The Natural Rate of Interest for an Emerging Economy: The Case of Uruguay

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Abstract

Vast evidence indicates that the so-called natural rate of interest has experienced a sustained fall in both advanced and emerging economies over the last 25 years. This situation threatens the central bank's ability to guide relevant macroeconomic variables close to their welfare-maximizing path because the range of maneuver is reduced a great deal when interest rates descend to the zero lower bound. In this document, I try to estimate the natural interest rate (NIR) for Uruguay, a small, open and dollarized emerging economy where monetary policy implementation has changed drastically, splitting the sample in two. The methodological approach is aimed at providing a novel framework for analyzing the long-run fundamentals of the NIR and also for explaining the reasons for short-run discrepancies between the real rate and its long-run equilibrium value. It is hoped that the fundamentals-based model adds to the myriad methods current in use at the Banco Central del Uruguay to estimate the NIR.

Keywords: interest rate determination, monetary policy, Uruguay.

JEL Classification code: C10, E43, E52.

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1. INTRODUCTION

The concept of "*natural interest rate*" (NIR) has recently been an increasingly important focus of both academics and policymakers. There are different definitions of the NIR based on theoretical components of particular emphasis. Perfect flexibility in prices and wages, closed output gap, full employment, among other factors, are the ideas related to the NIR. A satisfactory definition of the natural interest rate (also called *neutral* interest rate or simply r^* in this document) is the level of the short-run real interest rate that is consistent with output near its potential and inflation near its target (Laubach and Williams, 2003). Through the *interest rate gap,* the natural interest rate is a key variable in the definition of the monetary policy stance. The interest rate gap is measured as the difference between the current real interest rate and the natural interest rate. As such, a negative interest rate gap would indicate an expansionary stance, while a positive interest rate gap would indicate a contractionary stance, very appropriate if the economy is experiencing inflation. Assessing the interest rate gap in order to monitor the effectiveness of monetary policy is applied according to central bank´s differing regimes, that is, either the central bank is conducting an interest-rate management scheme or a money-targeting one. In an interest-rate scheme, the interest rate is the policy instrument, and the central bank can be made directly accountable; in a money-targeting framework, although interest rates are endogenous, they still have a central role in the transmission of monetary policy. In both cases, the central bank prefers to fix/to induce real interest rates as close as possible to the natural interest rate in order to approximate relevant economic variables (output, inflation, etc.) to their welfare-maximizing path.

In recent years and primarily in advanced economies since the 2008 crisis, natural interest rates have been at historically low and even negative levels. That is worrying because it challenges central banks to perform monetary policy near the zero lower bound. Some emerging economies have also experienced this situation. Researchers point to an increase of savings, a decrease of investment, or a combination of these factors. Population dynamics, for instance, could be an explanation because an aging population may increase the propensity to save and raise the supply of funds, causing the natural interest rate to fall. Additional factors at play may include negative productivity perspectives which may reduce new business opportunities and decrease the agent´s willingness to invest, reducing the natural interest rate.

In 1898 and 1906 works, Knut Wicksell coined and developed the terms "*market rate*" and "*natural interest rate*". With the first term, he referred to the effective value of the real interest rate; with the second, he referred to an equilibrium value of the same variable. As Leijonhufvud[1] points out, the term "natural" is framed within what would be a "natural" monetary system, that is, "*a monetary system in which all relative prices develop as they would be in a hypothetical world without paper money*." Wicksell points out three conditions of equilibrium that the interest rate should meet, the first of which being that the market rate should equal the rate that would prevail if the capital goods were borrowed *in natura*. The other two conditions refer to savings-investment coordination and price stability.

The interest rate must coordinate the savings decisions of households with decisions of corporate investment and, in addition, must balance the supply and the demand of credit. If the supply of credit always coincided with the savings of the families and the demand for credit with the investment, both functions of the interest rate could be fulfilled simultaneously. But this relationship between saving and investment on the one hand and supply and demand for credit on the other does not necessarily occur. The presence of the banking system leading the creation of money can establish a gap between saving and investment, occurring when banks set a market rate lower than the "natural" rate necessary for the coordination of real activities. As a result, inflation and endogenous growth of the money supply will be observed as long as the market rate is below the natural rate.

In standard models, the *steady state* natural rate of interest[2] is determined for the marginal product of capital so that in the long run,

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1 Leijonhufvud, Axel (1989).

2 The steady state is a situation of the national economy predicted by some classical economists (especially David Ricardo and RT Malthus) that would be reached in the long run when the profitability of productive investment was so low, because of the need to cultivate increasingly poor quality land to produce food, that the stimulus to invest would disappear. At that time, when the net investment was zero, the process of capital accumulation and population growth would stop and the steady state would have been reached. For Daly (1989) that state "is neither static nor eternal; it is a system

monetary policy has no effect on the real rate of return. Even in those models, where money is not superneutral[3], the effect of inflation on the real return of equilibrium is small. However, in the medium and short term, monetary policy can create gaps between the market rate and the natural rate, thus producing real effects.

The European Central Bank has defined the natural interest rate as "the real short-term rate that is consistent in the long run (...) with the product at its potential level and with a stable inflation rate"[4]. In this way, NIR could be considered as that steady state interest rate, consistent with a balanced growth path.

But the natural rate of interest is not observable and must be inferred from quantitative methods. In spite of the difficulties inherent in the measurement of an unobservable economic variable, the person in charge of conducting monetary policy needs to have some reliable estimate of the NIR, since it should be used as a reference when evaluating the monetary policy that is being implemented. Moreover, the NIR varies over time in response to different real shocks, either structural (e.g. potential output growth, demographics, a country's saving profile) or transitory (e. g. macroeconomic shocks[5]), which constitutes an additional challenge.

No single method best estimates the natural interest rate. Most of them are static (defining the NIR as a parametrized, steady state point estimate) while others are dynamic (estimating the temporal path of NIR). The former group includes the consumption-smoothing models and the uncovered interest rate parity condition. The latter group includes simple statistical filtering techniques – such as Hodrick-Prescott filters, linear de-trending, and moving averages –, real interest rates and maximum likelihood estimation as well as DSGE models and small-scale macroeconomic models which are estimated using a Kalman filter. Each method has advantages and limitations, but no one is preferred over the others. As a result, it seems plausible to apply a battery of models to estimate the natural interest rate and to present a consisted estimated range of values of it.

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in dynamic equilibrium within the entropic biosphere that contains and sustains it".

3 Money is superneutral when changes in the growth rate of the money supply have no effect on the growth rate of the real economic variables.

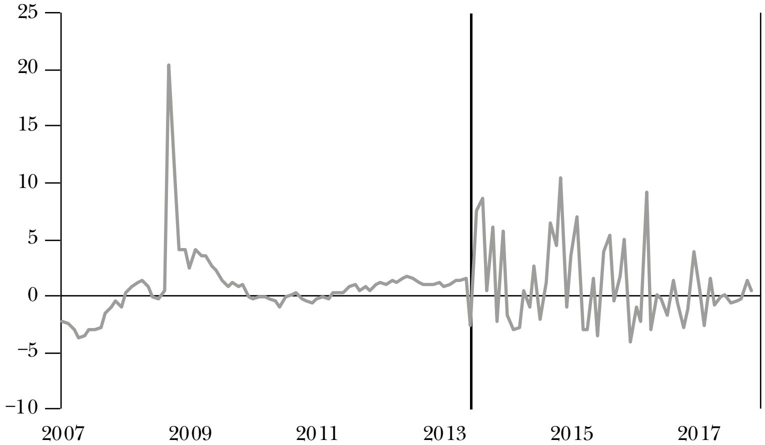
4 Monthly Bulletin, European Central Bank, May 2004.

