A Model of the Fed's View on Inflation

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"Challenges in Understanding the Monetary Transmission Mechanism"
Warsaw, 21 March 2019

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."

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Inflation dynamics:

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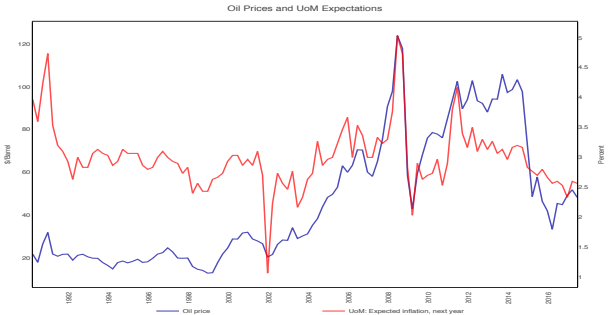
Puzzles in Inflation:

- **Weak empirical evidence** on the PC
- Inflation can be **forecast** by statistical processes **unrelated to slack**
- Evidence of the **flattening** (or **disappearance** of the Phillips Curve)
- **Missing deflation**...
- Disanchoring of consumers' expectation due to **oil shocks**

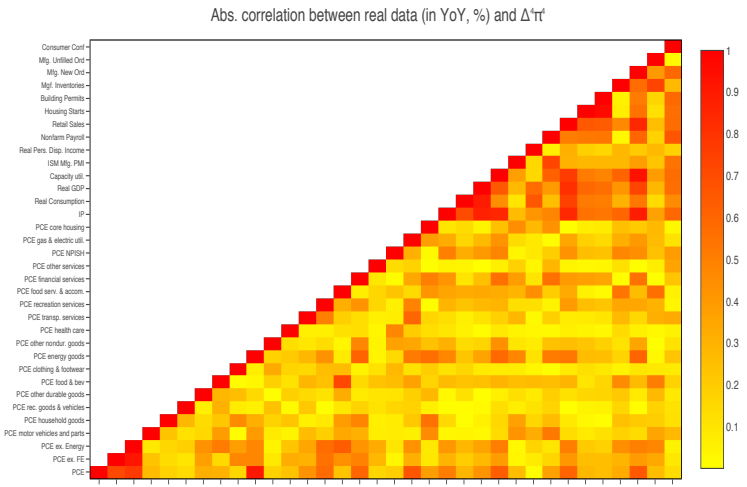
The Role of Oil Shocks in Inflation Expectations

Coibion, 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**

Weak Correlation Prices and Quantities



The Phillips curve: a Needle in the Haystack?

This Paper

An **Econometric Formalisation** of the **Policymakers'/Median Economist's View**:

- A **semi-structural** unobserved components **Trend-Cycle model**
- ... employing **survey data on inflation**
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A Stylised Rational Expectations Model

Stylised Rational Expectations Model

$$
\begin{aligned}
y_t &= \mu_t^y + \widehat{\psi}_t + \psi_t^y \\
\pi_t &= \mu_t^\pi + \delta_\pi \widehat{\psi}_t + \psi_t^\pi \\
\mathbb{E}_t[\pi_{t+h}] &= \mathbb{E}_t[\mu_{t+h}^\pi + \delta_\pi \widehat{\psi}_{t+h} + \psi_{t+h}^\pi]
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- μ_t^y and μ_t^π are independent random walk trends

$$
\begin{aligned}
\mu_t^y &= \bar{\mu}^y + \mu_{t-1}^y + u_t^y \\
\mu_t^\pi &= \mu_{t-1}^\pi + u_t^\pi
\end{aligned}
$$

- **Trend inflation** relates to long-run forecast for inflation

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

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- $\widehat{\psi}_t$ is the output gap reflected in a (hybrid) the Phillips curve

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

- A stochastic cycle – AR(2) with complex roots

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- ψ_t^y and ψ_t^π are other idiosyncratic disturbances

Reduced Form Representation – Trend & Cycle

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

1. Can accommodate different specifications for the Phillips Curve
2. An AR(1) $\widehat{\psi}_t$ would be the solution to a **purely forward** looking New-Keynesian Phillips Curve
3. It also nests the **backwards looking** 'Old-Keynesian' Phillips curve connecting output gap and prices

