A model of the Fed's view on inflation

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Modelling the Fed's View

The Federal Reserve's View

"Inflation is characterized by an underlying trend that has been essentially constant since the mid-1990s; …. Theory and evidence suggest that this **trend is strongly influenced by inflation expectations** that, in turn, depend on monetary policy. In particular, the remarkable stability of various measures of expected inflation in recent years presumably represents the fruits of the Federal Reserve's sustained effort since the early 1980s to bring down and stabilize inflation at a low level. The anchoring of inflation expectations …does not, however, prevent actual inflation from fluctuating from year to year in response to the temporary influence of movements in **energy prices and other disturbances**. In addition, inflation will tend to run above or below its underlying trend to the extent that **resource utilization–which may serve as an indicator of firms' marginal costs**–is persistently high or low."

— Janet Yellen, 60th Boston Fed Conference

An Econometric Model of the Policymakers' View

Inflation dynamics are dominated by three components

1. A **trend in inflation**, reflecting expectations
2. The **Phillips curve**, relating economic slack to prices
3. An **oil price component** unrelated to real variables

A Stylized Rational Expectations Model

For now, we are leaving out energy prices ...

$$
\begin{aligned}
y_t &= \mu_t^y + \psi_t^{PC} + \psi_t^y \,, \\
\pi_t &= \mu_t^\pi + \delta_\pi \psi_t^{PC} + \psi_t^\pi
\end{aligned}
$$

- μ^y and μ^π are independent random walk trends

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- μ^y and μ^π are independent random walk trends
- ψ^{PC} is a common output gap or Phillips curve cycle

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$$

- μ^y and μ^π are independent random walk trends
- ψ^{PC} is a common output gap or Phillips curve cycle
- ψ^y and ψ^π are other (idiosyncratic) disturbances

Standard Features of the Stylized Model

A Random Walk trend in inflation

Stochastic Trend Inflation

Unit root trend inflation

$$\mu_t^\pi = \tau^\pi + \mu_{t-1}^\pi + u_t^\pi$$

Trend inflation relates to long-run forecast for inflation

$$\lim_{h\to\infty} \mathbb{E}_t[\pi_{t+h}] = \lim_{h\to\infty} \{h\tau^\pi + \mu_t^\pi\}$$

Standard Features of the Stylized Model

Rational Expectations Phillips curve

A Stylized RE Model for Output and Inflation

- We model ψ_t^{PC} as a sationary **stochastic cycle** (Harvey, 1985)

$$\begin{bmatrix} \psi_t^{PC} \\ \bar{\psi}_t^{PC} \end{bmatrix} = \rho^{PC} \begin{bmatrix} \cos(\lambda^{PC}) & \sin(\lambda^{PC}) \\ -\sin(\lambda^{PC}) & \cos(\lambda^{PC}) \end{bmatrix} \begin{bmatrix} \psi_{t-1}^{PC} \\ \bar{\psi}_{t-1}^{PC} \end{bmatrix} + \begin{bmatrix} v_t^{PC} \\ \bar{v}_t^{PC} \end{bmatrix},$$

- This cycle corresponds to a stationary ARMA(2,1) with complex roots
- ψ_t^{PC} is solution to a hybrid New Keynesian Phillips Curve

$$\hat{\pi}_t = \sum_{i=1}^{2} \alpha_i \hat{\pi}_{t-i} + \beta \mathbb{E}_t \left[\hat{\pi}_{t+1}\right] + \gamma \hat{y}_t + v_t$$

Standard Features of the Stylized Model

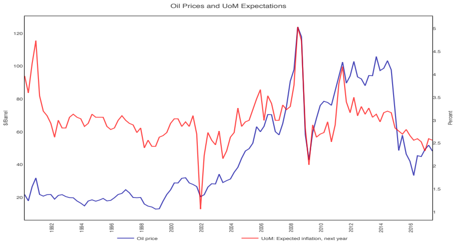
Reduced Form Representation

$$\begin{pmatrix} y_t \\ \pi_t \\ \mathbb{E}_t\left[\pi_{t+1}\right] - \tau^{\pi} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \delta_{\pi} & 1 \\ \delta_{exp,1} + \delta_{exp,2} L & 1 \end{pmatrix} \begin{pmatrix} \psi_t^{PC} \\ \mu_t^{\pi} \end{pmatrix} + \begin{pmatrix} \mu_t^y \\ 0 \\ 0 \end{pmatrix} + \begin{pmatrix} \psi_t^y \\ \psi_t^{\pi} \\ 0 \end{pmatrix}$$