5 Woodford (2003).

Our definition of the natural rate in this document is based on the nominal policy rate or the targeted interest rate —the overnight interbank rate or call rate—deflated by the 12-month expected inflation. Although in 2013 Uruguay reverted to a money targeting (MT) framework in the context of a disinflation strategy, it is fair to say that the call rate has maintained its relevance as the monetary policy indicator. This regime change, however, affects the estimation strategy and splits the sample in two.

Figure 1

URUGUAY: REAL INTEREST RATE



Note: Overnight nominal interest rate minus 12 month-ahead expected inflation rate. For the 2007M01-2017M12 sample, the mean value is 0.90 and the median value is 0.45. In 2013M06 there was a major change in the monetary policy scheme. Source: Own calculations based on BCU and INE (Instituto Nacional de Estadística) data.

The Uruguayan monetary authority (BCU) routinely uses a range for the NIR that comes from different models and estimation procedures[6]. One of the contributions of this paper relates to the provision of updated estimates for the NIR based on the application of several

[6] See España *et al.* (2010).

filters, the estimation of an augmented Taylor rule and, primarily, the adjustment of a fundamentals-based model. The latter is a novel approach for the Uruguayan case and focuses on the long-run determinants of the NIR—which move slowly, such as demographic characteristics, productivity shifts, financial deepening, and indebtedness profile, among others – and on the short-run shocks that move the short-run rate away from its long-run value. In essence, this is the main contribution of this paper because it presents a framework for understanding the difference between the NIR at short- and long-run equilibrium, clearly defines a rather simple way to estimate the natural interest rate, and provides an explanation for the differences between the long-run and short-run values.

The rest of the document is organized as follows. Section 2 discusses the methodological approach and presents the short-run and medium-run estimates of NIR for Uruguay. Section 3 analyzes the results. The final section concludes.

2. METHODOLOGICAL APPROACH

The natural interest rate is "difficult to estimate and impossible to know with precision".
Alan Blinder (1998)

This section deals with methodological issues related to different estimation approaches applied in this document to the natural interest rate in Uruguay. Many other methods —not presented here— were previously used by other researchers[7].

2.1 Simple methods

There are some rather simple and fast methods used to extrapolate the natural rate of interest in an economy. They can give a prior of the probable value of the NIR but fail to reveal the drivers behind its performance.

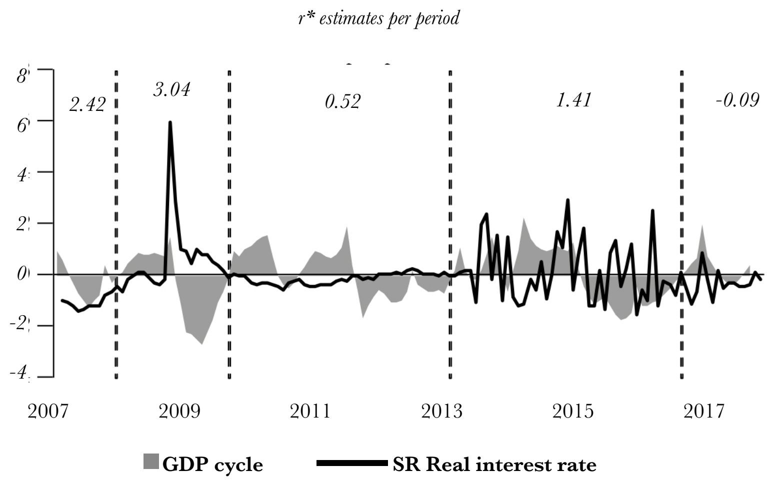
7 España (2008), Bucacos (2010), España et al. (2010), Magud et al. (2012), Lambert (2016).

2.1.1 Averages and trends

Following Carrillo *et al* (2018), a simple indicator of r* in the medium run is the *average* of the ex ante real interest rate over the course of a full business cycle, which is defined here as a completed downturn and upturn of output with respect to its longer-term level (Figure 2).

Figure 2

URUGUAY: *r ESTIMATES PER PERIOD, AVARAGES**



Source: Own estimates based on BCU data.

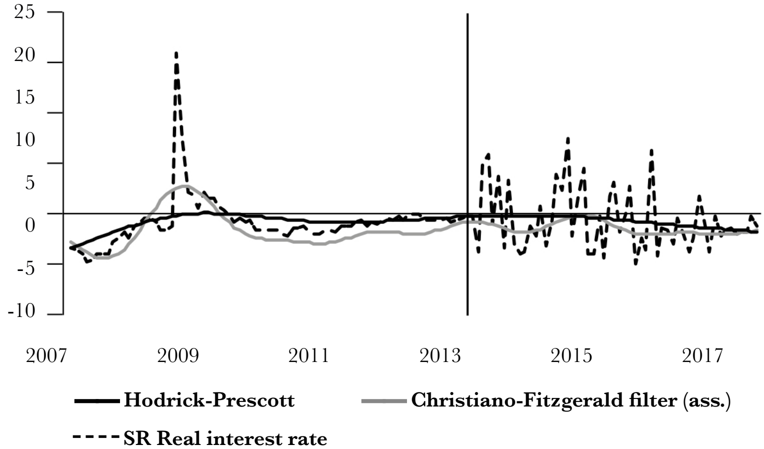
Our estimates show that there have been five full business cycles in the sample. According to this methodology varies substantially in the sample, showing a decline from October 2019 up to the policy regime change in 2013 –from interest-rate management back to money targeting– when the interest rate became endogenous to the system. From the last business cycle that began in September 2016 up until now, the estimate shows smaller and even negative values.

2.1.2 Univariate statistical filters

Another simple approach to estimate is to extract the *long-run component* of the ex ante real interest rate by applying univariate statistical filters such as the Hodrick-Prescott and Christiano-Fitzgerald (CF) ones[8]. Although both methods converge to near-zero values at the end of the sample, the HP trend is smoother, is almost always positive and indicates a declining path since the regime change in 2013; the CF trend is rougher, alternates negative and positive values and is more volatile (Figure 3).

Figure 3

URUGUAY: *r ESTIMATES PER PERIOD, STATISCAL FILTERS**



Source: Own estimates based on BCU and INE data.

The NIR estimates for HP and CF trends are: range, {-2.07%, 1.85%} and {-3.34%, 4.98%}; mean, 0.903 and -0.003; median, 1.08 and -0.36; and standard deviation, 0.798 and 1.679, respectively.

[8] Following Carrillo *et al.* (2018), for the Christiano and Fitzgerald (2003) filter, I use an asymmetric band-pass filter, isolating the cyclical components between 2 and 96 months (which is the usual belief in the length of business cycle); in the case of Hodrick-Prescott filter, I use a smoothing parameter of 14,400.

2.1.3 Augmented Taylor rule

Another method used to infer the natural rate of interest involves the estimation of the central bank´s reaction function or *Taylor rule*[9]. The Taylor principle points out that real interest rates need to increase when (expected) inflation[10] exceeds the target and/or when there is a positive output gap.

