Estimating The Natural Interest Rate in a Small Open Economy

The Czech Economy

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May 20, 2019

Objective

1. How to identify the natural rate in a small open economy?
2. What is the level of the natural rate in the Czech economy?

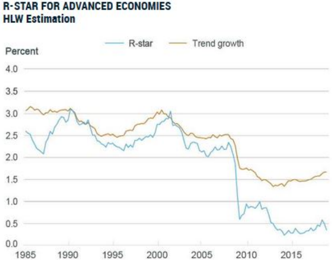
Natural interest rate, $\bar{r}$, is the level of a short-term real interest rate consistent with stable (expected) inflation at the target and the output on the equilibrium level.

Published as *Hlédik T. and J. Vlček, 2018. "Quantifying the Natural Rate of Interest in a Small Open Economy - The Czech Case", CNB WP 7/2018. CNB.*

Motivation

- Normalization of monetary policy in the Czech Republic
  - What is the "neutral" level of a policy interest rate? $i^{neutral} = \bar{r} + \pi^{Tar}$
  - How does the "neutral" level vary across time?
- Interest rates, both nominal and real, declined on average over last two decades in most of countries
- Several papers as for example Holston, Laubach and Williams(2017) find the natural rate of interest as declining in advanced countries

Source: Laubach and Williams (2003).
Note: We plot estimates of the natural rate of interest (r-star) along with those for the trend growth rate of the U.S. economy, a source of change driving r-star.



Sources: Holston, Laubach, and Williams (2017); Organisation for Economic Co-operation and Development (OECD).
Notes: Estimates are GDP-weighted averages across the United States, Canada, the Euro Area, and the United Kingdom. We use OECD estimates of GDP at purchasing power parity. For dates prior to 1995, Euro-Area weights are the summed weights of the eleven original Euro-Area countries.

Literature

Laubach and Williams (2003) and its variations – the mostly used structural approach to identify the natural rate

$$\bar{r}_t = c\Delta\bar{y}_t + w_t,$$

where $\bar{r}$ is the natural rate, $\Delta\bar{y}$ is the potential growth (RW process), and w_t captures other factor as preferences and follows either AR(2) or RW. Finally, c is a scaling parameter.

Accompanied by a reduced form measurement equations:

$$\hat{y}_t = A_y(L)\hat{y}_{t-1} + A_r(L)\left(r_{t-1} - \bar{r}_{t-1}\right) + \varepsilon_t^y$$

$$\pi_t = B_\pi(L)\pi_{t-1} + B_y(L)\hat{y}_{t-1} + B_x(L)x_t + \varepsilon_t^\pi,$$

where π is inflation, x are relative prices, and ε are measurement errors.

Advantages: Simple but comprehensive model structure and easily applicable
Disadvantages: No expectations and closed economy

What should be the level of the real interest rate?

Closed Economy

A simple closed economy model workhorse with a representative households maximizing discounted utility gives Euler equation as one of FOCs:

$$\frac{1}{c_t} = \beta E_t \left[\frac{1}{c_{t+1}} \left(R_t + 1 - \delta \right) \right]$$

Hence,

$$R_t = \frac{E_t c_{t+1}}{c_t} \frac{1}{\beta} - 1 + \delta$$

The real interest rate, R_t, in the long run equals to real GDP growth (productivity growth) adjusted by discounting, β, and depreciation rate of capital, δ.

What should be the level of the real interest rate?

Open Economy

- Real per-capita GDP convergence => faster real growth
- Faster real growth => higher natural rate of interest???