- Can accommodate different specifications for the Phillips Curve
- An AR(1) ψ_t^{PC} would be the solution to a **purely forward** looking New-Keynesian Phillips Curve
- It also nests the **backwards looking** Old-Keynesian Phillips curve connecting output gap and prices

Deviations from the Stylized Rational Expectations Model

Energy Price Cycle



Energy Cycle (Coibion and Gorodnichenko 2015)

- **Household** (and firms) expectations may be **not fully anchored**
- ... and can respond to **oil and commodity** price changes
- gasoline prices are among the most **visible prices**
- ... and may follow a **global demand cycle**

Deviations from the Stylized Rational Expectations Model

(More) Non-standard features

We model agents' (survey) expectations:

$$\mathbb{E}^*[\pi_{t+1}] = \mu_t^\pi + \delta_* \psi_t^{PC} + \gamma_* \psi_t^{EP} + \mu_t^* + \psi_t^*$$

1. Expectational oil disturbances (**transitory disanchoring**)

Deviations from the Stylized Rational Expectations Model

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1. Expectational oil disturbances (**transitory disanchoring**)

2. Time varying bias in expectations (**permanent disanchoring**)

Deviations from the Stylized Rational Expectations Model

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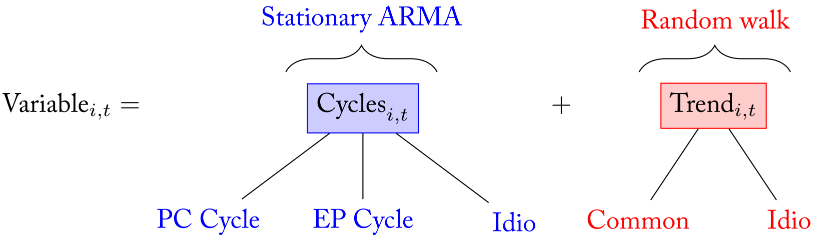
1. Expectational oil disturbances (**transitory disanchoring**)
2. Time varying bias in expectations (**permanent disanchoring**)
3. **Measurement error** in the variables

Bringing it all together

A Sketch of the Model



- Phillips Curve Cycle: Real variables, inflation expectations, and inflation
- Energy Price Cycle: Oil prices, inflation expectations, and inflation
- Common Trend: Inflation expectations and inflation

Bringing it all together
The Data

Variable	Transform	Loads on		
		PC Cycle	EP Cycle	Common Trend
Unemployment Rate	Levels	✓		
Gross Domestic Product	Levels	✓		
WTI Spot Oil Price	Levels		✓	
UoM: Expected Inflation	Levels	✓	✓	✓
SPF: Expected Inflation	Levels	✓	✓	✓
CPI: All Items	YoY	✓	✓	✓

Quarterly sample: Q1-1984 to Q2-2017

Bringing it all together

Identifying the unobserved components model

$$
\begin{pmatrix} u_t \\ y_t \\ oil_t \\ uom_t\{\pi\} \\ spf_t\{\pi\} \\ \pi_t \end{pmatrix}
=
\underbrace{\begin{pmatrix} \delta u & \gamma_u & \phi_u \\ \delta_y & \gamma_y & \phi_y \\ \delta_{oil} & \gamma_{oil} & \phi_{oil} \\ \delta_{uom} & \gamma_{uom} & \phi_{uom} \\ \delta_{spf} & \gamma_{spf} & \phi_{spf} \\ \delta_\pi & \gamma_\pi & \phi_\pi \end{pmatrix}
\begin{pmatrix} \psi_t^{PC} \\ \psi_t^{EP} \\ \mu_t^\pi \end{pmatrix}}_{\color{red}{Common\,Components}}
+
\underbrace{\begin{pmatrix} \psi_t^u \\ \psi_t^y \\ \psi_t^{oil} \\ \psi_t^\pi \\ \psi_t^{uom} \\ \psi_t^{spf} \end{pmatrix}}_{\color{red}{Idio\,Cycles}}
+
\underbrace{\begin{pmatrix} \mu_t^u \\ \mu_t^y \\ \mu_t^{oil} \\ \mu_t^{uom} \\ \mu_t^{spf} \\ 0 \end{pmatrix}}_{\color{red}{Idio\,Trends}}
$$

