

# Estimation and assessment of measures of the natural rate of interest: Evidence from LA economies with inflation targeting

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Workshop 2: Tax and interest rates

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# Introduction

- Era of low interest rates since the global financial crisis, specially in advanced economies, promoted research on the natural rate of interest (NRI).
- Recent period of high inflation has pushed back to higher interest rates.
- Key references: Laubach y Williams (2003) and Woodford (2003).

# Introduction

## The natural rate of interest (NRI)

- K. Wicksell (1898): The natural rate of interest (NRI) is the rate compatible with a stable price level.
- If  $r_t > r_t^n$ , lower output and lower prices, and viceversa.
- Woodford (2003) and New Keynesian framework:
  - NRI relates to productivity shocks, consumers' preferences.
  - Taylor rule to achieve NRI and price stability.

# Introduction

## Usefulness of the NRI

- NRI is useful for monetary policy and financial stability:
  - To determine the stance of monetary policy: if the real short-term interest rate is below (above) the NRI, then monetary policy is expansive (contractive)
  - To assess potential threats to financial stability: excessive risk-taking if real interest rates  $<$  NRI.
- **Fundamental problem:** NRI is unobservable.

# Introduction

Literature review: Alternative approaches to estimate NRI.

- Univariate filters (HP) or multivariate filters (Kalman filter), combined with theoretical relationships (Laubach y Williams, 2003; Holston et al., 2017, among others).
- Econometric models: TVP-VAR with stochastic volatility (Lubik y Matthes, 2015; Wang y Kwan, 2021, among others) and cointegration (Benati, 2020, 2023).
- Estimation and/or calibration of theoretical models (Doojav and Gantumur, 2020; Zhang et al., 2021). DGSE models (Giammarioli and Valla, 2004; Barsky et al., 2014).
- Borio (2021): indicators of expectations of market participants: e.g. a real forward rate (not control by the CB).

# Introduction

## Objective

- Estimate and assess two measures of the NRI for Chile and Peru (LATAM, IT).
- Estimation:
  - Time-varying parameter vector autoregression model with stochastic volatility (TVP-VAR-SV), Lubik y Matthes (2015).
  - M1 velocity is the permanent component of the real interest rate Benati (2020, 2023).
- Assessment: Transitory shocks do not affect NRI in the long run

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# Methodology

- Estimation of NRI: TVP-VAR-SV and Money Velocity
- Assessment: SVAR with long-run restrictions.

# Methodology

## Estimation: TVP-VAR-SV

- Proposed by Lubik y Matthes (2015): the rate of growth of GDP, inflation and ex ante real interest rate.
- Bayesian techniques as in Primiceri (2005) and Del Negro y Primiceri (2015).
- The NRI is the conditional long-run (5-year) forecast of the observed ex ante real interest rate.

# Methodology

## Estimation: TVP-VAR-SV

- Let  $y_t = (g_t, \pi_t, r_t)'$  and 2 lags (TVP-VAR convention). Then:

$$y_t = c_t + B_{1,t}y_{t-1} + B_{2,t}y_{t-2} + u_t \quad t = 1, \dots, T. \quad (1)$$

- $u_t \sim N(0, \Omega_t)$
- $c_t, B_{1,t}, B_{2,t}$  and  $\text{Var}(u_t) = \Omega_t$  are time varying.
- The variance covariance matrix  $\Omega_t$  is decomposed as:

$$\Omega_t = A_t^{-1} \Sigma_t \Sigma_t' A_t^{-1'}$$

# Methodology

## Estimation: TVP-VAR-SV

- Details of  $\Omega_t = A_t^{-1} \Sigma_t \Sigma_t' A_t^{-1'}$ :

$$A_t = \begin{pmatrix} 1 & 0 & 0 \\ \alpha_{21,t} & 1 & 0 \\ \alpha_{31,t} & \alpha_{32,t} & 1 \end{pmatrix}, \quad \Sigma_t = \begin{pmatrix} \sigma_{1,t} & 0 & 0 \\ 0 & \sigma_{2,t} & 0 \\ 0 & 0 & \sigma_{2,t} \end{pmatrix}$$

- Then, TVP-VAR-SV can be written as:

$$y_t = c_t + B_{1,t} y_{t-1} + B_{2,t} y_{t-2} + A_t^{-1} \Sigma_t \varepsilon_t, \quad t = 1, \dots, T.$$

where  $\text{Var}(\varepsilon_t) = I_n$ .

