# Forecasting and Policy Analysis with Trend-Cycle BVARs

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# Trend-Cycle VARs

TC-VARs model components of the time series:

$$Y_t = Y_t^T + Y_t^C + Y_t^E. \tag{1}$$

$Y_t^T$ – carefully specified low frequency dynamics, trends, ...
$Y_t^C$ – cyclical dynamics, business cycle, ...
$Y_t^E$ – high-frequency dynamics, measurement errors, ...

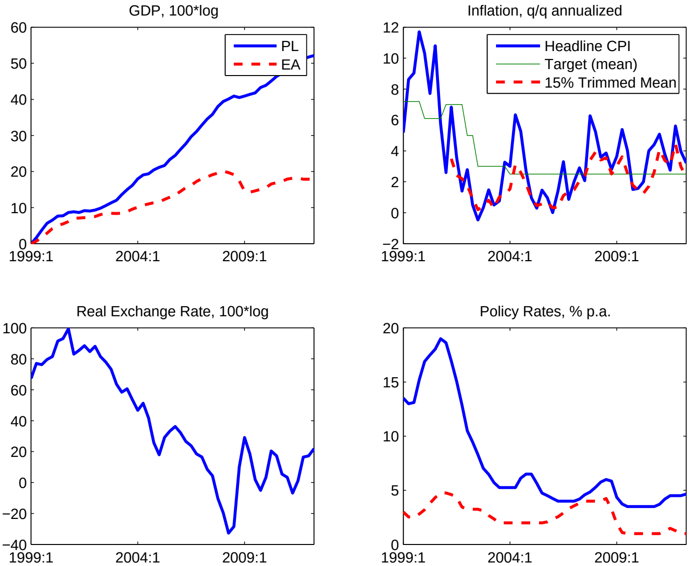
$Y_t^C$ is specified as a zero-mean VAR(k) model with appropriate transformation of variables and coefficients restrictions.

# Why Trend-Cycle VARs?

- Economic theory: trends and cycles are dominated by different shocks and transmission channels. Trends are more complex...
- Well-specified steady-state levels or growth rates of the macro variables, often time-varying and known
- More flexibility in variable transformations
- If the reduced-form VAR is 'messed up', no structural-shock identification wizardry will save the SVAR

Details in Andrle and Bruha (2014)

# Example: Poland vs. Euro Area




Andrle, Garcia-Saltos, and Ho (2013)

# Examples (I.)

- For IT country inflation must be modeled, not the price level!
- With inflation, the steady state should coincide with the inflation target (need not to happen without a restriction). For a constant target, just subtract it from the inflation series...
- With a time-varying explicit target, an explicit acknowledging of the target time variation is crucial.
- The target needs to be acknowledged also in the trend nominal interest rate or risk of serious misspecification (price puzzles, etc.)

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- Potential output vs. output gap and the link to inflation deviation from the long-term inflation expectations
- Steady-state growth of output is not constant in many economies and will converge to more developed countries gradually (convergence)
- A model with the level of policy rates with GDP growth rate will almost surely lead to permanent output change after transitory change of policy rates, etc.
- Trends in real exchange rates (HBS effect, etc.)

# Examples (II.)

- In labor market models, Okun's law usually stable, trend in labor-force participation, NAIRU concept, etc.
- International trade 'trend' openness driven by tariff changes, trade unions, EU entry, WTO policy, technology...

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- In models with multiple countries, different path of inflation targets, trend GDP dynamics, or real exchange rate trends are an issue
- In emerging and developing countries rapid development in trend growth rates, great ratios, trends in relative prices, in the exchange rate, disinflation... but cyclical dynamics better behaved
- Past growth rates are often poor indicators of future growth rates in the medium term, so a constant steady state won't do [needs to be a trend process]

Trend-Cycle models (structural or VAR) implemented successfully for Poland, Indonesia, Philippines, Kenya, Uganda, South Africa, Georgia, Armenia ...

# Are Trends and Cycles Independent?

**NO! They are not. They are intrinsically linked.**

Yet, oftentimes modeling and forecasting trends and cycles separately is a good approximation.

To model low-frequencies 'properly' (wealth effects, etc.), it is the structural/DSGE models that are better equipped to handle it than VARs.

Ironically, DSGE models are often ad-hoc de-trended while VARs are not…

# TC-BVAR Estimation

+ **Joint estimation of the parameters and states**

+ **'Standard' priors for the BVAR and trends**

  (marginal-independent priors, experiments with B-Lasso/Elastic Net)

+ **System priors for the whole model**

  - stationarity of the VAR component
  - penalty for excessively slow convergence
  - variance of the cyclical component mostly at BC freqs
  - filter frequency-transfer fun properties
  - ...
  - 'spriors' for shock identification [Andrle, Plasil 2017]

+ **Bayesian computations:**

  (a) Posterior-mode search with a homotopy, followed by RWM, or
  (b) Sequential MC as in Herbst and Schorfheide (2014) [**parallel**]

# Links to the Literature

**Builds on:**

- 'structural time-series models' (Harvey, 1989) and
- 'Quarterly Projection Model' (QPM) of Laxton et al (2001) with trend-cycle models.