Bringing it all together

Identifying the unobserved components model

$$
\begin{pmatrix} u_t \\ y_t \\ oil_t \\ uom_t\{\pi\} \\ spf_t\{\pi\} \\ \pi_t \end{pmatrix} = \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ \delta_y & 0 & 0 \\ 0 & 1 & 0 \\ \delta_{uom} & \gamma_{uom} & \phi_{uom} \\ \delta_{spf} & \gamma_{spf} & \phi_{spf} \\ \delta_{\pi} & \gamma_{\pi} & \phi_{\pi} \end{pmatrix} \begin{pmatrix} \psi_t^{PC} \\ \psi_t^{EP} \\ \mu_t^{\pi} \end{pmatrix}}_{Common\, Components} + \underbrace{\begin{pmatrix} \psi_t^{u} \\ \psi_t^{y} \\ \psi_t^{oil} \\ \psi_t^{\pi} \\ \psi_t^{uom} \\ \psi_t^{spf} \end{pmatrix}}_{Idio\, Cycles} + \underbrace{\begin{pmatrix} \mu_t^{u} \\ \mu_t^{y} \\ \mu_t^{oil} \\ \mu_t^{uom} \\ \mu_t^{spf} \\ 0 \end{pmatrix}}_{Idio\, Trends}
$$

Bayesian Estimation

Metropolis-Within-Gibbs Algorithm

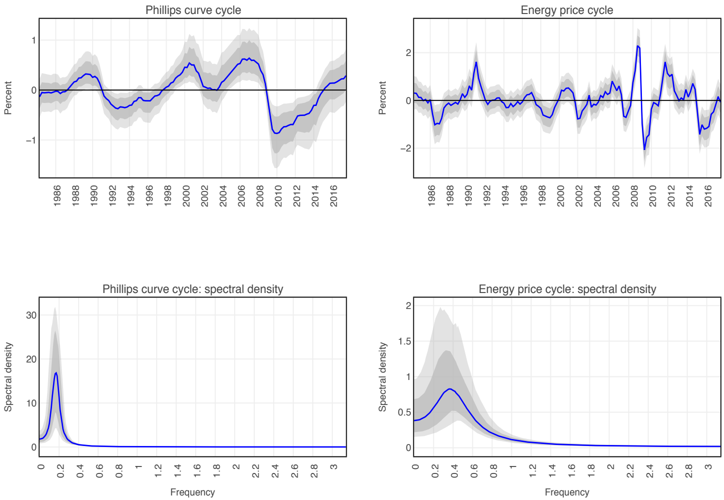
The algorithm is structured in two blocks (**priors are diffuse or weakly informative**):

MWG algorithm with two blocks

- The **first block** uses a Metropolis step for the **estimation of the state-space parameters**
- The **second block** uses a Gibbs step to draw the **unobserved states** conditional on the model parameters