The standard Taylor rule is

$$R_t = \rho R_{t-1} + (1-\rho)\left[r^* + \pi^* + \delta\left(\pi_t - \pi^*\right) + \theta \hat{y}_t\right] + \varepsilon_t \quad (1)$$

where R_t is the nominal overnight interest rate, r^* is the natural interest rate, π^* is the target inflation rate, π_t is the inflation rate, $\hat{y}_t$ is the output gap and ε_t captures any change in R_t not explained by the rule. The lag in the nominal interest rate shows that the central bank adjusts its policy rate gradually. The intercept r^* denotes the level of the real interest rate that should prevail when inflation equals the inflation target and the output gap equals zero; that is, it denotes the natural interest rate. As the BCU is reported to pay great attention to the stability of the exchange rate, (1) can be modified to allow the central bank to react whenever the spot exchange rate value differs from expected value in the long run[11].

This rule, however, has to be modified for the money-targeting period. In July 2013, BCU switched from using the overnight interest rate as its operational target to announcing reference ranges for the growth of a monetary aggregate (M1') within its inflationary target (IT) framework. This new money-targeting scheme has a gradually declining pattern of money growth to signal the BCU's commitment to a disinflation path and a medium-term inflation objective[12]. As Portillo (2015) points out, money targets are *ex ante* consistent with the desired levels of interest rates, i.e., consistent at the time these targets are set. Ex post, deviations between targets and actual money growth are inevitable, though the central bank

[9] John Taylor (1993).

[10] Hybrid Taylor rules have the expected inflation rate instead of the actual one.

[11] There is no exchange rate target in the sample period.

[12] Money targets are less indicative of the intended monetary stance than interest-rate targets.

can try to steer money growth toward its target within the quarter by injecting or withdrawing liquidity and influencing short-term interest rates. That is why the central bank has to have a view about the level of short-term interest rate required to help stabilize inflation; the main variable through which monetary policy can influence aggregate demand, the exchange rate, and inflation is the short-term interest rate.

The modified Taylor rule for the money targeting period[13] is:

$$R_t = \rho R_{t-1} + (1-\rho)\left[r^* + \pi^* + \delta(\pi_t - \pi^*) + \theta \hat{y}_t\right] + \psi(\mu_t - \mu^*) + \varepsilon_t \quad (2)$$

where μ_t and μ^* are actual and target money growth rates, respectively.

This specification implies that positive money-target deviations increase interest rates as the central bank tightens its monetary policy in order to force money growth towards its target. ψ captures the degree of money target adherence; that is to say, the higher ψ, the more aggressive the monetary authority is in response to money target deviations.

Equations (1) and (2) are estimated recursively on a monthly basis[14]. The results are not very plausible. In both cases, the goodness of fit is low, short-run interest rates only change in response to inflation deviations from their targets and the rest of the gaps do not play any statistically significant role. Moreover, equation (2) reports a negative R^2 statistics (the chosen model is worse than a horizontal line). Obviously, both Taylor rule specifications have to be improved. Figure 4 suggests missing arguments, and estimates for the whole sample seem to be overestimated.

2.2 Fundamentals-based model

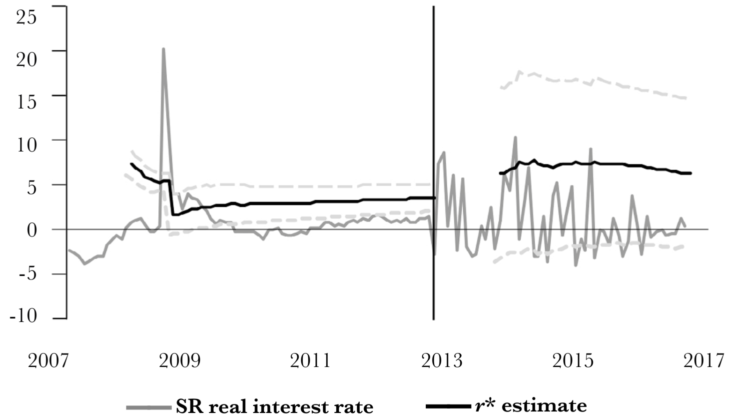
In the long run, all variables are in equilibrium. In the medium and short run, several unexpected shocks may create a wedge between current values and their long-run equilibrium values. Consequently, short-run equilibrium values depend on long-run equilibrium values

[13] The money-targeting period spans from 2013M7 to 2017M12.

[14] Both equations were estimated by applying OLS. I thank Cid Rodríguez-Pérez for his guidance.

Figure 4

URUGUAY: *r ESTIMATES PER PERIOD, TAYLOR RULE INTERCEPT**



Source: Own estimates based on BCU and INE data.

in addition to some wedges. Recognizing that all gaps close at the steady state, it is possible to find a locus for the natural interest rate where short-, medium-, and long-run equilibria coincide.

Following Bernhardsen and Herdrup (2007) and Goldfajn and Bicalho (2011), I estimate two parsimonious models for the real interest rate: one for the long-run equilibrium and another for the short-run equilibrium. I analyze the long-run fundamentals on the one hand and the short- and medium-run drivers on the other. Long-run equilibrium real interest rate (LRERIR) depends on economic fundamentals; that is to say, LRERIR is determined by structural factors that move slowly across a timespan: productivity, intertemporal preferences, sovereign risk premium, public indebtedness, financial deepening, institutional arrangements. Those variables are directly related to population. However, short-run equilibrium real interest rate (SRERIR) depends on both LRERIR and short-run situations that temporarily depart relevant economic variables from their long-run equilibrium paths. These include changes in government expenditure patterns, nominal and real exchange rate gaps, and changes in the global and regional economic growth, among others.

2.2.1 Long-run equilibrium

Increasing *public indebtedness* pressures the demand for loans and higher domestic debt relative to domestic output may worsen the country's credit record, pushing up its *country risk*, all of which increase the natural interest rate. *Productivity* gains encourage new investments and increase the willingness to invest, pushing up the natural interest rate. An aging *population* exerts a downward pressure on the natural interest rate. According to Galesi *et al* (2017), "gradual population aging induces people to accumulate savings during their working lives so as to be able to pay for their retirement", increasing the propensity to save. According to ECB (2004) financial market efficiency may help to optimally allocate savings along the time. An improvement in the market structure could, for example, widen the asset options in terms of returns, risk and liquidity available for those savers, just like a stimulus to savings, and would reduce the equilibrium real interest rate. A credit increase in the economy could be related with advances in those market structures, with the development of new products which could tend to reduce the interest rate. In sum, in the long-run relationship, we expect positive signs for the coefficients associated with public indebtedness, country risk and productivity and negative signs on the coefficients related to aging population and financial deepening.

A significance demographic shift has been taking place in Uruguay for a long time. Long-run welfare policies implemented since the early twentieth century determined an increase in life expectancy at birth[15] and, as a result, the percentage of people over 65 year-old has been steadily increasing[16]. The old-age support ratio, which indicates the number of working-age people (ages 15-64) per elderly person (65 and older), has declined from 4.10 to 3.82 in between 1996 and 2007 and remained close to that value since then[17]. Furthermore, "the Fourth Age"[18] has shown an average annual growth rate of 2.8 %. But global population figures hardly grew[19] which could be associated

[15] The life expectancy at birth indicator reflects the overall mortality level of a population. It is the average number of years that a newborn is expected to live if current mortality rates continue to apply. For Uruguay, in 2013, it was 75.33 years and reached 77.55 years in 2017.

[16] From 13.5% in 2007 to 14.2% in 2013.

[17] IMF, Regional Economic Outlook 2018.

[18] The Fourth Age starts at about age 80 or 85 and includes the last years of adulthood.

