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Natural interest rate in Brazil: further evidence from an AR-trend-bound model

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Abstract

The main objective of this study is to estimate the natural interest rate for Brazil using a parsimonious AR-trend-bound model proposed by Chan, Koop and Potter (2013). This model considers a time varying autoregressive process for the interest rate gap (difference between real interest rate and natural interest rate) and stochastic volatility (time-variant uncertainty). The interest rate gap measures the monetary policy stance. Furthermore, the unobserved latent states are limited, which can help to reduce the uncertainty regarding the estimation of these variables. This method presents plausible results for the Brazilian case. The average natural interest rate is around 5.41% p.a. The interest rate gap is positive until mid 2009, which indicates a restrictive policy for the period. Since then, the gap has had predominantly negative values, which indicates an expansionist policy. This result is consistent with the dynamics of the Brazilian economy.

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1. Introduction

The Brazilian interest rate is often cited as being excessively high and is, in fact, higher than the rates prevailing in other emerging economies. Several hypotheses have been identified to explain the high level of real interest rates in Brazil; these include the multiple objectives of using the real interest rate as an instrument of policy; the existence of multiple equilibria (Bresser-Pereira and Nakano, 2002); the fiscal structure and labor structure of the Brazilian economy (Arida, 2003); and jurisdictional uncertainty (Arida et al, 2004), among others.

In this context and in light of the fact that Brazil has had an inflation-targeting regime since June 1999, knowing the natural rate of interest is crucial to the Central Bank, since this is the rate that is consistent with a neutral monetary policy. According to the Keynesian theory (Clarida et al., 1999; Woodford, 2003), the natural rate of interest is the rate which equals the aggregate demand of the economy to in relation to its natural rate of product or, yet, the rate that should prevail if prices were perfectly flexible. Therefore, the natural rate of interest can be viewed as an equilibrium rate. According to Amato (2005), the natural rate of interest is a key indicator of an appropriate monetary policy in a regime of inflation targeting, since the adoption of an expansionary or contractionary monetary policy depends on the interest rate gap, i.e., whether the current interest rate is below or above, respectively, the natural rate.

Despite its importance, there is great difficulty to measure the natural interest rate, because it is an inherently unobservable variable. Specifically for the Brazilian case, some empirical studies have been done. Ribeiro and Teles (2013) used the Kalman filter and the Laubach and Williams (2003) model to estimate the natural rate of interest in Brazil, and found an average annual rate 8.21%. By analyzing the interest rate gap, the authors conclude that the Central Bank was more conservative between 2001 and 2005, but more recently adopted a relatively neutral policy. Borges and Silva (2006) used a structural VAR (SVAR) model to estimate a monthly series of the natural rate interest during the period 2000 to 2003 and have found the value of 10% p.a. Muinhos and Nakane (2006) used various approaches to estimate the natural interest rate; the results were quite sensitive to the approach used, which, according to the authors, is justified by the short time available. Estimates for the Brazilian natural real interest rate ranged between 4.6% p.a. and 20% p.a. Barcellos and Portugal (2009) used a simplified macroeconomic model in state-space format for the period 1999-2005. The results showed an average natural interest rate of around 9.62%. The minimum estimated rate was 5% (in late 2003), the highest, 12.5% (in mid-2005). The authors conclude that, on average, the monetary authority cannot be classified as conservative in the period. Umezu (2011) used Bayesian methods to estimate the natural interest rate in Brazil during the period 2001 to 2010 and found the value of 5%p.a. Araújo and Silva (2013) used statistical filters and state space models for the period 2002 to 2012. The results showed a natural interest rate of around 3.5%p.a. Magud and Tsounta (2012) used various methodologies (static and dynamic) and found an average natural interest rate of 5.1% in May 2012. Siqueira (2011) measures natural interest rate during 1999 to 2010 using basically the Kalman Filter. The results showed a natural rate between 6%p.a. and 7%p.a.

Thus, the importance of estimating the natural rate of interest in the Brazilian economy in the post-inflation targeting period is clear. The innovation of this study lies in the use of a new method related to statistical filters and unobserved component models for estimating the natural rates. The method used is the AR-trend-bound model proposed by Chan, Koop and Potter (2013) for inflation forecasting. The proposed model restricts

the trend variable and the time-varying AR coefficient to lie within bounds, which contributes to reducing uncertainty regarding the estimation of this variable. The model consists of an AR(1) for the interest rate gap (interest rate − natural interest rate, interpreted here as the trend in interest rates), and stochastic volatility in the error term. The unobserved latent states are treated as random walks.