Bringing the model to the data

Rich Inflation Dynamics

1. **Heterogenous dynamics** along the **business cycle**
   $\Longrightarrow$ Lagged relations prices-slack

2. Labour market dynamics along the **business cycle**
   $\Longrightarrow$ **Okun's law** connecting slack-unemployment

3. Energy price movement impact CPI directly

$$\pi_t = \pi_t^c + \upsilon_1 \pi_t^{en} + \upsilon_2 \pi_t^{food}$$

   $\Longrightarrow$ Difference between CPI **Headline** and **Core**

4. **Non-fundamental fluctuations**
   $\Longrightarrow$ Oil shocks perturb inflation via expectations

5. Deviations from full-information RE
   $\Longrightarrow$ **Bias**, disanchoring, ...

Model Assumptions

$$\begin{pmatrix} y_t \\ e_t \\ u_t \\ oil_t \\ \pi_t \\ \pi_t^c \\ F_t^{uom}\pi_{t+4} \\ F_t^{spf}\pi_{t+4} \end{pmatrix} =$$

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- Independent trend in output (**output potential**)

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- Stationary idiosyncratic disturbances... and idiosyncratic trends

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- Independent trend in output (**output potential**)
- Independent trend in employment/unemployment (**trend employment/equilibrium unemployment**)
- **Output gap** informs stationary **Business Cycle** fluctuations
- ... connects to labour market variables via **Okun's law**
- ... and to prices and expectations via the **Phillips curve**
- Prices and expectations share common **trend inflation**
- Oil price, prices and expectations are connected by an **Energy Cycle**
- Stationary idiosyncratic disturbances... and idiosyncratic trends

Model Assumptions

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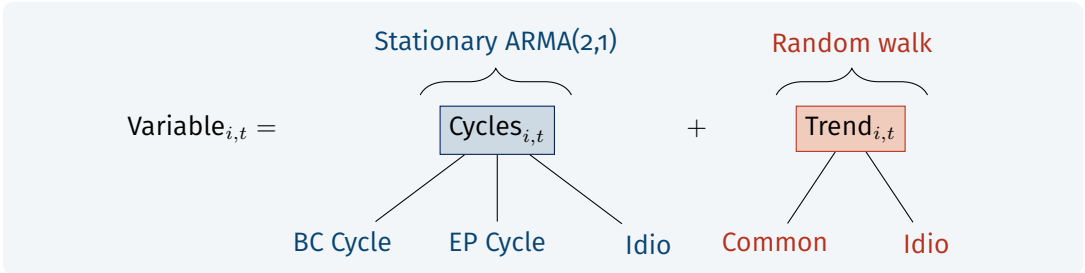
The Model in a Nutshell



- Stationary Cycles

$$\begin{pmatrix} \psi_t^j \\ \psi_t^{*j} \end{pmatrix} = \rho^j \begin{pmatrix} \cos(\lambda^j) & \sin(\lambda^j) \\ -\sin(\lambda^j) & \cos(\lambda^j) \end{pmatrix} \begin{pmatrix} \psi_{t-1}^j \\ \psi_{t-1}^{*j} \end{pmatrix} + \begin{pmatrix} v_t^j \\ v_t^{*j} \end{pmatrix}, \quad \begin{pmatrix} v_t^j \\ v_t^{*j} \end{pmatrix} \sim \mathcal{N}(0, \varsigma_j^2 \, I_2)$$

- Unit Root Trends (w/ or w/o drift)

$$\mu_t^j = \mu_0^j + \mu_{t-1}^j + u_t^j, \quad u_t^j \sim \mathcal{N}(0, \sigma_j^2) \, .$$

Bringing the Model to the Data

Variable	Transformation	Loads on		
		BC Cycle	EP Cycle	Common Trend
Gross Domestic Product	Levels	✓	✗	✗
Employment	Levels	✓	✗	✗
Unemployment Rate	Levels	✓	✗	✗
WTI Spot Oil Price	Levels	✗	✓	✗
CPI: All Items	YoY	✓	✓	✓
Core CPI	YoY	✓	✓	✓
UoM: Expected Inflation	Levels	✓	✓	✓
SPF: Expected Inflation	Levels	✓	✓	✓