[19] Total population was 3:358.794 and 3:493.205 people in 2007 and 2017, respectively, according to official data. The natural growth rate was 0.433

with late motherhood[20] and a drop in the fertility rate[21]. So, not only is Uruguayan population getting older on average, but an increasing proportion of elderly citizens has to financially support their old parents because life expectancy is high and the alredy low birth rate has not improved. The over-aging ratio, which measures the relative weight of 85-and-more-year old people related to 65-and-more-year old ones, shows a steady increase through the sample. See Figure 5.

Uruguay run fiscal deficits through the sample that required new debt issues every year resulting in an increase in the stock of public debt. Nevertheless, the net public debt-to-output ratio[22] is lower in 2017 (40 % of GDP) than ten years before (48 % of GDP), mainly owing to significant output growth in the period. This improvement is also reflected in Uruguay's country risk level. In the second semester of 2015 public finances deteriorate and the debt increases pushing up the indebtedness ratio.

In order for the credit to reduce the equilibrium real interest rate it is necessary that its expansion has been caused by asymmetric information reductions, institutional advances that accelerate the collateral recuperation, and other structural changes in the financial markets. But when credit increases are caused by demand, the impact of more credit on the equilibrium interest rate may be positive[23].

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and 0.366% for those years, respectively; if the migration rate is added, those figures become -0.034% and 0.366%, respectively. Source: Instituto Nacional de Estadística, INE.

[20] The average age of motherhood index shows the mean age of women at first child-birth. For Uruguayan data, it was 27.48 in 2007 and 27.78 in 2017. In Western, Northern, and Southern Europe, first-time mothers are on average 27 to 29 years old, up from 23 to 25 years at the start of the 1970s.

[21] The fertility rate gives the number of children born alive by a woman. This indicator shows the population change potential of a country. A value of two children per woman is considered the replacement rate for a population, because it gives stability in terms of the global numbers. Fertility rates higher than two children show populations that grow in size and have diminishing average age. Fertility rates lower than two children indicate shrinking and aging populations. In Uruguay, the fertility rate dropped from 1.98 in 2007 to 1.81 in 2017.

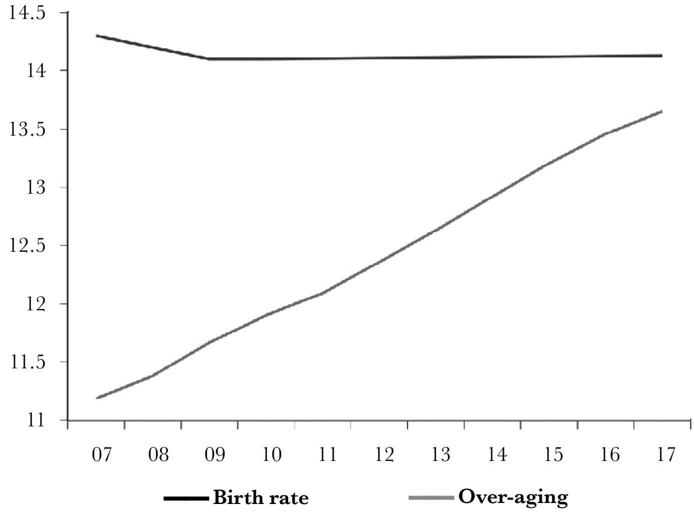
[22] Net public debt measures the debt that the Government faces less the amount of its free disposal international reserves. The net public-debt-to-GDP ratio measures the capability of the country to pay its international obligations, that is, it relates the net debt to the income generated by the country.

[23] That is the result found in the second regime. This outcome may be indicative of poor financial deepening.

Figure 5

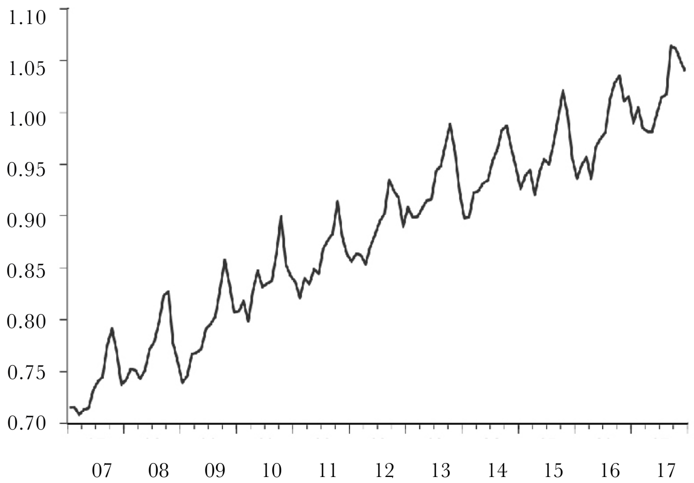
URUGUAY: LONG-RUN DETERMINANTS OF *r**

(a) Population ratios



Source: Own calculations based on INE (Instituto Nacional de Estadística) data. Productivity is measured as GDP per employee.

(b) Productivity



Source: Own calculations based on INE (Instituto Nacional de Estadística) data. Productivity is measured as GDP per employee.

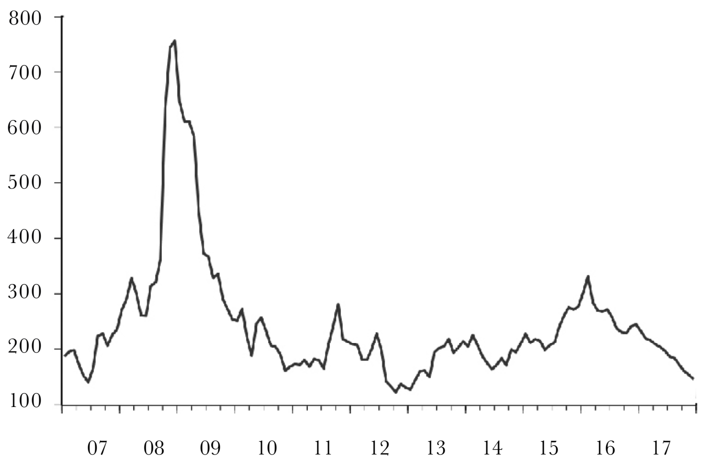
Figure 5 (cont.)

URUGUAY: LONG-RUN DETERMINANTS OF *r**

(c) Public indebtedness

Source: Own calculations based on BCU data.

(d) UY country risk



Source: Own calculations based on República AFAP data.

Figure 5 (cont.)

URUGUAY: LONG-RUN DETERMINANTS OF r^*

(e) Private credit

Source: BCU data.

Table 1

SIMPLE SWITCHING RESULTS

January 2007 – December2017, 131 obs. after adjustments

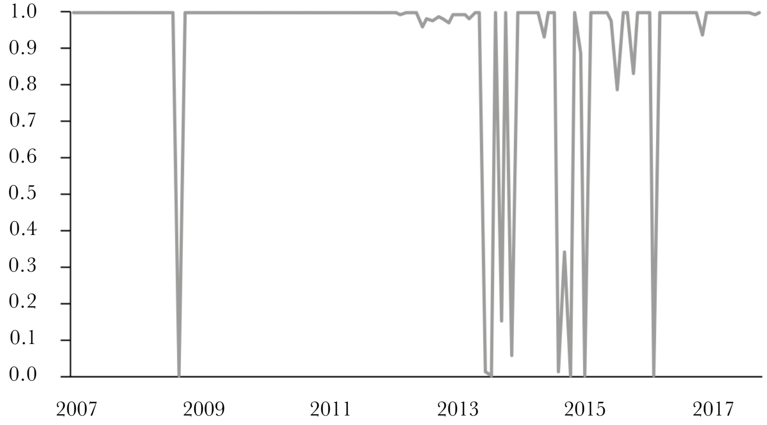
	Constant transition probabilities		*Constant expected durations*	
	1	2	1	2
1	0.3187	0.6813	1.4678	16.9376
2	0.0590	0.9410		

Source: Own calculations.