**Previous work using TC-[B]VARs:**

Bruha, Pierluigi, Serafini (ECB, 2011) – labor market model
Andrle, Ho, Garcia-Saltos (IMF, 2013) – MP VAR for Poland
Andrle, Bruha (2014) – Learning about MP Using VARs: Some Issues and Solutions

**The use of system priors:**

Andrle, Benes (2013) [DSGE models], Andrle, Plasil (2016) [tseries, VARs]

# U.S. Model

Specification and Results

# Simple TC-BVAR (a): The Model

**[A] Aggregation:**

$$y_t = \bar{y}_t + \hat{y}_t + u_{y,t} \qquad (2)$$

$$\pi_t = \bar{\pi}_t + \hat{\pi}_t + u_{\pi,t} \qquad (3)$$

$$i_t = \max[\hat{i}_t + \bar{i}_t,\ i_{\text{floor},t}] + u_{i,t} \qquad (4)$$

**[B] Cyclical Dynamics:**

$$\mathbf{A0}\begin{bmatrix}\hat{y}_t\\ \hat{\pi}_t\\ \hat{i}_t\end{bmatrix} = \mathbf{A}_1\begin{bmatrix}\hat{y}_{t-1}\\ \hat{\pi}_{t-1}\\ \hat{i}_{t-1}\end{bmatrix} + \cdots + \mathbf{A}_k\begin{bmatrix}\hat{y}_{t-k}\\ \hat{\pi}_{t-k}\\ \hat{i}_{t-k}\end{bmatrix} + \mathbf{C}\begin{bmatrix}e_{\hat{y},t}\\ e_{\hat{\pi},t}\\ e_{\hat{i},t}\end{bmatrix} \qquad (5)$$

**[C] Trend Component:**

$$\bar{y}_t = \bar{y}_{t-1} + g_t/4 + u_{\bar{y},t} \qquad (6)$$

$$g_t = \rho_g g_{t-1} + (1-\rho_g)g_{ss} + u_{g,t} \qquad (7)$$

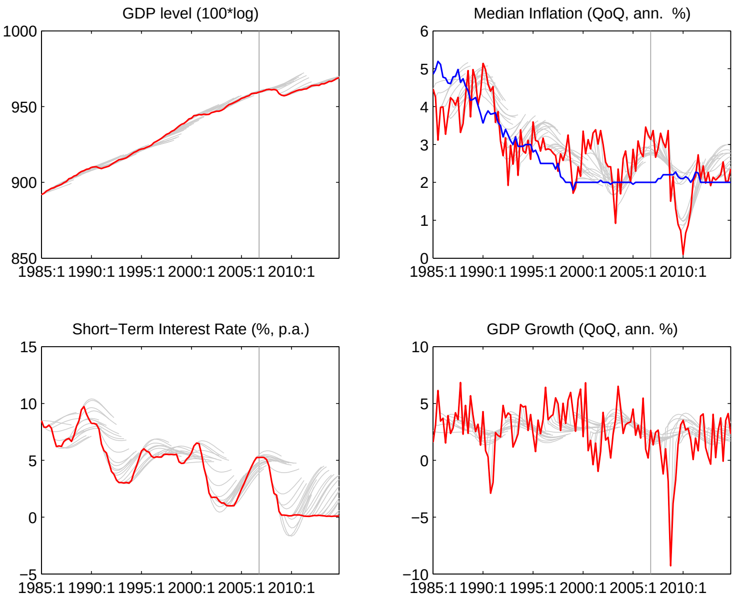
$$\bar{\pi}_t = \bar{\pi}_{t-1} + u_{\bar{\pi},t} \quad \text{and} \quad E[\pi_{t+j|t}] = \bar{\pi}_t \text{ for } j \to \infty \qquad (8)$$

$$\bar{i}_t = \bar{r}_t + \bar{\pi}_t \qquad (9)$$

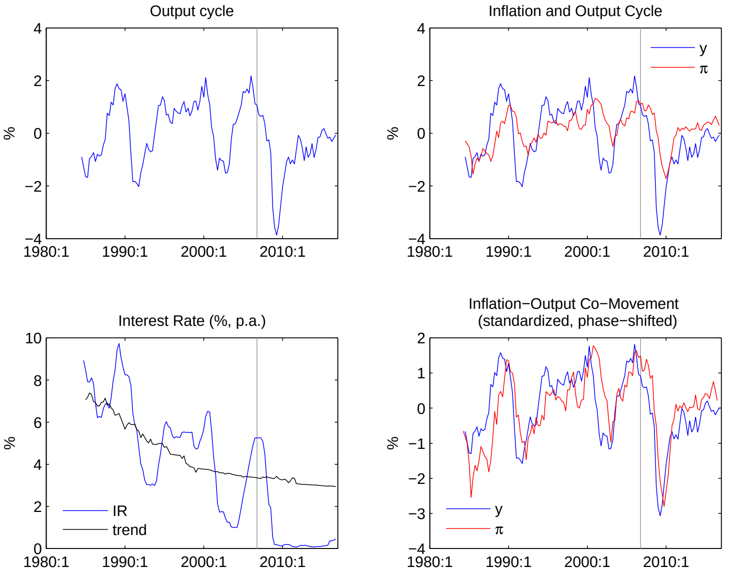
$$\bar{r}_t = \rho_{\bar{r}}\bar{r}_{t-1} + (1-\rho_{\bar{r}})\bar{r}_{ss} + u_{\bar{r}} \qquad (10)$$