Sample: Quarterly, Q1-1984 to Q2-2017

The Modelling of Expectations

Deviation from Textbook Rational Expectation Model

We model agents' (survey) expectations

$$F_t^* \pi_{t+4} = \mu_t^\pi + \delta_*(L)\widehat{\psi}_t + \gamma_*(L)\psi_t^{EP} + \psi_t^* + \mu_t^*$$

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Allow for:

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

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2. Non-classical **measurement error** in the variables

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Allow for:

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

Bayesian Estimation

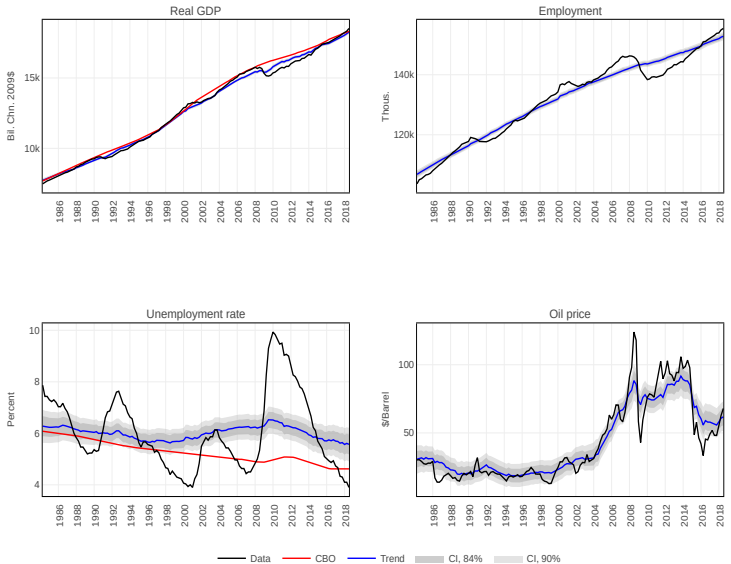
Metropolis-Within-Gibbs Algorithm

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

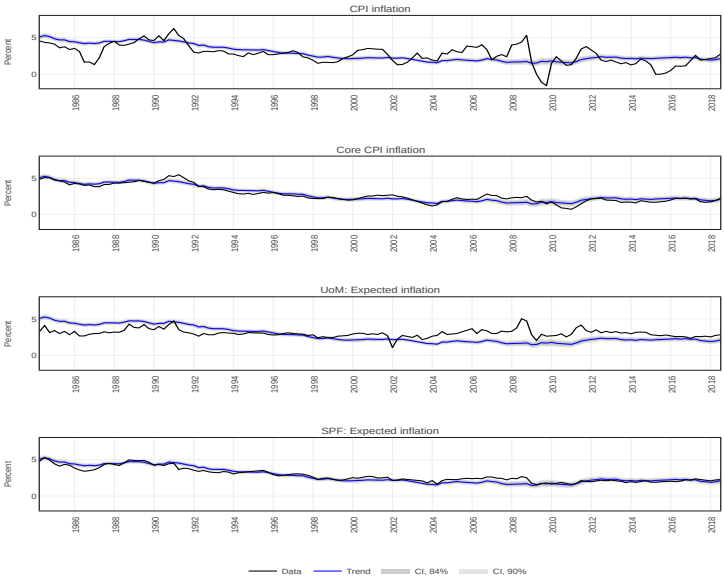
- The **first block** uses a Metropolis step for the **estimation of the state-space parameters**
- The **second block** uses a Gibbs step to draw the **unobserved states** conditional on the model parameters