Figure 6

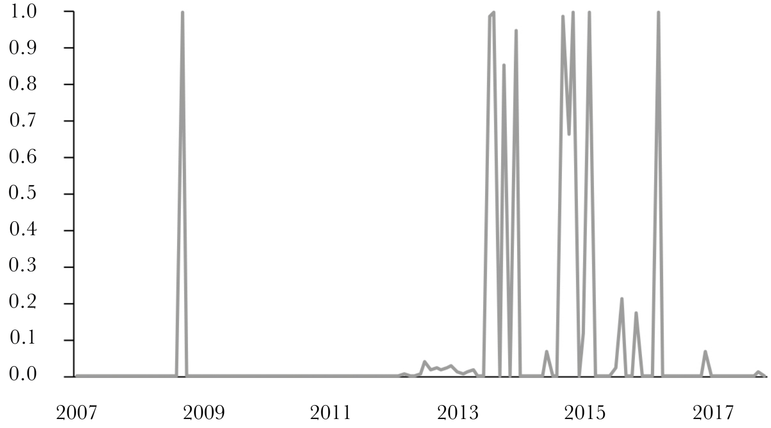
URUGUAY: SMOOTHED REGIME PROBABILITIES

A. REGIME 1: INTEREST RATE INSTRUMENT



Source: Own calculations.

B: REGIME 2; MONEY TARGETING



Source: Own calculations.

As it has been previously mentioned, the change in July 2013 from interest-rate to money targeting resulted in a structural break that split the sample in two (Table 1 and Figure 6). Regime-smoothed probabilities from a simple switching regression model[24] estimation show two distinct frameworks for the long-run real interest rate determinants, which almost entirely coincide with the different monetary policy management. By the end of the sample, however, the distinction between the two regimes blurs.

The estimates presented in Table 2, which are consistent with the priors outlined, fit the data fairly well and easily pass the usual diagnostic tests. Productivity, which coincidentally showed a slowdown since 2013, is not a meaningful determinant in the second regime.

2.2.2 Short-run equilibrium

Following the seminal work by Rudebusch and Svensson (1999), adapted by Bernhardsen and Gerdrup (2007) for Norway, and Goldfajn and Bicalho (2011) and Perrelli and Roache (2014) for Brazil, short-run interest rate movement from its long-run neutral trajectory can be analyzed by a simplified IS model. Basically, the IS curve can be expressed as:

3
$$\begin{aligned}(y_t-\tilde{y}_t)=\alpha(y_{t-1}-\tilde{y}_{t-1})+\beta(w_t-\tilde{w}_t)+\gamma(r_{t-1}-\tilde{r}_{t-1})\\ +\delta(e_t-\tilde{e}_t)+\theta(g_t-\tilde{g}_t)+\rho(m_t-\tilde{m}_t)+\varepsilon_t\end{aligned}$$

where:

$(y_t-\tilde{y}_t)=$ Uruguayan output gap (actual minus potential output)

$(w_t-\tilde{w}_t)=$ Foreign output gap (actual minus potential output)

$(r_{t-1}-\tilde{r}_{t-1})=$ real interest rate gap (actual minus long-run equilibrium real interest rate, previously estimated)

$(e_t-\tilde{e}_t)=$ nominal[25] exchange rate gap (actual minus its long-run HP trend)

$(g_t-\tilde{g}_t)=$ Government consumption gap (actual minus its long-run HP trend)

$(m_t-\tilde{m}_t)=$ monetary growth gap[26] (actual minus target)

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24 Model selection is done using information-based (SIC) criteria and log-likelihood values for different switching types of models.

25 The inclusion of the real exchange rate gap was tested but was not statistically significant.

26 This gap was included during the money-targeting regime.

Table 2

URUGUAY: DETERMINANTS OF LONG-RUN EQUILIBRIUM REAL INTEREST RATES

Dependent variable: overnight nominal interest rate deflated by 12-month ahead expected inflation		
	Regime 1: Interest rate January 2007 - June 2013 (lead=0, lag=8)	*Regime 2: Money targeting July 2013 - December 2017 DOLS(lead=1, lag=0)*
Public indebtedness	0.2453 (0.0777)*	0.0148 (0.0002)***
Sovereign country risk	2.4433 (0.0001)***	4.5414 (0.0005)****
Over-aging	-12.010 (0.0098)***	-1.0571 (0.0163)**
Productivity	1.5582 (0.0099)***	-
Private credit	-	0.0559 (0.0962)*
Adjusted R2	0.79	0.58
Engle-Granger cointegration test[a]	0.000	- [b]
Nº observations after adjustments	77	51

Notes: Cointegration estimates, based on Dynamic Least Squares (DOLS) regressions. The exogenous variables are: public indebtedness calculated as total public debt over GDP ratio; sovereign country risk, approximated by EMBI index; population ageing, represented by the over-ageing ratio; productivity, calculated as GDP per employee. All variables are I(1); test on stationarity are available upon request. Other regressors were tried but their inclusion was not statistically significant. Public indebtedness and sovereign risk are affected by a change in 2015M06.

Standard errors in parenthesis: * statistically significant at 8%, ** significant at 5%, *** significant at 1%.

[a] Both the Engle-Granger tau-statistic (t-statistic) and the normalized autocorrelation coefficient (z-statistic) reject the null hypothesis of no cointegration (unit root in the residual) at the 1 % level.

[b] Too few observations to accurately perform the test.

The reported estimates are statistically significant and have the expected sign[27]. The Uruguayan output gap may come from different determinants. In effect, only in the second period, when the monetary policy is implemented by a monetary targeting scheme and interest rates are endogenous, does the nominal exchange rate gap influence the aggregate demand[28].

By definition, the equilibrium real rate is the one compatible with a null output gap, that is, with real output at its potential level. So:

$$y_t - \tilde{y}_t$$

Using the estimates from Table 3, equation (3) is solved for to determine the short-run real interest rate equilibrium:

$$r_t = \tilde{r}_t - \frac{1}{\gamma}\left[\beta\left(w_t - \tilde{w}_t\right) + \delta\left(e_t - \tilde{e}_t\right) + \theta\left(g_t - \tilde{g}_t\right) + \rho\left(m_t - \tilde{m}_t\right)\right] \quad (4)$$

This expression states that there is a difference between the short-run and long-run equilibrium interest rates coming from transitory shocks, which prevent relevant variables from reaching their long-run path. Thus, the short-run equilibrium real interest rate oscillates around the long-run equilibrium one while there are variables that still have not reached their potential levels. In the first regime,

[27] Given an excess aggregate foreign demand, a higher natural rate is compatible with a closed output gap because a higher natural rate discourages domestic investment, reducing domestic aggregate demand until reaching the level of potential domestic output. A non-linear relationship between foreign and domestic output gaps is found, however, and the estimated coefficient is negative in the second regime. This results from the evolution of the foreign output gap; by steadily reducing it from negative to near-zero values, an increase in fact means a reduction. When the spot nominal exchange rate exceeds its long-run trend - a depreciation of domestic currency from its equilibrium value -negative real effects appear, such as a reduction in consumption, leading to a fall in aggregate demand; this requires a compensating increase in investment via a fall in the real interest rate to close the gap.

