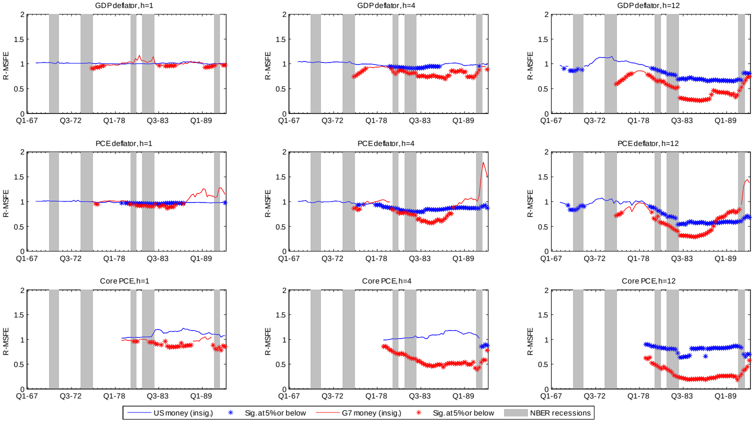
Stylized facts: REER (FD) vs. REER (HP1)



Stylized facts: REER (FD) vs. REER (HP1)



Stylized facts: US vs. G7 money growth



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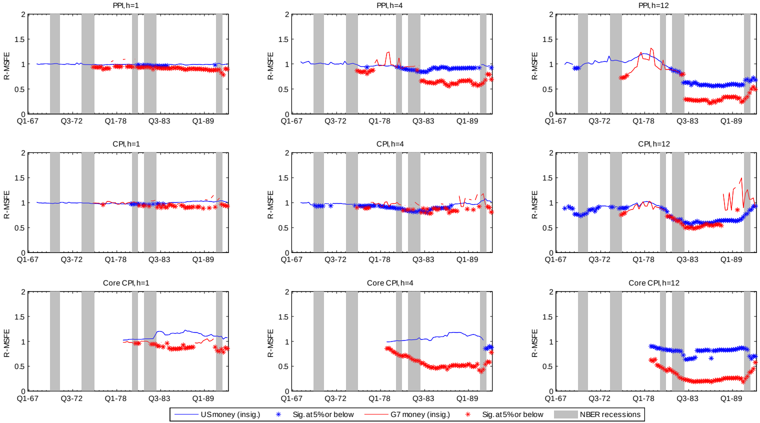
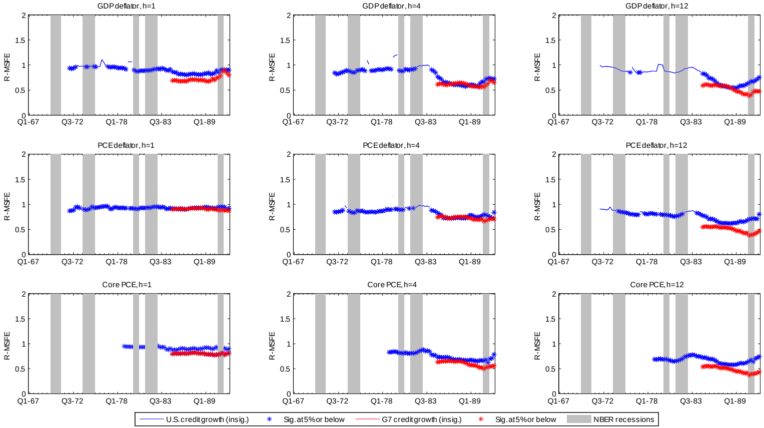
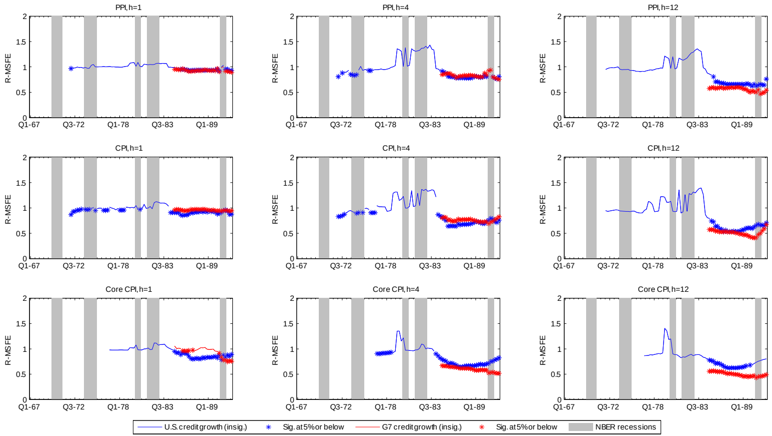