Trends & Cycles in US Inflation

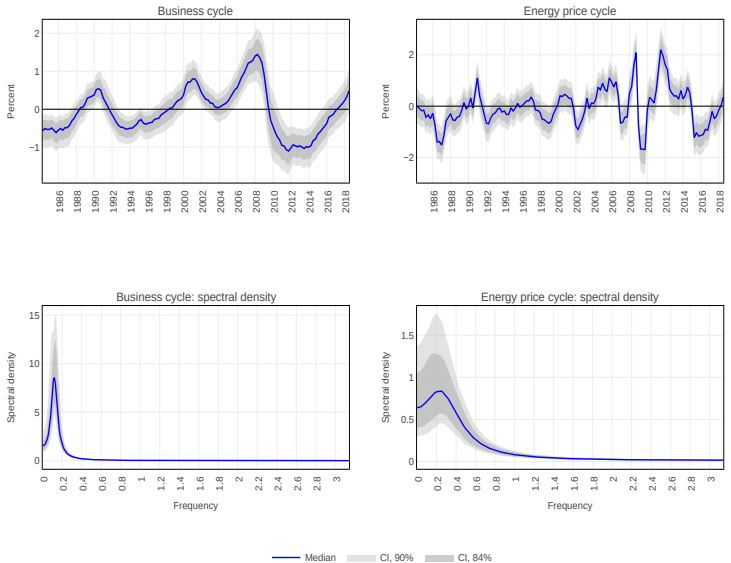
Output Potential, Equilibrium Employment