# Methodology

## Estimation: TVP-VAR-SV

- In compact form:  $y_t = X_t' B_t + A_t^{-1} \Sigma_t \varepsilon_t$ .
- It is assumed that the time varying parameters follow random walk processes:

$$B_t = B_{t-1} + v_{B,t}$$

$$\alpha_t = \alpha_{t-1} + v_{\alpha,t}$$

$$\log \sigma_t = \log \sigma_{t-1} + v_{\sigma,t}$$

where  $u_t, v_{B,t}, v_{\alpha,t}, v_{\sigma,t}$  are mutually independent.

# Methodology

## Estimation: TVP-VAR-SV

- Assumptions:
  - Initial states for the coefficients, the covariances, log volatilities and hyperparameters are independent of each other.
  - Priors for the hyperparameters  $Q$ ,  $W$  and the blocks of  $S$  are distributed as independent inverse-Wishart.
  - Normal priors on the entire sequences of  $B's$ ,  $\alpha's$ , and  $\log \sigma's$  (conditional on  $Q$ ,  $W$ , and  $S$ ).
- Posterior distributions of  $B$ ,  $A$ , and  $\Sigma$  and  $V$  are evaluated using Gibbs sampling as in [Del Negro and Primiceri \(2015\)](#).

# Methodology

## Estimation: TVP-VAR-SV

- The first 6 years to calibrate the priors distributions.
- Following Wang y Kwan (2021), draw 10,000 samples from the posterior distribution, discard first 2,000 samples (chain should converge).
- NRI is the conditional 5-year (long run) forecast of the observed ex ante real interest rate:

$$r_t^* = (0, 0, 1) * E_t(y_{t+20}) = (0, 0, 1) * X_t' \beta_t^{20}$$

# Methodology

## Estimation: M1 velocity

- Benati (2020): M1 velocity is, approximately, the permanent component of the short-term rate.
- Implication: Decision of wealth allocation to non interest-bearing M1, react to permanent shocks to the opportunity cost, essentially ignoring transitory shocks.
- Then, M1 velocity can be considered as a reliable estimate of the nominal NRI Benati (2023).
- Estimation of NRI based on Cochrane (1994): permanent component of GDP from consumption information.



# Methodology

## Estimation: M1 velocity

- The permanent component of the nominal NRI,  $R_t^P$ , is determined by permanent shocks to inflation,  $\pi_t^P$ , and to real NRI  $r_t^N$ :

$$R_t^P = \pi_t^P + r_t^N$$

- Under IT, permanent changes in M1 velocity reflect permanent fluctuations in the NIR, and thus:

$$V_t = \beta_1 + \beta_2 r_t^N + v_t$$

# Methodology

## Estimation: M1 velocity

- A two-step procedure:
  - Project the monetary policy rate on M1 velocity and get estimated nominal NR.
  - Real TNI = estimated nominal TNI and the inflation target (or average inflation).
- Econometrically: (i) Cointegrated VAR as in Cochrane (1994), (ii) Projection using OLS regression.

# Methodology

## Assessment: SVAR with long-run restrictions

- Criterion: the NRI does not react to transitory shocks (shocks that have no long-run effect on real interest rate).
- Estimation of a two-variable VAR for the ex-ante real interest rate  $r_t$  and  $r_t^N$ .
- Identification of transitory and permanent shocks: a transitory shock has no effect on the ex ante real interest rate in the long-run.
- $r_t^N$  is a good NRI measure if (i) the response of  $r_t^N$  to a transitory shock is close to zero, and (ii) the contribution of the transitory shock to the variance of  $r_t^N$  is very small.