Not necessarily

- Faster real growth and usually capital (FDI) inflows
- Real convergence => real exchange rate appreciation

=>

Real interest rate might be lower in a small open and converging economy as real appreciation provides additional return

$$s = s^e_{+1} - i/4 + i^*/4 + prem/4$$

$$r = r^* + \Delta z^e_{+1} + prem$$

- Small open economy DSGE (for example Gali (2008)) where $\bar{r} = f(\Delta a, \Delta a^*)$

Open Economy

- Czech real 3M rate roughly same as the EA 3M real rate
- Revisions of equilibrium real exchange appreciation and the natural rate of interest in 2002–2006

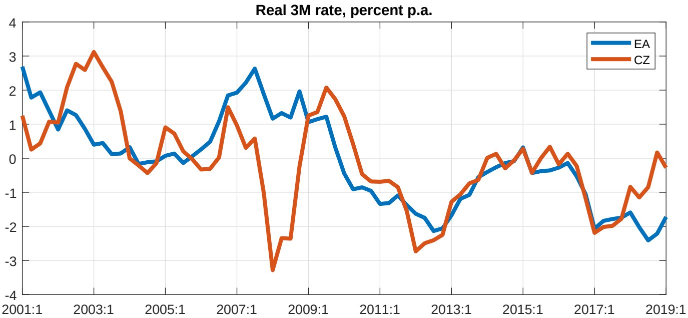


Figure: 3M real rates (in percent p.a.)

Our approach

We modify the general Laubach and Williams (LW) approach in two aspects:

1. Small open economy with free capital flows and real convergence

$$\bar{r}_t = c\,(\Delta\bar{y}_t + \Delta\bar{z}_t)\,,$$

   where $\bar{z}$ is equilibrium real exchange rate depreciation.

2. (Semi) structural model based filtration
   - Model closed by a policy rule – enable to solve under rational expectations
   - A simple gap model similar to the CNB's QPM

Model and Key Identification Restrictions

(Semi) structural model of the Czech economy in a gap form (all gaps as percentage deviations from eq.)

1. Process for the natural rate

$$\bar{r}_t = \rho \bar{r}_{t-1} + (1-\rho)(\Delta^4 \bar{y}_t + \Delta^4 \bar{z}_t),$$

2. IS curve

$$\hat{y}_t = b_1 \hat{y}_{t-1} - b_2 \left(b_4 \hat{r}_t + (1-b_4)(-\hat{z}_t)\right) + b_3 \hat{y*}_t + \varepsilon_t^{\hat{y}}$$

where $\hat{y}$ is the output gap, $\hat{z}$ is the real exchange rate gap, $\hat{r}$ is the real interest rate, $\hat{y*}_t$ is the foreign output gap, and $\varepsilon_t^{\hat{y}}$ is a demand shock.

Key Identification Restrictions (cont.)

3. Phillips curve

$$\pi_t^i = a_1^i \pi_{t+1}^i + (1 - a_1^i)\pi_{t-1}^i + a_2^i(a_3^i \hat{y}_t + (1 - a_3^i)\hat{z}_t) + \varepsilon_t^{\pi^i}$$

   where π_t^i is inflation of $i-th$ CPI sub-component and $\varepsilon_t^{\pi^i}$ is a supply shock.

4. Policy Rule

$$i_t = g_1 i_{t-1} + (1 - g_1)\left[\bar{r}_t + \pi_{t+1}^{yoy} + g_2(\pi_{t+3}^{yoy} - \pi^{tar}) + g_3\hat{y}_t\right] + \varepsilon_t^i$$

where i_t is the short term policy rate, $\bar{r}_t + \pi_{t+1}^{yoy}$ is the policy neutral rate, $\pi_t^{yoy} - \pi^{tar}$ is the deviation of expected inflation 4 quarters ahead from the inflation target, $\hat{y}_t$ is the output gap, and ε_t^i is the MP shock.

The rule cannot be binding!

Model Calibration/Estimation

- We calibrate all the model parameters except those in equation defining the dynamics of the natural rate of interest.
  - Weak identification
- We rewrite the natural rate equation as:

$$\bar{r}_t = \rho \bar{r}_{t-1} + (1-\rho) 2c \left[w^{\bar{y}} \Delta \bar{y}_t^{yoy} + (1 - w^{\bar{y}}) \Delta \bar{z}_t^{yoy}) \right]$$

- Using identification tests, we find that the only combination of parameters which can be estimated simultaneously consists of ρ and $w^{\hat{y}}$.
- Therefore, we calibrate c equal to 1 in line with Laubach and Williams (2003) and we estimate the remaining parameters.