Therefore, the main objective of this study is to estimate the natural rate of interest for the Brazilian economy in the post inflation targeting period (July 2001 to December 2015), using the AR-trend-bound model proposed by Chan, Koop and Potter (2013). Furthermore, we can assess the conduct of the monetary policy of the Central Bank of Brazil in the period analyzed, verifying whether it was in fact "extremely conservative," as often labeled. The Bayesian estimation is particularly interesting for the Brazilian case, since it allows to compensate for the small sample through information provided estimated similar models for other countries (Silveira, 2008).

The remainder of this paper is organized as follows. In section 2, we present the AR-trend-bound model. In section 3, we describe the data used and the chosen priors. Section 4 presents the results and section 5 is dedicated to the conclusions.

2. AR-trend-bound model with stochastic volatility

The model used in this paper was proposed by Chan, Koop and Potter (2013) for USA inflation forecasting. In this study, we use this model for estimating the natural real interest rate for Brazil after implementation of the inflation-targeting regime. The natural interest rate is interpreted as the interest rate trend, which is an unobserved latent variable in the model. The model is defined by equations (1) to (7).

$$r_t - \tau_t = \rho_t(r_{t-1} - \tau_{t-1}) + \varepsilon_t \exp(\tfrac{h_t}{2}) \quad (1)$$

$$\tau_t = \tau_{t-1} + \varepsilon_t^{\tau} \quad (2)$$

$$\rho_t = \rho_{t-1} + \varepsilon_t^{\rho} \quad (3)$$

$$h_t = h_{t-1} + \varepsilon_t^{h} \quad (4)$$

$$\varepsilon_t^{\tau} \sim TN(a - \tau_{t-1}, b - \tau_{t-1}; 0, \sigma_{\tau}^2) \quad (5)$$

$$\varepsilon_t^{\rho} \sim TN\left(-\rho_{t-1}, 1 - \rho_{t-1}; 0, \sigma_{\rho}^2\right) \quad (6)$$

$$\varepsilon_t^{h} \sim N(0, \sigma_h^2) \quad (7)$$

where r_t is the real interest rate, τ_t is the natural interest rate, ρ_t is the time-varying autoregressive coefficient. The variables τ_t (interest rate trend), ρ_t (first order autoregressive coefficient) and h_t (interest rate volatility) are the unobserved latent states of the model. τ_t, and ρ_t are limited by assuming the truncated normal distribution for the error term (equations (5) and (6)). The notation $TN\left(a, b; 0, \sigma^2\right)$ refers to the truncated normal distribution within of the limits *a* and *b*, with zero mean and variance given by σ^2 parameter. The limits *a* and *b* are defined a priori.

3. Data and priors

All data is measured in monthly frequency, covering the period July 2001 to December 2015, totaling 174 observations. We used for the estimation the real SELIC[1] rate ex ante (nominal SELIC deflated by the IPCA[2] accumulated for 12 months). The data are described below.

- Annualized inflation rate (IPCA): IPCA over 12 months (percentage variation). Source: IBGE (Brazilian Institute of Geography and Statistics).
- Nominal interest rate (annualized SELIC rate). Source: Central Bank of Brazil.

It is necessary to define priors for the initial values for the state equations and for the parameters model. We follow the same priors adopted in Chan, Koop and Potter (2013), which are basically non-informative priors. The chosen priors are presented in Table 1 and Table 2. The limits (bounds) for the interest rate trend are a = 4 and b = 10.

Table 1. Priors: initial values for the state equations

Distribution	Parameters
$\tau_1 \sim TN(a, b; \tau_0, \varpi_\tau^2)$	$\tau_0 = 5;\ \varpi_\tau^2 = 5$ $a = 4\ ;\ b = 10$
$\rho_1 \sim TN(0,1; \rho_0, \varpi_{\rho\pi}^2)$	$\rho_0 = 0;\ \varpi_\rho^2 = 5$
$h_1 \sim N(h_0, \varpi_h^2)$	$h_0 = 0;\ \varpi_h^2 = 5$

Table 2. Parameters priors

Parameter	Description	Prior
σ_τ^2	Error variance (interest rate trend)	Inverse Gamma (10; 0,18) $\sqrt{E(\sigma_\tau^2)} = 0{,}141$
σ_ρ^2	Error variance (AR(1) coefficient)	Inverse Gamma (10; 0,009) $\sqrt{E(\sigma_\rho^2)} = 0{,}0316$
σ_h^2	Error variance (interest rate volatility)	Inverse Gamma (10; 0,45) $\sqrt{E(\sigma_h^2)} = 0{,}224$

[1] The SELIC rate (Special System for Settlement and Custody) is the main instrument of monetary policy in Brazilian inflation-targeting regime.
[2] The IPCA—Broad National Consumer Price—is the official inflation index in Brazil.