# Methodology

## Assessment: SVAR with long-run restrictions

- The VMA representation for  $\Delta r_t$  and  $\Delta r_t^N$  in terms of fundamental innovations can be written as:

$$\begin{bmatrix} \Delta r_t \\ \Delta r_t^N \end{bmatrix} = \begin{bmatrix} \bar{r} \\ \bar{r}^N \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{t-i}^P \\ \varepsilon_{t-i}^T \end{bmatrix} \quad (2)$$

- Identification using a long-run restriction (Blanchard and Quah, 1989): an innovation to  $\varepsilon_t^T$  has no long-run effect on the ex ante real interest rate, i.e.  $\sum_{i=0}^{\infty} \phi_{12}(i) = 0$ .

# Methodology

## Assessment: SVAR with long-run restrictions

- $r_t^N$  is a good NRI measure if:
  - i Cumulative IRF to  $\varepsilon_t^T$  shocks is close to zero:  $\sum_{i=0}^{\infty} \phi_{22}(i) \rightarrow 0$ .
  - ii The contribution of  $\varepsilon_t^T$  shocks to fluctuations in  $r_t^N$  is close to zero.

# Data

## TVP-VAR-SV

- The data obtained from the corresponding central banks.
- Peru: 1995Q4-2023Q2 for Peru, Chile: 1997Q1-2023Q2.
- Series: real GDP growth, the ex-ante real interest rate, and inflation.
- Real GDP growth: percentage changes on year-over-year basis.
- Inflation: annual growth rate of CPI excluding food and energy.

# Data

## TVP-VAR-SV

- The ex-ante real interest rate: policy interest rate minus inflation expectations (four-quarter moving average of past inflation).
- 24 quarters used as the presample to calibrate priors and include 2 lags in the VAR, the estimated NRI starts in 2002Q2 for Peru and 2003Q3 for Chile.
- The estimation of TVP-VAR-SV was performed in R using the package “bvarsv” Krueger (2022).

# Data

## Money velocity

- Real interest rate as the difference between nominal interest rate and the inflation target.
- M1 velocity is the ratio between nominal GDP and M1.

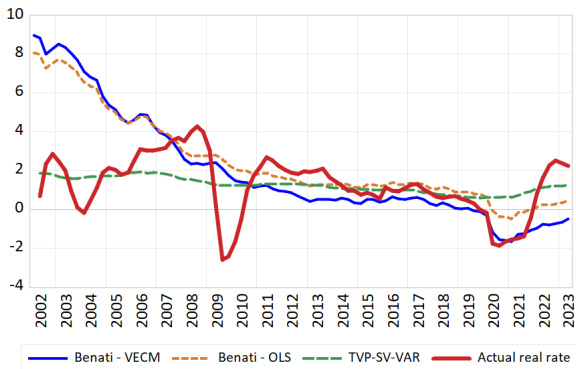


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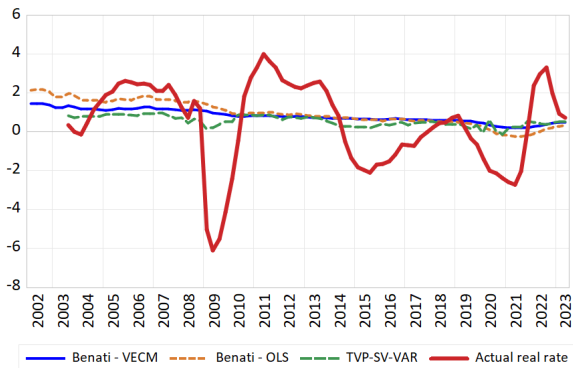
# Results

Estimation of the NRI: Peru, 1995Q4-2023Q2.