[28] On average, the UY Peso/US dollar gap fell 0.7 and 0.3 percent on an annual basis in the first and second regimes, respectively. During the second regime, the exchange rate gap experienced great swings, from 0.4% to 7.0% and even decreased 8.3%.

Table 3

URUGUAY: DETERMINANTS OF SHORT-RUN EQUILIBRIUM REAL INTEREST RATES

Dependent variable: Uruguayan output gap

	Regime 1: Interest rate January 2007 - June 2013	*Regime 2: Money targeting July 2013 - December 2017*
Uruguayan output gap$_{-1}$	1.7603 (0.0000)***	1.6857 (0.0000)***
Uruguayan output gap$_{-2}$	-0.8181 (0.0000)***	-0.7775 (0.0000)***
Foreign output gap	0.8619 (0.0000)***	-
Foreign output gap$_{-1}$	-1.5589 (0.0000)***	-0.4130 (0.0010)**
Foreign output gap$_{-2}$	0.7244 (0.0000)***	-
Real interest rate gap$_{-1}$[a]	-6.89e-05 (0.0396)**	-0.0002 (0.0021)***
Nominal exchange rate gap	-	-0.0178 (0.0054)***
Government Consumption gap	-	-
Monetary growth gap	-	-

Notes: Own calculations.
Standard errors in parenthesis: * statistically significant at 8%, ** significant at 5%, *** significant at 1%.
[a] The inclusion of the long-run equilibrium real interest rate (a generated regressor) required a correction (White) to obtain a heteroskedasticity-robust variance-covariance matrix of the estimator.

the only driver is foreign output gap, and this process seems to expand for some time – at least two months; in the second regime, the exchange-rate gap also plays a role making a wedge between the two equilibrium real interest rates.

In the long run as all variables are in equilibrium, all gaps close and both rates coincide:

$$r_t = \tilde{r}_t - \frac{1}{\gamma}\left[\beta\left(\cancel{w_t - \tilde{w}_t}\right) + \delta\left(\cancel{e_t - \tilde{e}_t}\right) + \theta\left(\cancel{g_t - \tilde{g}_t}\right) + \rho\left(\cancel{m_t - \tilde{m}_t}\right)\right] \tag{4.1}$$

So:

$$r_t = \tilde{r}_t \tag{5}$$

Once that situation occurs, there is no difference between long-run, medium-run, or short-run, and a locus for the natural interest rate can be found[29]. See Figure 7. A bootstrap analysis (3,000 replications) determined a range of variation of 1.26<<r*<<1.90 for the natural interest rate locus.

3. RESULTS

So far, several approaches have been applied in the search of the natural interest rate for Uruguay. Table 4 presents the estimates obtained.

It is well-known that natural interest rates not only are difficult to estimate but also there is great uncertainty surrounding the estimates. This investigation is not the exception. As a result, there is a range of possible values for r* that goes from -3.34% to 4.98% according to the different methods employed[30].

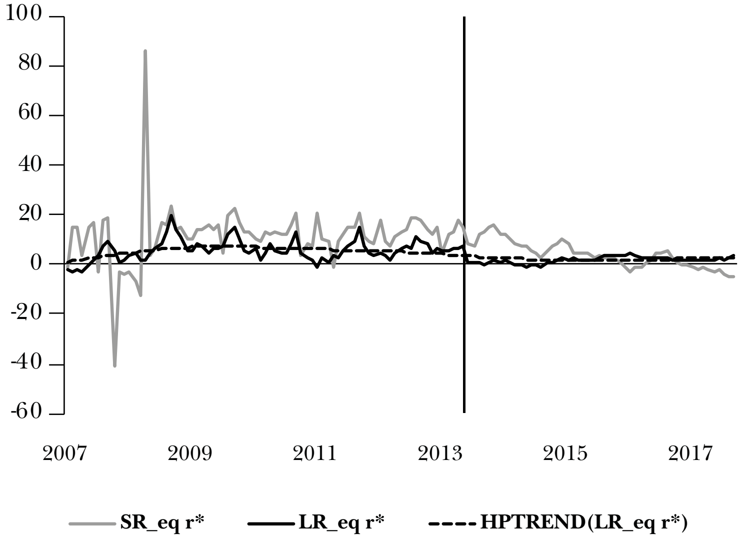
The fundamentals-based model estimates have certain advantages because: *(i)* they show a smaller range of values and *(ii)* they provide insight into the long-run determinants as well as into possible

[29] In order to find that locus, not only is a coincidence required between the short-run and the long-run equilibrium values for r*, but the relevant medium-run horizon for the monetary policy implementation has to be considered as well.

[30] Leaving aside the augmented Taylor rule estimates.

Figure 7

URUGUAY: R* ESTIMATES, FUNDAMENTALS-BASES MODEL



Source: Own calculations.

Table 4

URUGUAY: DIFFERENT R* ESTIMATES
2007M01-2017M12

Method	*Range*		*Mean*	*Median*
Average (whole cycle)	-2.42	3.04		
HP filter	-2.07	1.85	0.90	1.08
CF filter	-3.34	4.98	-0.03	-0.36
Augmented Taylor rule[a]	1.82	7.88		
Fundamentals-based model (Bootstrap 3,000 replications)	1.26	1.90		

Source: Own calculations.
[a] Not very accurate, the estimation needs improvement.

causes of fluctuations in the short-run. Thus, this approach combines the old tradition in economic literature regarding a long-run slowly moving equilibrium level with the concept of a short-run rate affected by transitory shocks. That is, in the long run, the natural rate should reflect the marginal product of capital goods and may only change as a result of structural factors, such as population dynamics, productivity, or other changes in the economic environment, such as financial deepening and public indebtedness. But in the short run, the interest rate can be affected by transitory shocks such as foreign demand and/or nominal exchange rate shocks.

The *interest rate gap* – calculated as the difference between the actual short-run interest rate and the natural interest rate– r*, can shed some light on the monetary stance. We can see that for a majority of the time studied the monetary policy seems to have been expansionary; the 12-month inflation rate[31] has followed the usual corresponding pattern. See Figure 8, (a) and (b). However, as Magud and Tsounta (2012) point out, "… the estimated interest rate gap may not accurately reflect the current monetary stance given weaker monetary transmission mechanisms (reflected through a small response of market interest rates to a change in the monetary policy rate, e.g., due to excess liquidity); a monetary framework that is still under development; and segmented short-term funding markets which could result in policy rates that do not accurately reflect financing conditions in all markets."