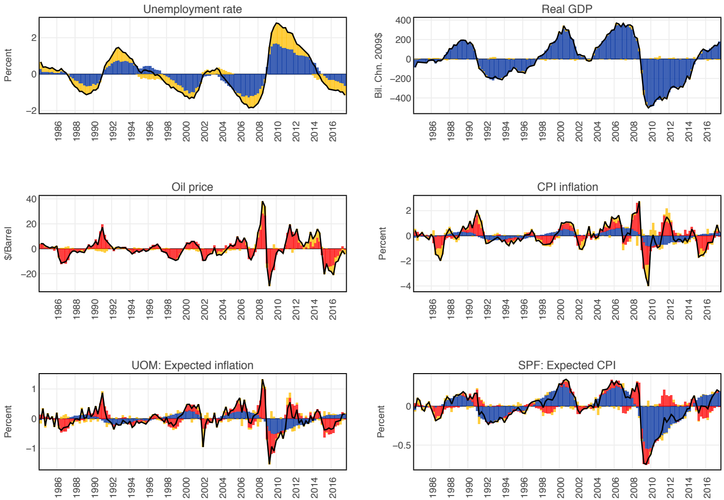
Trends and Cycles in US Inflation

Common Cycles in time and frequency domain



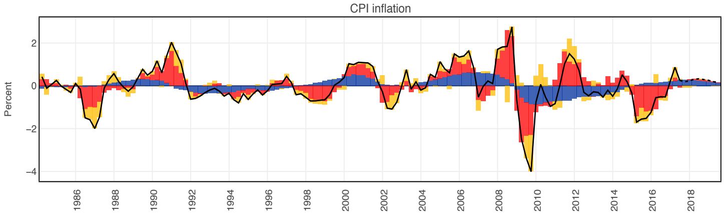
Cycles

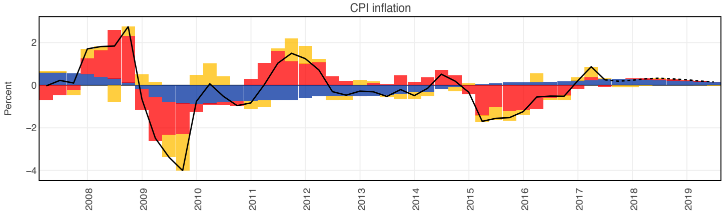
Historical Decomposition



Cycles

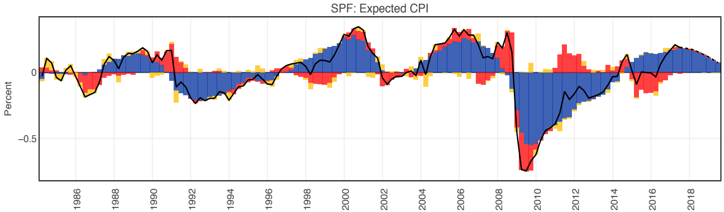
Historical Decomposition of the CPI Cycles

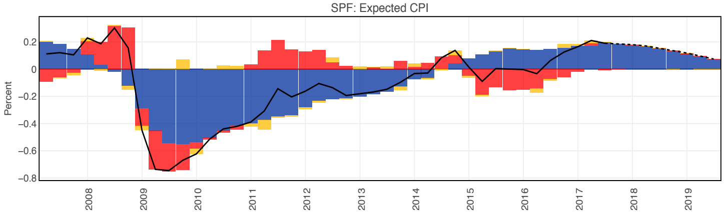




Cycles

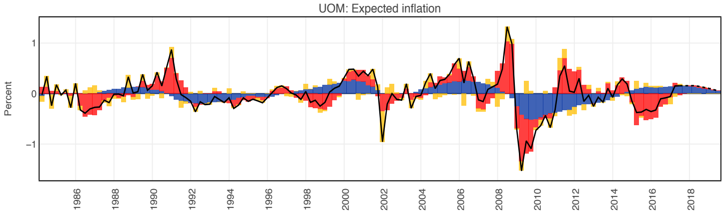
Historical Decomposition of the SPF Expectations Cycles