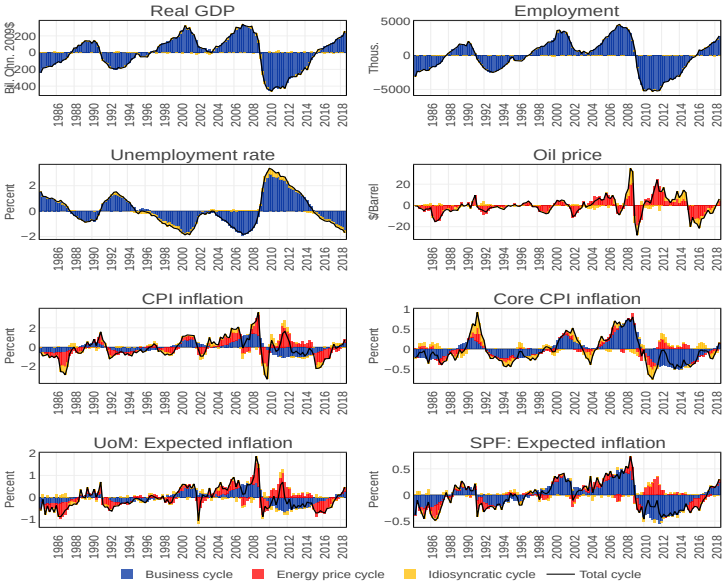
Common Trend and Inflation



Common Cycles

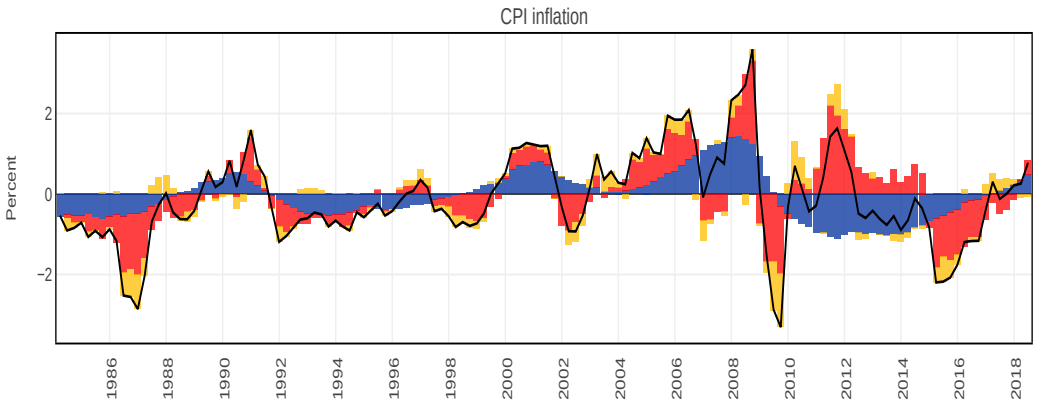


Historical Decomposition of the Cycles



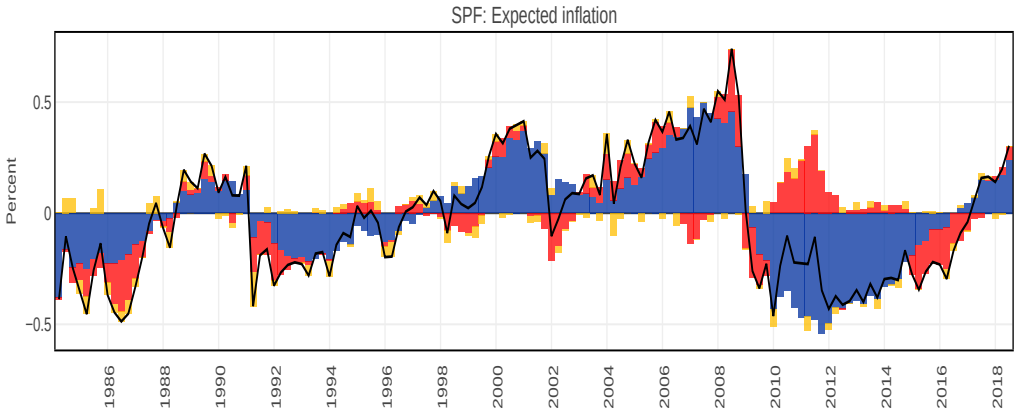
Historical Decomposition of the Cycles

Headline CPI



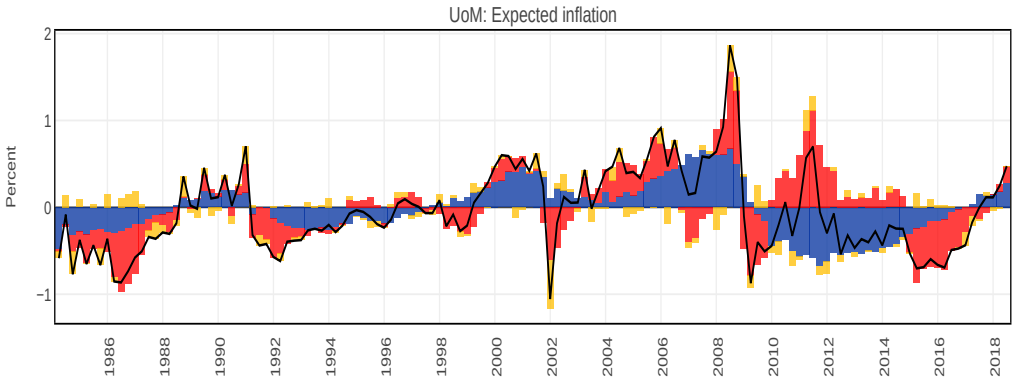
Historical Decomposition of the Cycles

Survey of Professional Forecasters



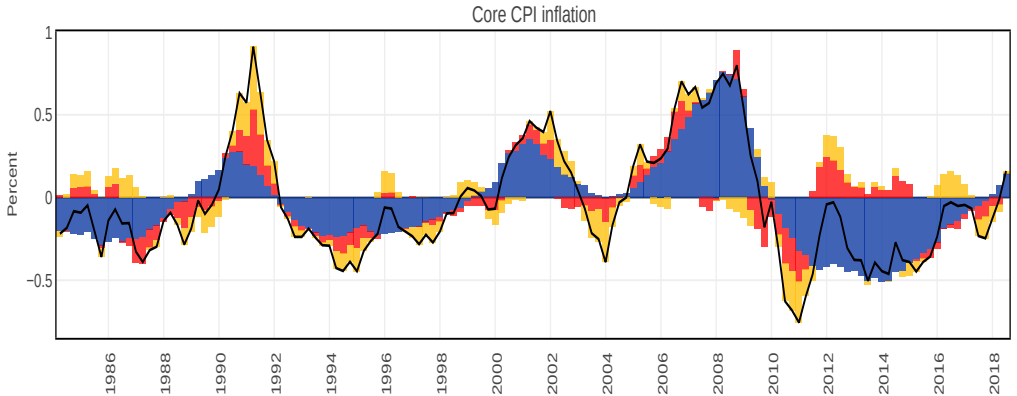