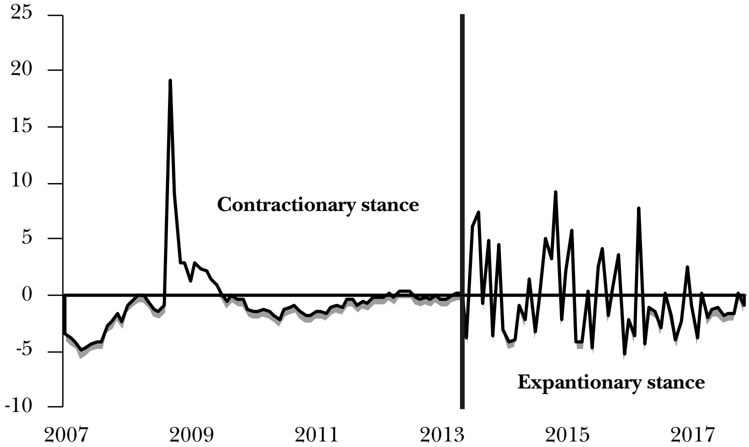
Magud and Tsounta (2012) point out that many factors could raise the effective market interest rate for the private sector, resulting in tighter financial conditions than those captured by the policy rate. Among these factors, high financial dollarization and low financial intermediation, reduce the effectiveness of the policy rate by hindering the proper functioning of the transmission channel of monetary policy (see Medina Cas and others, 2011a, b). High levels of financial dollarization may reduce the impact that changes in the policy rate have on banks' interest rates in local currency because the borrowers can easily switch to foreign-currency instruments. A stylized fact of Uruguay is dollarization. There have been important attempts to alleviate this problem, but Uruguayan economy still remains highly dollarized: as of December of 2017, almost

[31] Calculated on the CPI.

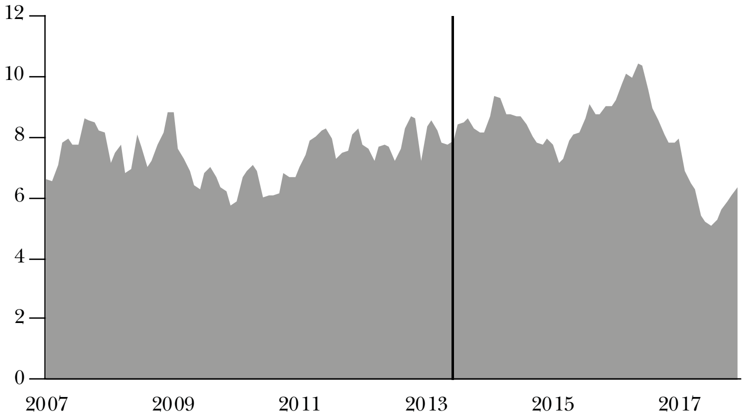
Figure 8

URUGUAY: MONETARY POLICY STANCE 2007M01-2017M12

A. INTEREST RATE GAP



B. 12-MONTH INFLATION RATE



Source: Own calculations and INE. (a) Monetary policy stance measures the gap between the SR real interest rate and r* estimates using the fundamentals-based model. (b) Headline inflation rate.

80% of total deposits and close to 60% of total credits in the banking system are foreign currency-denominated[32]. However, the de-dollarization process of the Uruguayan financial system that is being implemented for more than ten years by now, has strengthened the interest-rate transmission (Leiderman *et al.*, 2006).

Bank concentration limits competition and lowers banks' reaction to the policy rate which may undermine the interest rate transmission mechanism. The response of banks' rates to changes in the policy rate depends on the banks' adjustment costs derived from the elasticity of demand for bank loans, which is influenced by the structure of the financial system (Cotarelli and Korelis, 1994; De Bond, 2002): relatively inelastic demand is more likely when there is higher bank concentration. When banks have substantial market power, policy rate changes may impact banking spreads rather than market rates because banks may try to profit from a reduction in the policy rate keeping lending rates fixed. The Uruguayan credit market is highly segmented[33]. The segmentation permeates the banking sector, which exhibits a high degree of concentration, particularly with regard to the peso deposit and credit markets. Indeed, the Herfindahl-Hirschman index (HHI) for the peso credit market yields a concentration level of 0.26, while the U.S. dollar credit market is slightly less concentrated at 0.19.[34]

The development of the financial system strengthens the interest-rate transmission mechanism as more alternative sources of capital increase the elasticity of demand for bank loans (Cotarelli and Korelis, 1994). Financial shallowness is generally associated with higher excess liquidity in banks, discouraging the development of an active interbank market and reducing the effectiveness of transmission. According to IMF Uruguay Report (2016),

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[32] The main problem, though, is currency mismatches. According to recent studies, 87% of Uruguayan firms report to have liabilities denominated in currencies (mainly US dollars) different from those of their incomes (mainly Uruguayan pesos).

[33] In 2014, 60% of total credit went to firms, 35% to households, and 5% to the public sector. Of the credit extended to firms, 87% was denominated in U.S. dollars, whereas for households, only 4% of credit was U.S. dollar denominated, and 35% in the case of the public sector. Consequently, 55% of total credit in 2014 was U.S. dollar denominated.

[34] From a scale of 0 to 1, 1 being a perfect monopoly.

> "A broad-based index of financial development indicates that Uruguay lags behind regional peers, and also relative to what could be expected given its own macroeconomic fundamentals. Uruguay's score of 0.2 in the composite financial development index (based on 2013 data) is equivalent to half the LA5 average, and below the individual scores of all LA5 countries (as reported in Heng and others, 2015). Furthermore, a regression analysis suggests that Uruguay scores worse on the index than would be predicted by its own economic fundamentals (including income per capita, government size, trade openness, inflation, educational attainment, and others). A decomposition of the results shows that this "underdevelopment" relative to fundamentals mostly reflects low access to finance in Uruguay (both through financial institutions and through markets) and low financial institution depth (measured through variables such as private sector credit). All other LA5 countries have index scores better than or equivalent to what their fundamentals would predict."

These results point to the importance of complementing NRIR estimations with, e.g., financial/monetary condition indices to better assess the monetary policy stance.

4. CONCLUDING REMARKS

In this document, we applied different methods to estimate the natural rate of interest for Uruguay, a small, open, and dollarized economy. The natural rate of interest describes the real interest rate for a situation regarded as optimal from a particular point of view, such as price stability, full employment, or a rigidity-free environment. It follows that an optimal monetary policy should be conducted so as to approximate the actual real interest rate to that desirable rate because, consequently, GDP, unemployment, inflation, etc. should follow their welfare-maximizing paths. When the central bank's instrument is the nominal interest rate, that objective can be directly monitored; when the central bank has money targets, its fulfilment is hard to assess because the current real interest rate is endogenous and fluctuates too much. In a dollarized economy, it is even more difficult because the monetary policy design has to take into account the presence of foreign currency demand together with the domestic currency either competing with or complementing with each other.

Notwithstanding those difficulties, we provide some estimates for the NIR using varied approaches, we offer a useful framework where to analyze the difference between long-run and short-run differences, and we assess the monetary policy stance for the whole sample period. Specifically, the fundamentals-based model helps us to deal with the difference between the short- and long-run NIR and is intended to be an addition to the myriad approaches actually in use in the Banco Central del Uruguay (BCU).

Some discussion of the debate over decreasing NIR is needed. Our estimates point to a sharp decrease in the movement in the short-run equilibrium natural rate since 2013 (owing to international drivers) which is smaller in the long run. Long run equilibrium natural interest rate evolves smoothly with an almost unnoticeable deceleration (Figure 7). That seems to be the result of two opposing forces: on the one hand, the increase –but at a declining speed– in the over-aging index augments the propensity to save and pushes the natural interest rate down; on the other, the increase in both public indebtedness and perceived country risk reduces the agents' willingness to invest and pushes the natural interest rate up. Productivity – measured as output per occupied worker – reinforces this effect during the first regime.

As a corollary of this research, it can be said that "[u]nfortunately, we have as yet devised no method to estimate accurately and readily the natural rate of either interest or unemployment".[35] This is a work in progress.

[35] Milton Friedman (1968).

