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MEASURING THE UNSEEABLE:
NEUTRAL RATES IN BRAZIL

São Paulo

November 2019

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Bachelor thesis presented to the Department of Economics of the School of Economics, Business and Accounting of the University of São Paulo in partial fulfillment of the requirements for the degree of Bachelor of Economics

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São Paulo

November 2019

ACKNOWLEDGMENTS

To my parents, Danuse and Sérgio, for their endless love and support. Thank you for always backing up my decisions and guiding me through them with passion and comprehension. I love and respect you fiercely. I am very lucky to be your son.

To my first direct bosses at Morgan Stanley Latam Economics, Lucas Almeida and Thiago Machado. Lucas, your kind approach as a mentor and sense of responsibility inspire me. Thiago, your econometric suggestions and overall support during the process of writing this thesis were paramount not only to the thesis itself but also to my upbringing as an economist. To you both, thank you for the two amazing years as your intern.

"HAMLET: (...) All which, sir, though I most powerfully and potently believe, yet I hold it not honesty to have it thus set down; for yourself, sir, should be old as I am, if like a crab you could go backward.

POLONIUS: (aside) Though it be madness, yet there is method in it"

(Shakespeare, Hamlet, Act 2, Scene 2)

ABSTRACT

In the famous (and poetic) words of John H. Williams, “the natural rate is an abstraction; like faith, it is only seen by its works” (WILLIAMS, 1931, p. 578). Nevertheless, it is an important guidance to monetary policy conduct. This work aims at estimating the real neutral interest rate for the Brazilian economy in the past years. To do so, we will use different econometric models: the first is an IS curve in which the neutral rate is defined as the one that closes the output gap; the second, a long-term model defined by structural variables and the third is a state space model based on the Kalman Filter. Once the models are estimated, we should be able to gauge Brazilian monetary policy stance in the last years and position ourselves in the recent debate on whether there is space for more monetary flexibilization from the Brazilian Central Bank.

Key words: Neutral rates; Kalman filter; monetary policy

JEL Classification: E43, E52, E58, C32

RESUMO

Nas famosas (e poéticas) palavras de John H. Williams, “a taxa de juros natural é uma abstração; como a fé, só é vista por seus frutos” (WILLIAMS, 1931, p. 578, tradução própria). Ainda assim, ela é um importante guia para a condução da política monetária. Este trabalho tem por objetivo estimar a taxa de juros real neutra para a economia brasileira nos últimos anos. Para tanto, usaremos diferentes modelos econométricos: o primeiro será uma curva IS, em que a taxa de juros real neutra será definida como aquela que zera o hiato do produto, o segundo será um modelo de longo prazo em função de variáveis estruturais da economia e o terceiro, um modelo state-space baseado no filtro de Kalman. Uma vez estimados os modelos, devemos ser capazes de caracterizar a política monetária do Brasil nos últimos anos, bem como nos posicionar no debate recente acerca da existência ou não de espaço para mais afrouxamento monetário por parte do Banco Central do Brasil.