Historical Decomposition of the Cycles

University of Michigan Consumers Survey

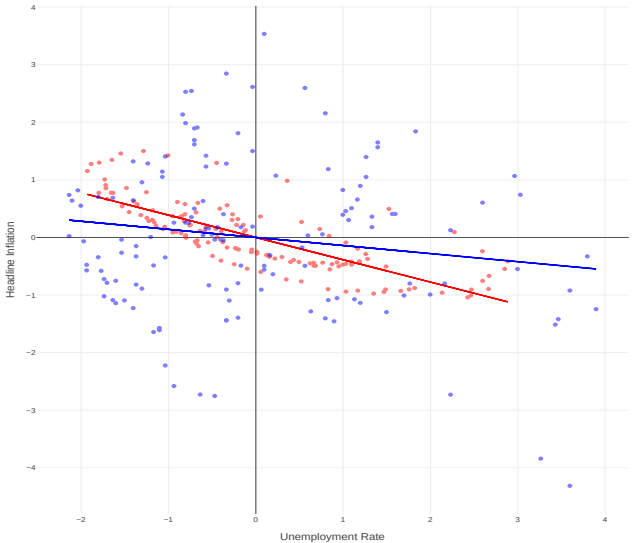


Historical Decomposition of the Cycles

Core CPI



The Slope of the Phillips Curve

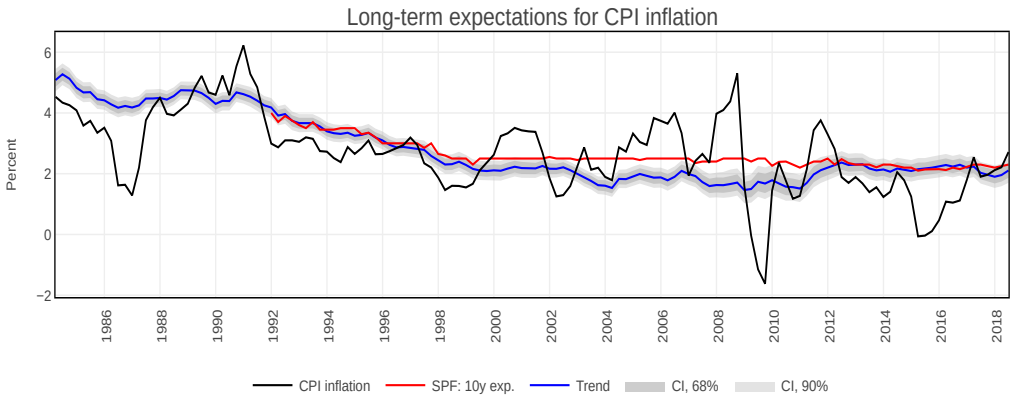


Phillips Curve slope

- Blue line is **-0.14**
- Red line is **-0.39**

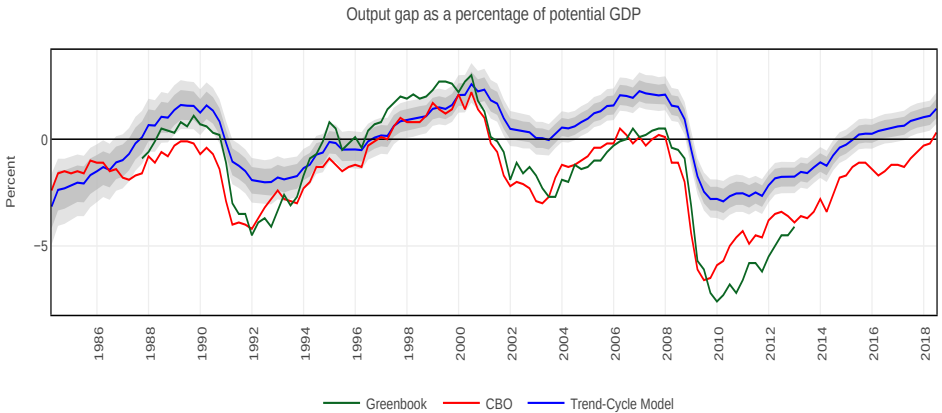
Common Inflation Trend and 10-year Expectations