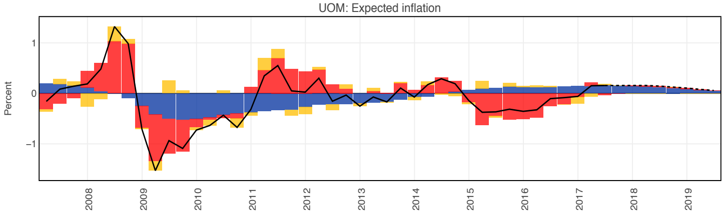




Cycles

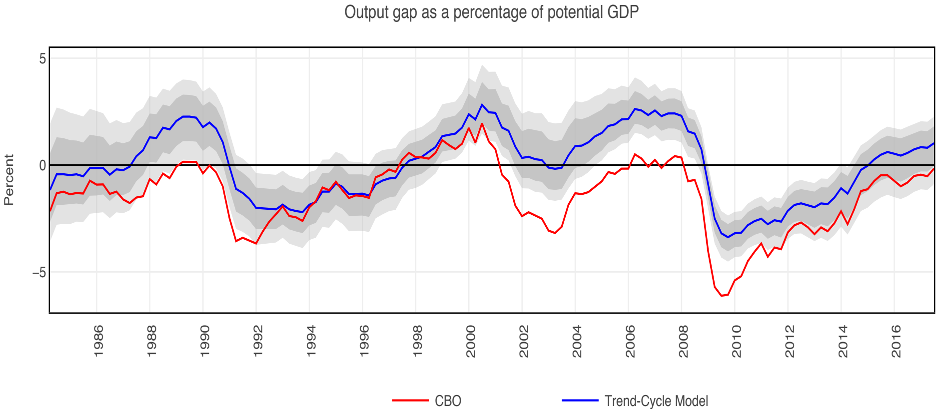
Historical Decomposition of the UoM Exoectations Cycles