Palavras-chave: Taxa de juros neutra; filtro de Kalman; política monetária

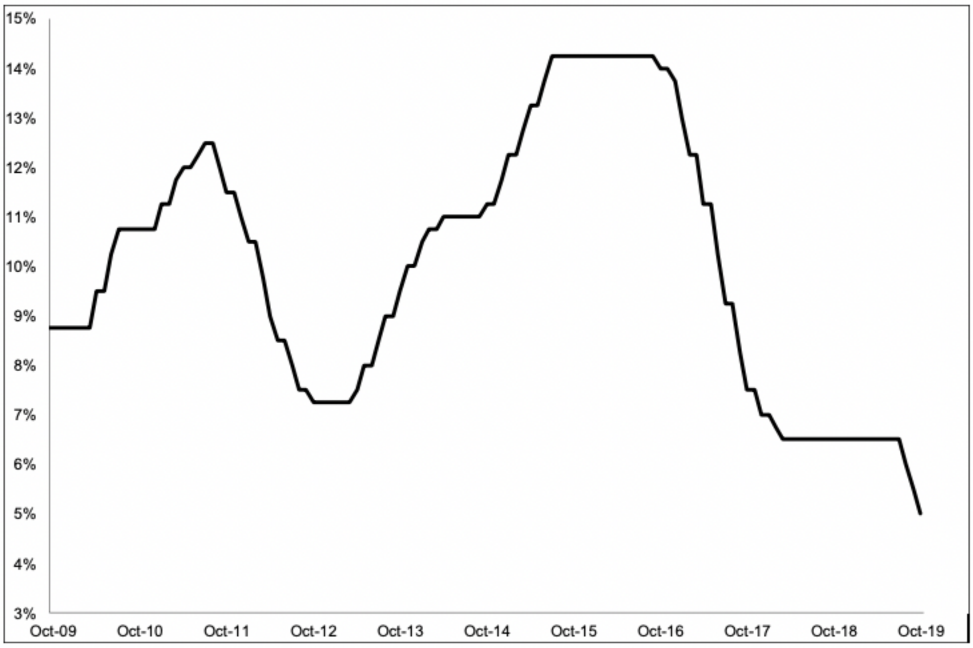
Código JEL: E43, E52, E58, C32

CONTENTS

1 INTRODUCTION

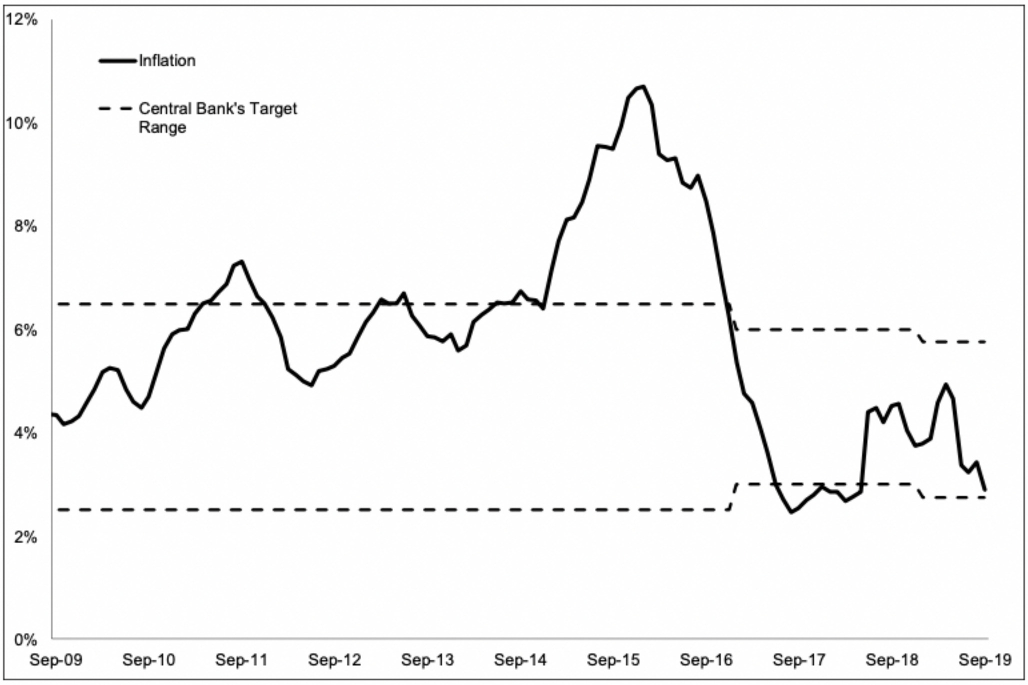
In the past years, the Brazilian economy has experienced unusual equilibrium, with low interest rates, low inflation and low growth appearing to be the new normal. The Brazilian Central Bank (BCB) had already brought Selic Brazil's base rates down to a historical low at 6.50% when, after ten on-hold decisions, it cut rates again to 6.00% in the July 2019 meeting and delivered two more consecutive 50 base points cuts, bringing Selic down to 5.00% in the October meeting, as Figure 1 portrays. Inflation, usually a concern to Brazil watchers, closed the last two years below target and runs 2019 well behaved, as shows Figure 2, with the yearly change of Brazilian consumer price index. These two positive vertices on the "low" triangular equilibrium encounter a negative one: GDP growth remains disappointing and has averaged only 1.1% y-o-y in the past two years, as depicts Figure 3, which shows the yearly change and seasonally adjusted quarterly annualized rate of change of the Brazilian GDP.