The Trend in Inflation



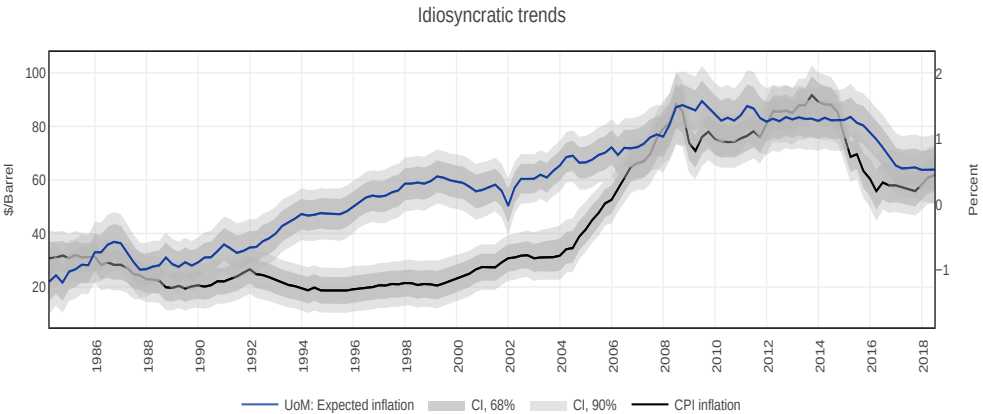
Output Gap

How Deep a Recession?



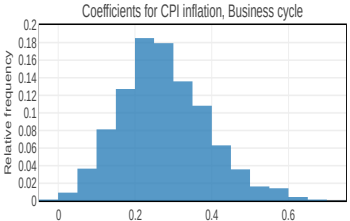
The Role of Oil

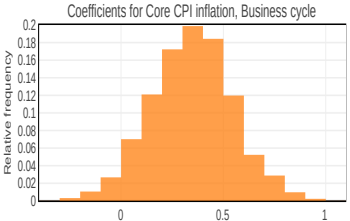
Unmodelled Components?