Model Estimation

- The parameters are estimated using maximum likelihood along with the penalty function
  - Penalty on likelihood if the natural rate being negative.
- This estimation procedure resembles the system-based priors introduced and described in Andrle and Benes (2013).

$$\bar{r}_t = \rho \bar{r}_{t-1} + (1-\rho) 2c \left[w^{\bar{y}} \Delta \bar{y}_t^{yoy} + (1 - w^{\bar{y}}) \Delta \bar{z}_t^{yoy}) \right]$$

Parameter	Mean	Std Dev
ρ	0.68	0.086
$w^{\bar{y}}$	0.53	0.033

Model Calibration

The model calibrated to match stylized facts of the Czech economy and the transmission mechanism.

- Four groups of parameters:
  1. Parameters determining dynamic properties
     - 1.1 Parameters determining the steady-state – either set by policy or historical averages
     - 1.2 Parameters in structural equations – literature and other models
     - 1.3 Parameters in non-structural (ad-hoc) equations – match the data
  2. Parameters determining stochastic properties
     - 2.1 Stds of shocks – gaps identified based on inflation, weak link from the policy rule to the natural rate
- Calibration checks – Filtration of the data, in-sample simulations, and impulse responses

Model Filtration

The model employed to interpret the Czech data (Kalman filration) and to identify the unobserved variables.

- Observed variables:
  - PRIBOR 3M
  - Headline CPI inflation and sub-components (core excluding food and energy, food, energy, and regulated prices)
  - Nom. exchange rate against EUR
  - Real GDP
  - Foreign variables – effective EU

Findings

- The identified natural rate hovers around 1 percent.
- Real rate below na natural level since 2010

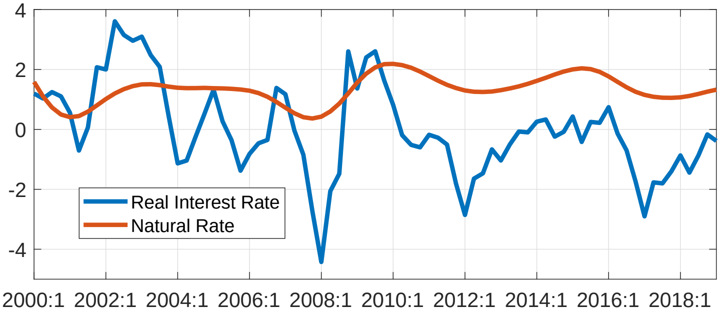


Figure: Natural Interest Rate and Real Interest Rate (in percent p.a.)

Findings (cont.)

- Potential GDP growth offset by real eq. appreciation
- Relative stable natural rate of interest

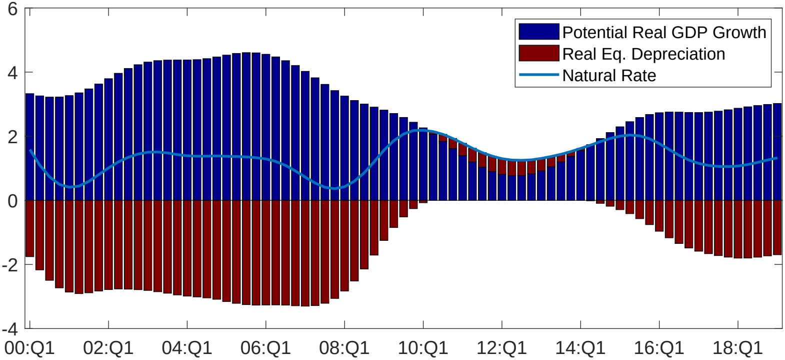


Figure: Decompostion of Natural Interest Rate (in p.p.)