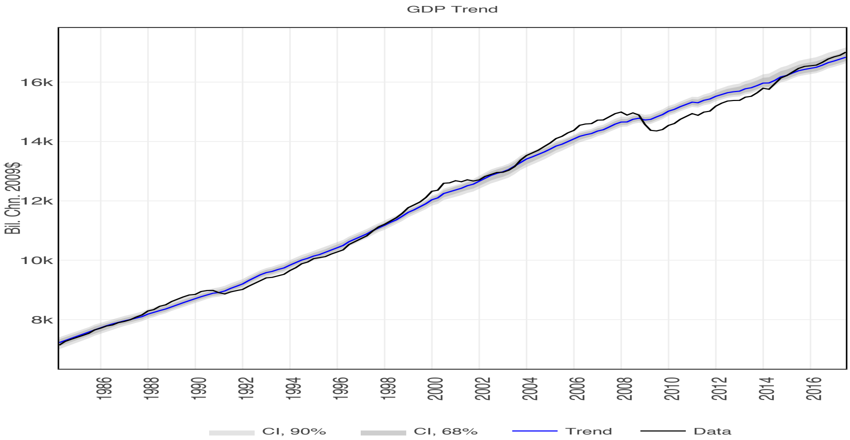
Cycles

Output Gaps



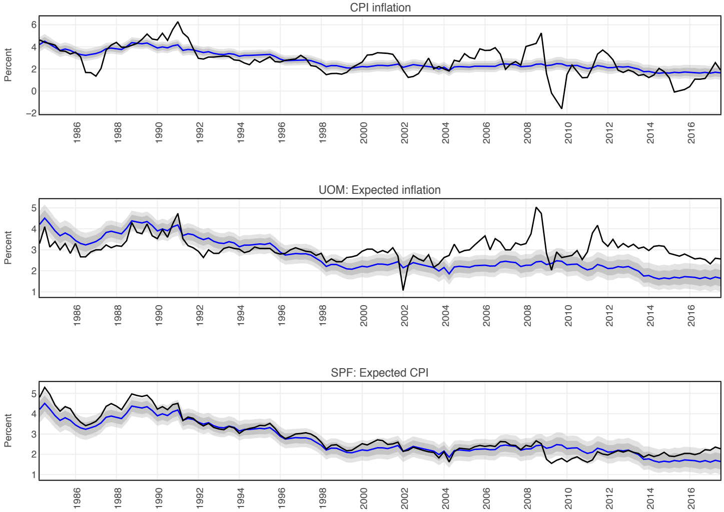
Trends

Idiosyncratic trend in GDP



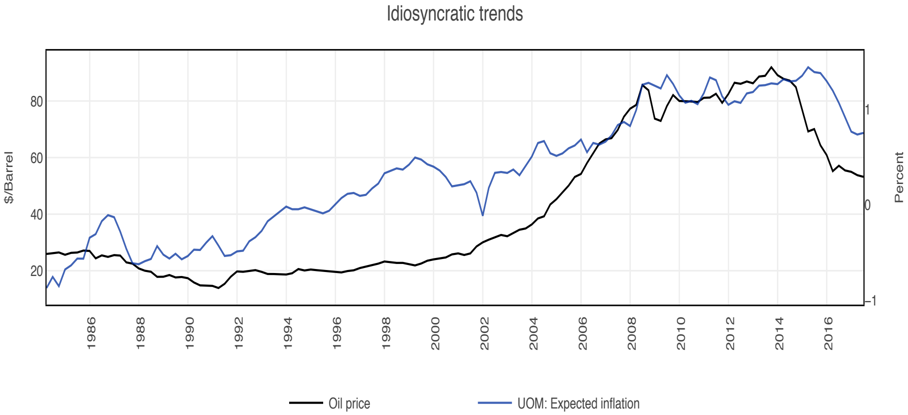
Common Inflation Trend

Common trend between inflation and inflation expectations



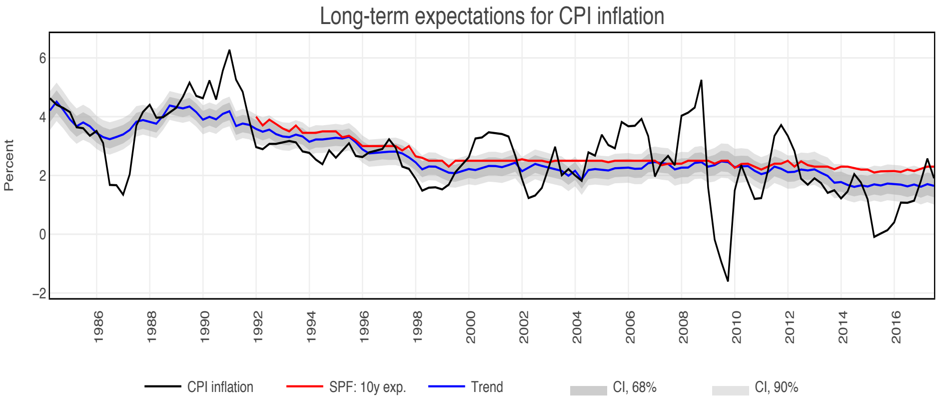
Time Varying Bias in UoM Expectations

Warning: two different axis



Common Inflation Trend

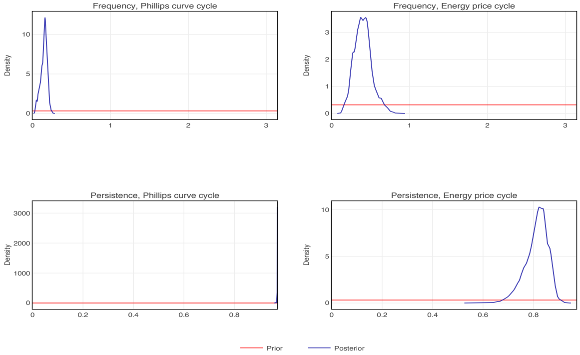
The trend is similar to 10-year Expectations



Model Diagnostics and Forecasting

Priors and Posteriors

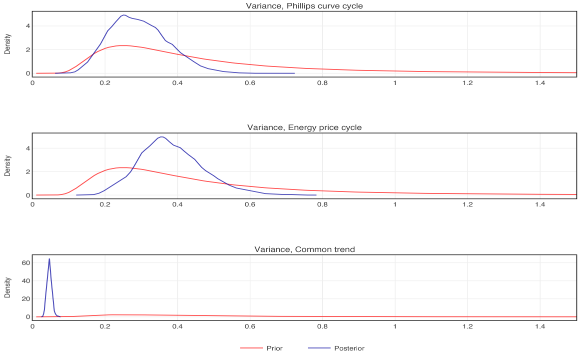
(Maximum) Frequency and Persistence



Prior	Density
Frequency	Uniform(ξ, π)
Persistence	Uniform(ξ, 0.97)
Variance	Inverse-Gamma(3, 1)