References

Acosta-Ormachea, S., & Coble, D. (2011). The monetary transmission in dollarized economies: the cases of Chile, New Zealand, Peru, and Uruguay. *IMF Working Paper 11/87 (Washington: International Monetay Fund).*

Bernhardsen, T., & Gerdrup, K. (2007). The neutral real interest rate. *Norges Bank Economic Bulletin 2, Vol. 78, pp.52-64.*

Bucacos, E. (2012). La tasa natural de interés para la economía uruguaya: un enfoque basado en un modelo DSGE. *Mimeo, BCU.*

Calderón, C., & Gallego, F. (2002). La tasa de interés real neutral en Chile. *Banco Central de Chile, Vol. 11, Nº2.*

Carrillo, J. A., Elizondo, R., Alonso Rodríguez-Pérez, C., & Roldán-Peña, J. (July, 2017). What determines the neutral rate of interest in an emerging economy? *Banco de México.*

Chananenco, P., & Savino, M. P. (2009). The natural rate of interest in Brazil between 1999 and 2005. *Revista Brasileira de Economia, Rio de Janeiro,* Vol. *63, Nº2*, 103-18.

Cottarelli, C., & Kourelis, A. (1994). Financial structure, bank lending rates and the transmission mechanism of monetary policy. *IMF Working Paper WP/94/39.*

Daly, H., & Cobb, J. (1989). For the common good. *Boston Beacon Press.*

De Bondt, G. (2002). Retail bank interest rate pass-through: new evidence at the Euro Area level. *European Central Bank* Working *Papar 136.*

Del Negro, M., Giannone, D., Giannoni, M. P., & Tambalotti, A. (Spring 2017). Safety, liquidity, and the natural rate of interest. *Brookings Papers on* Economic *Activity.*

Duarte , J. (2010). Measuring the natural interest rate in Brazil. Institute of Brazilian Business and Public Management Issues (Washington: George Washington University).

Fuentes, R., & Gredig, F. (2008). La tasa de interés neutral: estimaciones para Chile. *Economía Chilena, Vol. 11, Nº2.*

Galesi, A., Nuño, G., & Thomas, C. (2017). The natural interest rate: concept, determinants and implications for monetary policy. *Analytical articles* 2017, *Banco de España, Eurosistema.*

Goldfajn, I., & Bicalho, A. (2011). A longa travessia para a normalidade: os juros reais no Brasil. in Novos Dilemas da Politica Economica - Ensaios em homenagem a Dionisio Dias Carnerio, edited by E.L. Bacha e M. B. de Bolle Rio de Janeiro: Grupo Editorial Nacional.

González, A., Ocampo, S., Perez, J., & Rodriguez, D. (2012). Output gap and neutral interest rate measures for Colombia. *Borradores de Economía, Nº726 (Bogotá: Banco de la República)*.

Heng, D., Iavanova, A., Mariscal, R., Ramaksidhnan, U., & Cheng Wong, J. (2016). Advancing financial development in Latin America and the Caribbean. *IMF Working Paper WP/16/81*.

Holston , K., Laubach, T., & Williams, J. (December 2016). Measuring the natural rate of interest: international trends and determinants. *Working paper 2016-11, Federal Reserve Bank of San Francisco*.

IMF. (2011). Dominican Republic: Fourth review under the Standby Arragement and Request of Waiver of Nonobservance of Performance Criterion - Staff Report. *July (Washington: International Monetary Fund)*.

IMF, Figliuoli, L., Flamini , V., Mowatt, R., Puig, J., Lambert, F., y otros. (2018). Growing pains: is Latin America prepared for population aging? *Regional Economic Outlook, April 2018, IMF*.

Lambert, F. (2017). Uruguay's neutral interest rate. IMF Country Report 17/29, Uruguay, selected issues, International Monetary Fund.

Leiderman, L., Maino, R., & Parrado, E. (2006). Inflation targeting in dollarized economies. *IMF Working Paper, WP/06/157*.

Leijonhufvud, A. (1989). Natural interest rate and market interest rate. *in: Money. The New Palgrave*.

Licandro, G., Mello, M., & Odriozola, J. (2014). Uso de derivados en Uruguay. *Documento de trabajo, Nº004-2014, Banco Central del Uruguay*.

Magud, N., & Tsounta, E. (2012). To cut or not to cut? That is the (Central Bank's) question. In search of the natural interest rate in Latin America. *IMF, Working Paper Series, WP/12/243*.

Minella, A., Freitas, Goldfajn, I., & Muinhos, M. (2002). Inflation targeting in Brazil: lessons and challenges. *Working Paper Series, Nº53, Banco Central do Brazil*.

Perrelli, R., & Roache, S. (2014). Time-varying neutral interest rate - the case of Brazil. *IMF Working Paper 14/84*.

Perrelli, R., & Roache, S. (2014). Time-varying neutral interest rate: the case of Brazil. *IMF Working paper, WP/14/84, International Monetary Fund*.

Portillo, R., & Ustyugonova, Y. (2015). A model for monetary policy analysis in Uruguay. *IMF Working Paper Series, WP/15/170*.

Roache, S. K. (2014). Inflation pesistence in Brazil - a cross country comparison. *IMF Working Paper, 14/55*.

Rudebusch, G., & Svensson, L. (1999). Policy rules for inflation targeting. in Monetary policy rules, edited by J.B. Taylor. Chicago: University of Chicago Press.

Taylor, J. B. (1993). Discretion vs policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy 39*, 195-214.

Woodford, M. (2003). Interest and prices. *Princeton* University *Press*.

APPENDIX

OTHER ESTIMATES OF THE NEUTRAL INTEREST RATE: SUMMARY RESULTS FROM VARIOUS METHODOLOGIES

May 2012[36]

%

	Uncovered Interest Parity	*Con-sumption-Based CAPM*	*HP Filter*	*Implicit Common Stochastic Trend*	*Dynamic Taylor rule*	*Expected-Inflation Augmented Taylor rule*	*General Equilibrium model*	*Average*
Brazil	4.5	4.5	4.8	5.4	5.7	5.5	5.5	5.1
Chile	1.3	2.9	2.0	2.1	2.3	2.2	1.2	2.0
Colombia	2.5	4.4	1.9	1.8	1.6	1.7	2.1	2.3
Mexico	2.0	4.2	1.7	1.3	1.3	1.3	2.9	2.1
Peru	2.3	5.0	1.3	1.5	1.8	1.0	1.3	2.0
Uruguay	3.6	3.3	1.3	2.1	5.3	-	7.2	3.8
Costa Rica	2.6	4.1	-	-	-	-	3.7	3.5
Dominican Republic	3.2	4.2	1.7	2.7	3.8	3.1	3.9	3.2
Guatemala	2.3	3.2	-	-	-	2.0	3.7	2.8
Paraguay	2.0	3.8	1.0	1.3	2.2	2.2	3.2	2.2

Note: For Costa Rica, Guatemala, and Uruguay, a subsample of methodologies is used due to data limitations.
Source: Author's calculations.

[36] Presented in Magud and Tsounta (2012). The sources are: Calderon and Gallego (2002), and Fuentes and Gredig (2007) for Chile; Minella *et al.* (2002), Portugal and Barcellos (2009), Duarte (2010), Bloomberg (2012), and Perrelli *et al.* (2014) for Brazil; IMF (2012) for Paraguay; Gonzalez *et al.* (2012) for Colombia; and IMF (2011) for Dominican Republic.