Stylized facts: US vs. G7 credit growth



Stylized facts: US vs. G7 credit growth

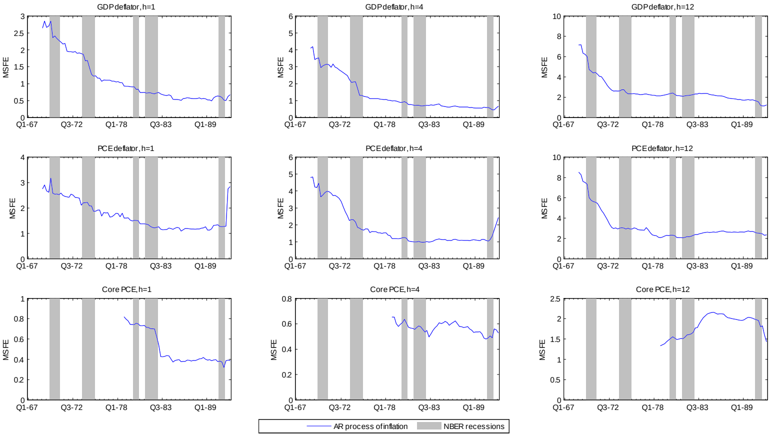


Conclusions

- The paper provides empirical and theoretical support for global slack hypothesis
- Open economy Phillips curves help forecast inflation, but we need reliable global economic measures to proxy global slack—terms of trade, REER, global money and credit growth can be used
- Global macroeconomic measures, in general, help forecast inflation better than their domestic counterparts

Thank you!

Absolute MSFEs of AR processes of inflation



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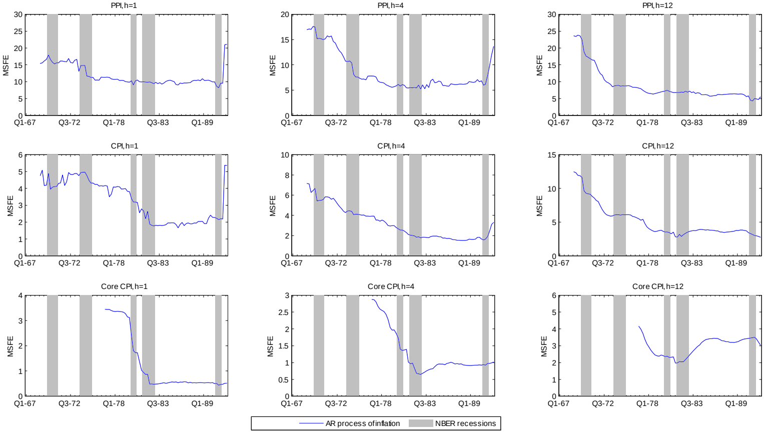
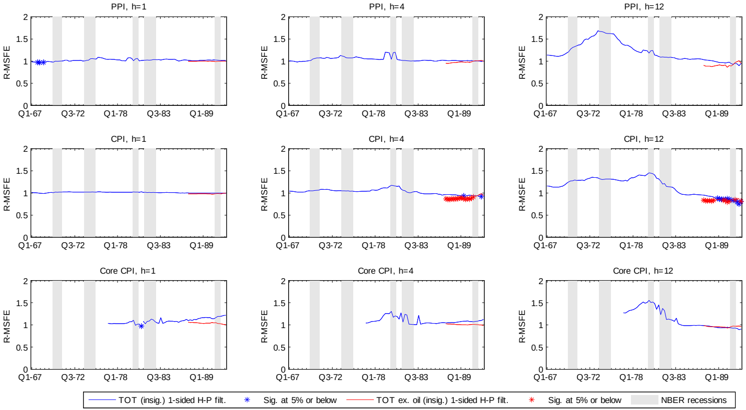
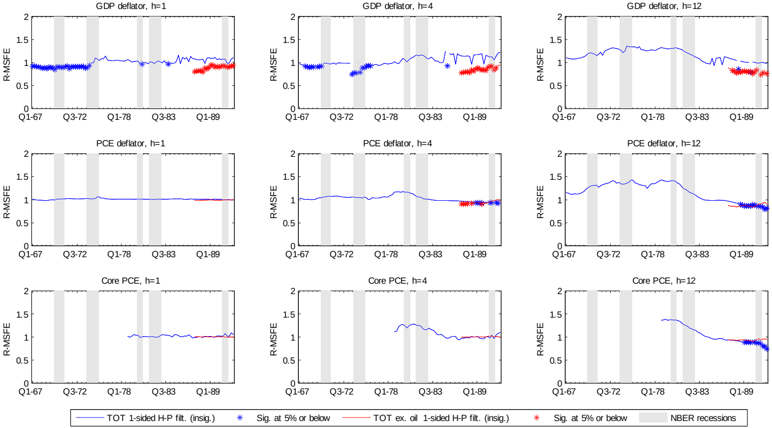


ToT vs ToT ex. oil (HP1)



ToT vs ToT ex. oil (HP1) (cont'd)



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