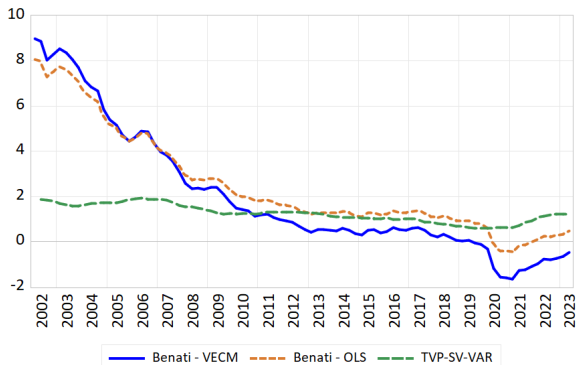
# Results

Estimation of the NRI: Chile, 1997Q1-2023Q2.



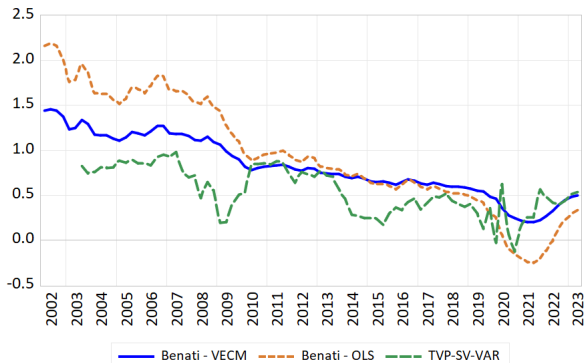
# Results

Estimation of the NRI: Peru, 1995Q4-2023Q2.



# Results

Estimation of the NRI: Chile, 1997Q1-2023Q2.



# Results

Assessment: Cumulative IRF after a transitory shock.

Table. NRI estimates for Perú: Cumulative IRF

Quarter	Benati-VECM	Benati-OLS	TVP-VAR-SV
1	-0.04*	-0.03*	0.01*
2	0.00	0.00	0.01
3	0.04	0.04	0.01
4	0.09	0.07	0.01
8	-0.01	-0.01	0.00
20	0.00	0.00	0.00

# Results

Assessment: Variance decomposition.

Table. NRI estimates for Peru: Variance decomposition

Quarter	Benati-VECM	Benati-OLS	TVP-VAR-SV
1	2.98	2.98	16.99
2	4.49	4.49	10.78
3	7.37	7.37	10.10
4	9.96	9.96	9.69
8	17.43	17.43	10.38
20	17.86	17.86	10.44

# Results

Assessment: Cumulative IRF after a transitory shock.

Table. NRI estimates for Chile: Cumulative IRF

Quarter	Benati-VECM	Benati-OLS	TVP-VAR-SV
1	-0.02*	-0.04*	0.04*
2	-0.02*	-0.05*	0.04*
3	-0.01	-0.01	0.01
4	0.00	0.01	0.02
8	0.01	0.01	0.00
20	0.00	0.00	0.00



# Results

Assessment: Variance decomposition.

Table. NRI estimates for Chile: Variance decomposition

Quarter	Benati-VECM	Benati-OLS	TVP-VAR-SV
1	42.66	42.66	5.74
2	36.89	36.89	5.12
3	48.59	48.59	8.38
4	49.31	49.31	8.32
8	48.68	48.68	8.67
20	49.56	49.56	8.69

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## Conclusions

- We estimated and assessed two measures of NRI for Chile and Perú: (i) TVP-VAR-SV Lubik y Matthes (2015), and (ii) M1 velocity Benati (2023).
- Assessment based on identification of transitory shocks to real interest rate.
- Criterion: NRI does not react to transitory structural shocks (IRF, VD).
- Both are good measures, TVP-NRI measures are relatively superior.

# Conclusions

## The agenda

- Include Brazil, Colombia, and Mexico.
- Assess other measures, e.g. Laubach y Williams (2003) and Holston et al. (2017).
- Include alternative NRI measures for Peru.

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# Estimation and assessment of measures of the natural rate of interest: Evidence from LA economies with inflation targeting

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