Figure 1 – Brazil: Central Bank's Target Rate (annual rate)



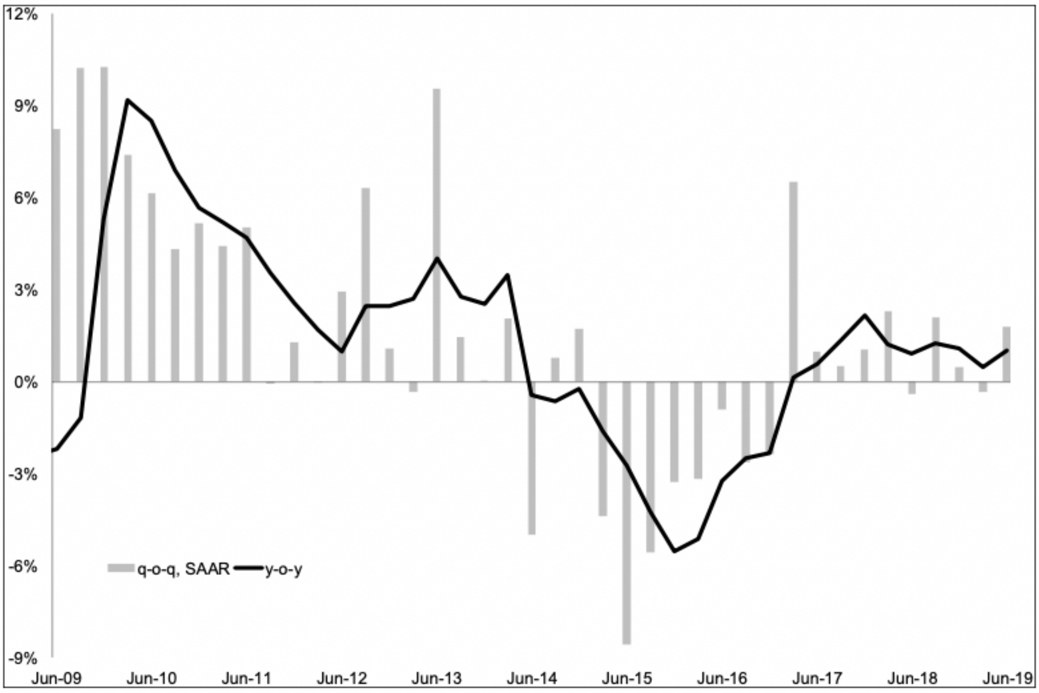
Source – BCB, author's elaboration.

Figure 2 – Brazil: Headline Inflation (% change y-o-y)



Source – IBGE, BCB, author's elaboration.

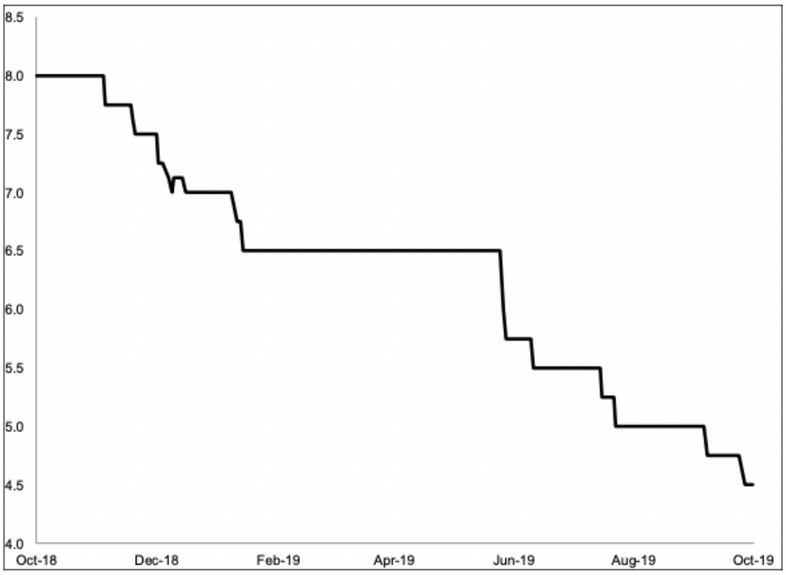
Figure 3 – Brazil: Real GDP Growth (% change)



Source – IBGE, author's elaboration.