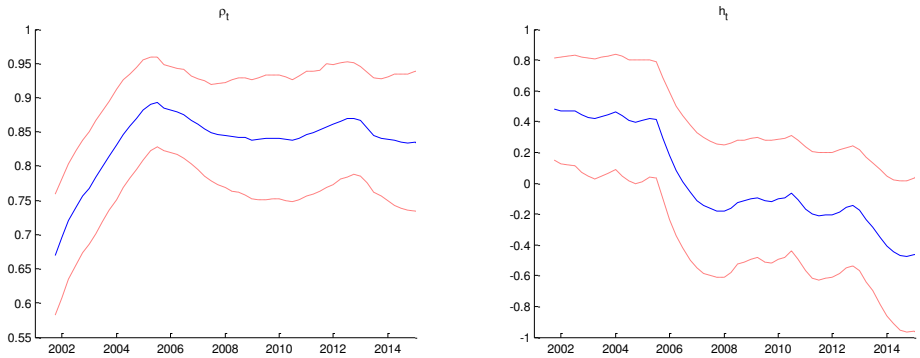
4. Results

The model presented in the previous section was estimated by the algorithm developed by Chan, Koop and Potter (2013)[3]. The results are based on 35000 draws from the algorithm after a burn-in period of 5000. The results are presented in Figure 1, which plots the smoothing values for the unobserved variables of the model[4], i.e., τ_t (natural interest rate), ρ_t(AR coefficient), h_t (stochastic volatility).

Figure 1. Smoothing estimates for unobserved variables

a) Natural interest rate

b) Time varying AR coefficient and stochastic volatility



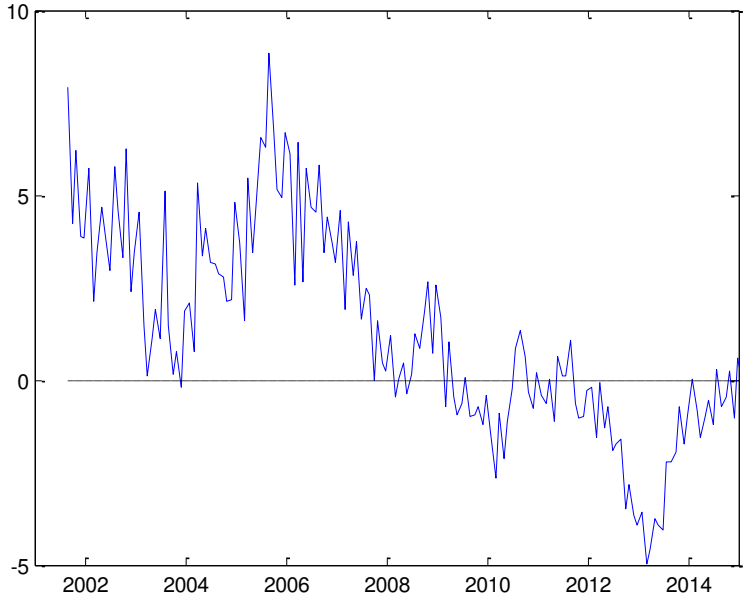
Source: Calculated by authors

[3] This algorithm is adapted from Chan and Strachan (2012). For details, see Chan, Koop and Potter (2013).

[4] The estimates based on information available up to the end of the sample (T).

The results point to a downward trend in the natural interest rate (average of 5.41% p.a. in the period). The average of the natural rate is consistent with the results found by the Central Bank of Brazil Survey (2012), which indicates a natural interest rate of 5.5% among market experts. The estimates of ρ_t, i.e., the time varying AR coefficient, are close to 1. Thus, the interest rate is very persistent, which is consistent with the interest rate smoothing behavior of the Central Bank of Brazil (or policy inertia). The figure 2 presents the interest rate gap, i.e., the difference between real SELIC rate and the natural rate. This gap measures the monetary policy stance.