(RER positive bars – depreciation, negative bars appreciation).

Identification Checks

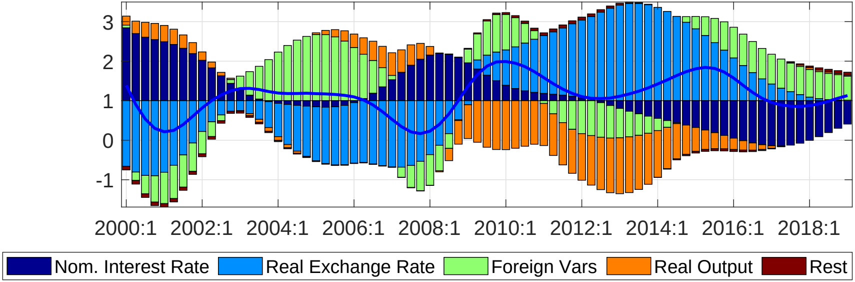


Figure: Natural Interest Rate and its Decomposition to Observed Variables (contributions in percentage points)

Robustness Checks

- The estimate of the natural rate of interest is subject to uncertainty.
- The confidence band capturing 90 percent is wide about ±100 basic points

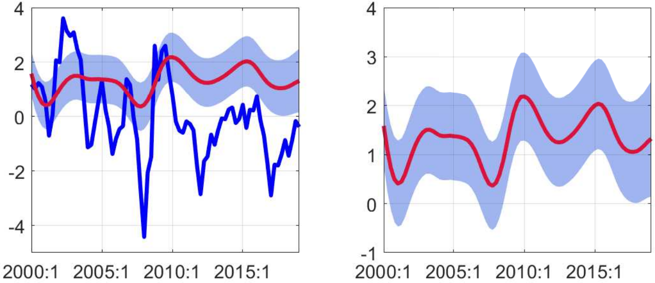


Figure: Natural Interest Rate with Confidence Bands (in percent p.a.)

Comparison

- The estimate of the natural rate of interest deviates from estimates based on LW and common univariate filters.

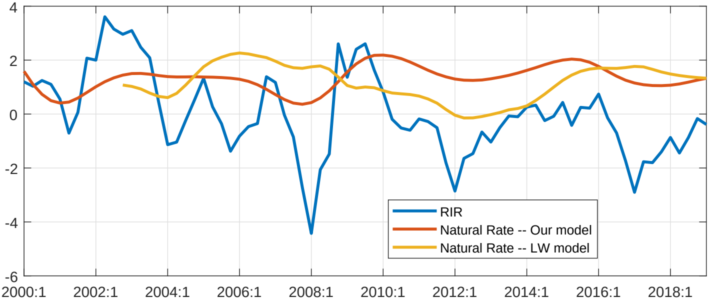


Figure: Natural Interest Rate – Comparison of our model and LW based estimates (in percent p.a.)

Summary

- LW approach is useful for the closed economy case and needs to be modified to reflect country openness.
- Small open economy – The natural rate driven by the equilibrium (potential) real growth adjusted by equilibrium real exchange rate depreciation.
- If faster equilibrium growth accompanied by equilibrium real exchange appreciation, the natural rate might be relatively stable

- A semi-structural model is used to identify the natural interest rate in the Czech economy.
- The natural interest rate hovers around 1 percent nowadays.
- Estimates subject to uncertainty.

Thank you

Thank you for your attention

Backup slides

Robustness Checks

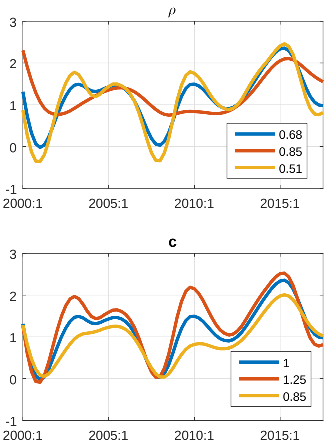


Figure: Robustness with respect to parameters)