$$i^N_{t|t} = (1/N)\sum_{i=0}^{N} i_{t+i|t} \quad \text{for } N = 4,\ 20,\ 40. \qquad (11)$$

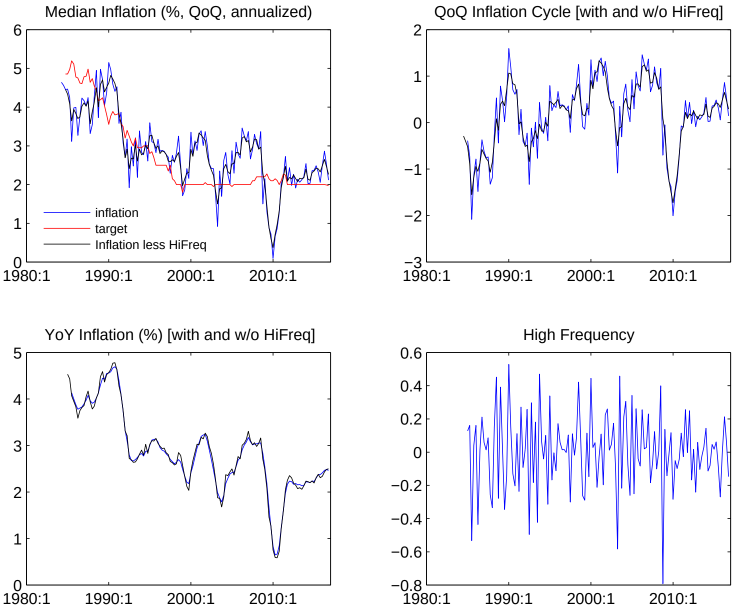
# Simple TC-BVAR (b): Recursive Forecasts



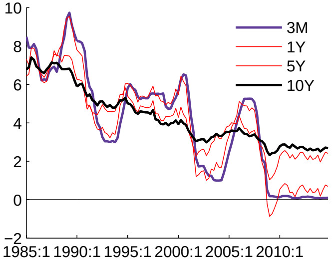
# Simple TC-BVAR (c): Trend and Cycles

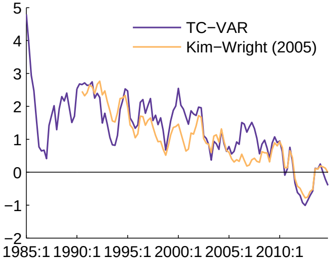


# Simple TC-BVAR (d): Inflation Decomposition

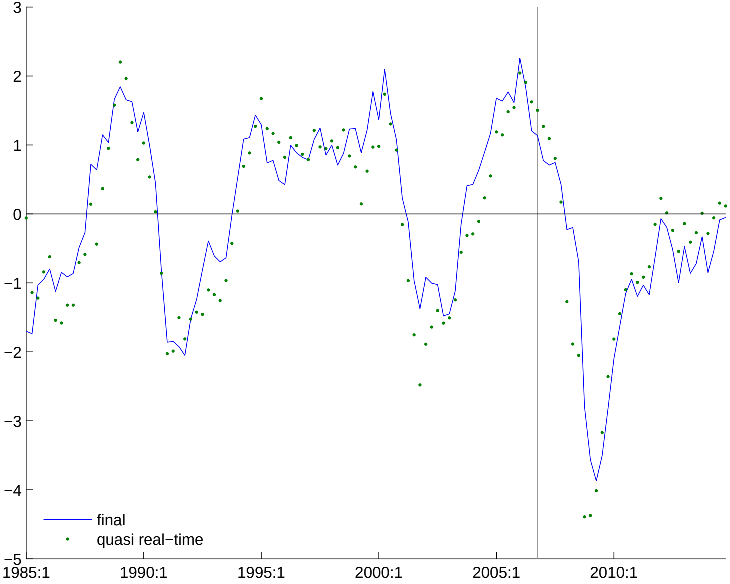


# Simple TC-BVAR (e): Yield Curve



# Simple TC-BVAR (f): Quasi Real-Time Output Cycle



# Conclusion

TC-VARs offer a great alternative for forecasting and analysis

- Flexible and easy to use
- Separates business cycle and trends when appropriate

- Well-defined long and medium term dynamics
- Less restrictive on data transformation for the VAR

- Competitive forecasting performance
- Forecasting with expert judgment and satellite models on trends going forward is simple

**Thank you for your patience. . .**