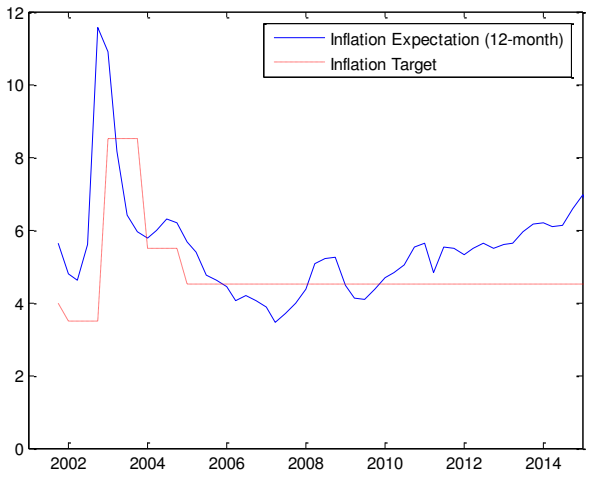
Figure 2. Interest rate gap



Source: Calculated by authors

The behavior of the interest rate gap is very interesting. The gap is positive until mid-2009. Since then, the gap takes predominantly negative values. Therefore, this result indicates that monetary policy in Brazil was conservative until 2009 and it has become expansionary thereafter. This result is very plausible for the Brazilian case. Figure 3 presents the graph of the inflation expectations 12-month ahead and the inflation target. The inflation expectations have remained persistently above of the inflation target since 2010, which is compatible with an expansionary monetary policy and a minor concern about inflation by the Central Bank. This period corresponds to the "Tombini era" of the Central Bank of Brazil, which has often referred to as an era with improved growth and a more lenient inflation rate.

Figure 3. Inflation Expectation and the Inflation Target[5]



Source: Data from Central Bank of Brazil

Table 3 presents the results for some others studies in the literature related to Brazil. Barcellos and Portugal (2007) found an average rate of 9.62% p.a. and Ribeiro and Teles (2013) found a downward trend for the natural interest rate, but only in recent years. It should be emphasized that previous studies mostly encountered volatile results for the series of the natural interest rate. Importantly, this result (downward trajectory and low volatility) is new for the Brazilian case and is consistent with the current perception of many market analysts (Bittencourt and Pinto, 2012). Moreover, our estimate of the natural rate of interest is very close to those provided by the private agents. The survey of analysts of the Central Bank of Brazil found a value of 5.5% p.a. for the natural interest rate perceived by the market.

Table 3. Comparison with some previous studies

Authors	**Period**	**Methodology**	**Natural interest rate mean**
Borges and Silva (2006)	Sept 2000 to Dec 2003	Structural vector autoregressive model	9.97% p.a.
Muinhos and Nakane (2006)	2000 to 2004	HP Filter	10% p.a.
Barcelos and Portugal (2009)	Sept 1999 to Sept 2005	Kalman Filter	9.62% p.a.
Ribeiro and Teles (2013)	2001 Q4 to 2010 Q2	Kalman Filter	8.21% p.a.
Umezu (2011)	Jan 2001 to Mar 2010	Bayesian methods	5%p.a.
Siqueira (2011)	1999 Q1 to 2011Q1	Kalman Filter	7%p.a.
Magud and Tsounta (2012)	2000 to 2013	Static and dynamic methodologies	5.10% p.a.
Araújo and Silva (2013)	2002 to 2012	Statistical filter and state space model	3.5%p.a.
This study	Jul 2001 to Dec 2015	AR-trend-bound model	5.41% p.a.

[5] For the years 2003 and 2004, we used the adjusted targets.

5. Conclusions

The purpose of this study was to estimate the natural interest rate for Brazil using a parsimonious AR-trend-bound model proposed by Chan, Koop and Potter (2013). It is difficult to estimate natural rates since they are unobservable variables. Several methodologies have been used for estimating natural rates, from statistics filters (HP filters) to macroeconomic models (for example, Dynamic Stochastic General Equilibrium models). In this paper, we used the AR-trend-bound-model for estimating natural interest rate; the results obtained were plausible. The proposed methodology is related to both i) the use of statistical filters (because it aims to estimate the trend in interest rates) and ii) unobserved components models (providing confidence intervals for the estimates). Both methods are often used to estimate natural rates and explore the statistical properties of the data. The natural interest rate is interpreted as the trend component of the SELIC rate (long-term real interest rate) and may be considered as a long-term interest rate anchor for monetary policy. The AR-trend-bound model considers a time varying autoregressive process for the interest rate gap (real interest rate − natural interest rate) and stochastic volatility. Furthermore, the unobserved latent states are limited, which can help reduce the uncertainty regarding the estimation of these variables. The results point to a downward trend in the natural interest rate (average of 5.41% p.a. in the period). Still, based on an assessment of the interest rate gap, one can say that the Central Bank adopted a conservative policy until mid-2009, while aiming to reduce inflation and strengthen its credibility, which is consistent with the inflation-targeting regime. Since 2009/2010, however, the interest rate gap is negative, indicating an expansionary monetary policy more lenient with inflation. The results indicate that the falling trajectory of the SELIC adopted by the Central Bank in the recent period is not consistent with the objective of reducing inflation; in other words, Central Bank failed to be vigilant vis-à-vis price stability. Indeed, the Brazilian inflation rate has remained above the inflation target center in a sustained manner in the period, thus corroborating the results found in this work.

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