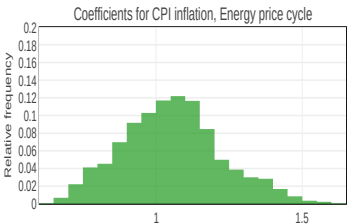


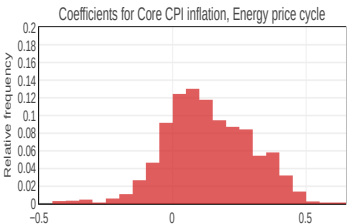
Diagnostics

Common Cycles Loadings



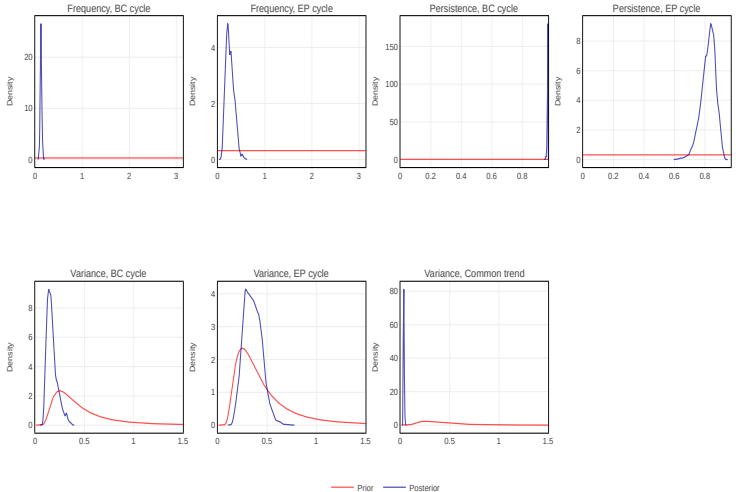






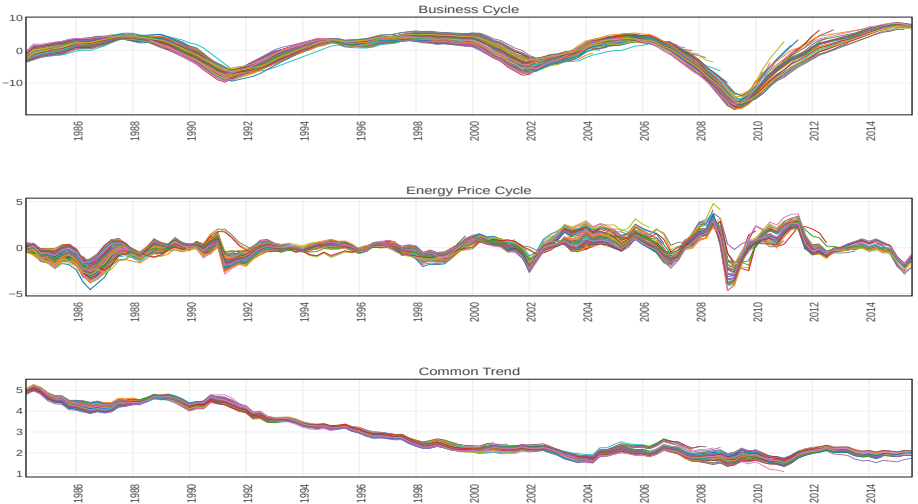
Priors and Posteriors

Variance of Shocks to the Components



Model Forecasting Performances

Out-of-Sample Cycle & Trend Revisions



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	Real GDP	1.04	**0.93**	x
	Employment	0.98	**0.76**	x
	Unemployment rate	0.85	**0.67**	x
	Oil price	**1.03**	1.08	x
	CPI Inflation	0.94	**0.91**	1.00
	Core CPI Inflation	**1.01**	1.04	**1.01**
	UOM: Expected inflation	**0.98**	1.04	x
	SPF: Expected CPI	**0.95**	1.06	x
h=2	Real GDP	1.06	**0.93**	x
	Employment	1.00	**0.76**	x
	Unemployment rate	0.85	**0.71**	x
	Oil price	**1.04**	1.18	x
	CPI Inflation	**0.90**	0.98	0.99
	Core CPI Inflation	**0.99**	1.15	**0.99**
	UOM: Expected inflation	**0.98**	1.09	x
	SPF: Expected CPI	**0.94**	1.18	x

Horizon	Variable	TC Model	BVAR	UC-SV
h=4	Real GDP	1.11	**1.01**	x
	Employment	1.06	**0.82**	x
	Unemployment rate	0.86	**0.83**	x
	Oil price	**1.03**	1.26	x
	CPI Inflation	**0.87**	1.13	0.97
	Core CPI Inflation	**0.95**	1.22	0.96
	UOM: Expected inflation	**0.96**	1.14	x
	SPF: Expected CPI	**0.92**	1.31	x
h=8	Real GDP	**1.17**	1.21	x
	Employment	1.13	**1.01**	x
	Unemployment rate	**0.85**	1.02	x
	Oil price	**0.99**	1.36	x
	CPI Inflation	**0.81**	1.09	0.95
	Core CPI Inflation	**0.84**	1.30	0.91
	UOM: Expected inflation	**0.92**	1.28	x
	SPF: Expected CPI	**0.88**	1.34	x

Conclusions (I)

- Our trend-cycle model captures a number of commonly accepted economic laws and and provides a **powerful new tool** for policy analysis.
- The model correctly captures inflation dynamics since the 1980s and identifies a stable and fairly steep **Phillips Curve**
- The Phillips Curve is **not** always the **dominant component**
- Large **oil price fluctuations** can **move consumers' expectations** away from the real-nominal relationship

Conclusions (II)

- Explicit modelling of **trends & cycles** and **parsimonious** characterisation of the relations amongst macro variables
- Similar to VARs but **informed by Economic theory** – Phillips Curve, Okun's Law
- Encompasses **REH** but allows for **deviations** from **full information and perfect rationality**
- Can deal with **trending variables** and **multiple cycles**
- **No need of data transformation** generating spurious correlations
- ... nor of tight parametrisation as DSGE models.
- **Good forecasting model**, a **story telling device** and for **nowcasting**