Priors and Posteriors

Variance of Shocks to the Components



Prior	Density
Frequency	Uniform(ξ, π)
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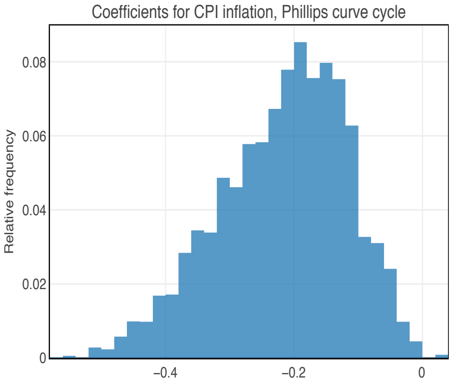
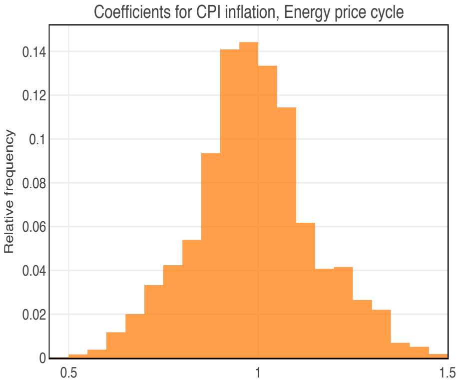
Variance	Inverse-Gamma(3, 1)

Coefficients

Posteriors of the coefficients for the common cycles of inflation





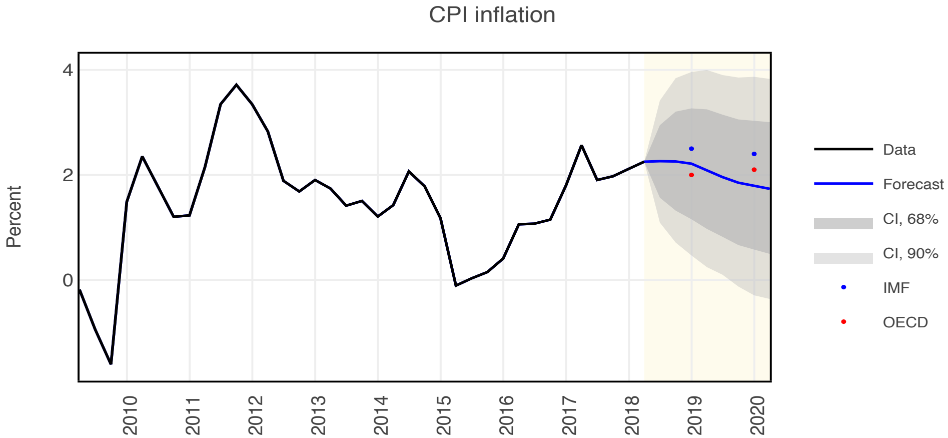
Out-of-Sample Forecast Evaluation

Root Mean Squared Forecast Error relative to the Random Walk with drift

Horizon	Variable	TC Model	BVAR	UC-SV
h=1	Unemployment rate	0.83	**0.65**	x
	Real GDP	1.00	**0.92**	x
	Oil price	**1.02**	1.08	x
	CPI Inflation	0.92	**0.91**	1.00
	UOM: Expected inflation	**0.97**	1.03	x
	SPF: Expected CPI	**0.95**	1.10	x
h=2	Unemployment rate	0.85	**0.68**	x
	Real GDP	1.03	**0.91**	x
	Oil price	**1.04**	1.18	x
	CPI Inflation	**0.87**	1.00	0.99
	UOM: Expected inflation	**0.95**	1.09	x
	SPF: Expected CPI	**0.95**	1.24	x
h=4	Unemployment rate	0.89	**0.79**	x
	Real GDP	1.09	**0.97**	x
	Oil price	**1.04**	1.26	x
	CPI Inflation	**0.81**	1.13	0.98
	UOM: Expected inflation	**0.93**	1.14	x
	SPF: Expected CPI	**0.87**	1.35	x
h=8	Unemployment rate	**0.93**	0.97	x
	Real GDP	**1.17**	1.18	x
	Oil price	**1.04**	1.39	x
	CPI Inflation	**0.79**	1.07	0.96
	UOM: Expected inflation	**0.92**	1.30	x
	SPF: Expected CPI	**0.84**	1.39	x

Out-of-Sample Forecast Evaluation

Probability that US inflation will be below 2% is 42% in 2018 and 56% in 2019



Conclusion

Conclusions

- The **Phillips Curve** is well identified and **fairly stable**
- **Not** always the **dominant component**
- Large **oil price fluctuations** can **move consumers' expectations** away from the real-nominal relationship
- **Forecast:** larger than 50% probability of inflation falling below 2% in 2019
  - Trend expectations are in line with last ten years
  - Oil price pressures will remain subdued
  - The economy will start slowing down in early 2019