The central bank's Focus Survey, a weekly market read-out, signals the equilibrium is poised to remain untouched in 2019. Market participants forecast Selic at 4.50% by year-end, with inflation running around 3.3% and GDP growth at 0.88%. Figures 4, 5 and 6 show the Focus forecasts for 2019 of Selic, inflation and real GDP growth, respectively. While there are many ways in which those variables interact affecting each other, the main focus of this essay will be the trajectory of the monetary policy target, especially the estimates of its neutral value: the one associated with monetary policy at neither expansionary nor contractionary stance. Its magnitude, although unknown and unseeable, is commonly associated both with short term measures, like the output gap and inflation, and long term ones, like the credit market, a country's idiosyncratic risk and debt path. The first step towards this estimation is to understand what is behind monetary policy in Brazil in the past year and the possible spillovers on neutral rates.

Figure 4 – Brazil: Selic at 2019 year-end expectation (annual rate)

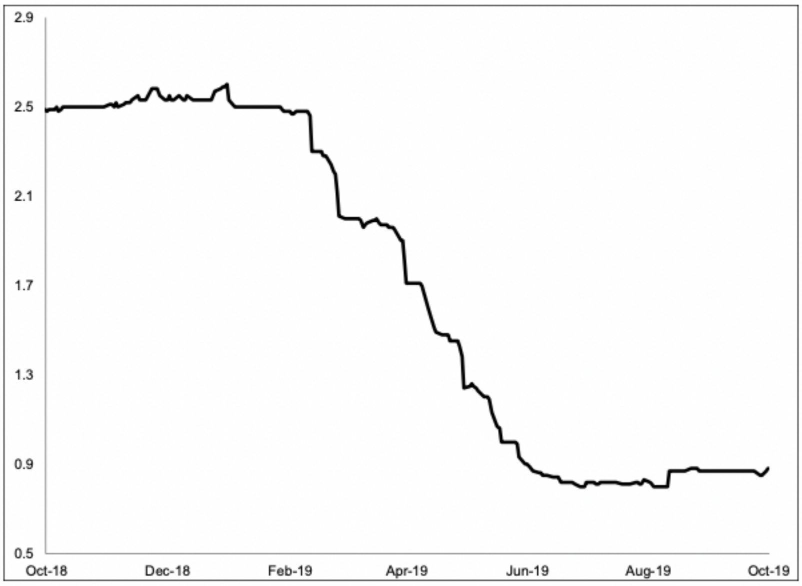


Source – BCB, author's elaboration.

Figure 5 – Brazil: 2019 Median Inflation Expectations (% change y-o-y)

Source – BCB, author's elaboration.

Figure 6 – Brazil: Median 2019 Real GDP Growth Expectations (%)



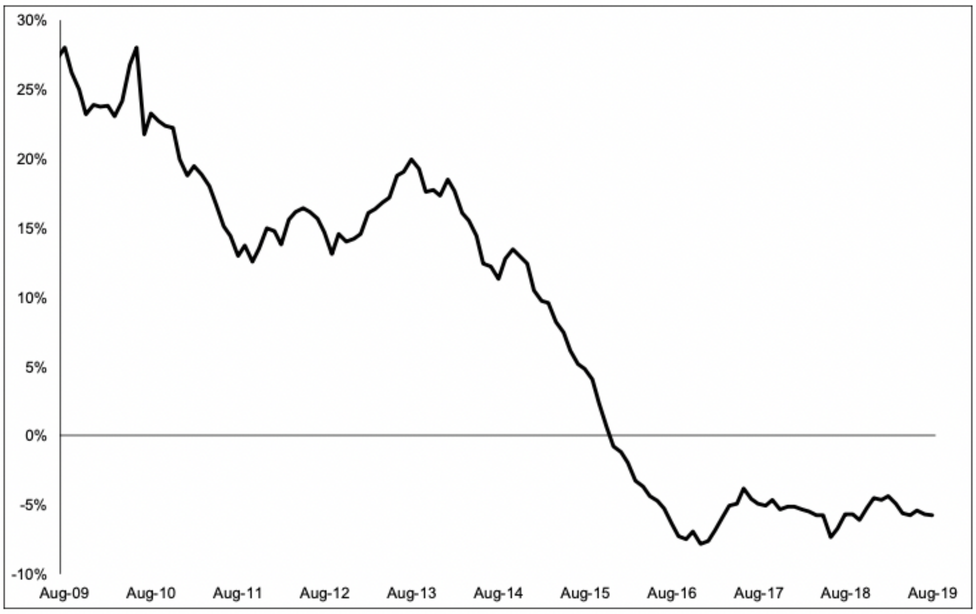
Source – BCB, author's elaboration.

The monetary easing cycle between October 2016 and March 2018, which cut off 775 basis points of Selic (from 14.25% to 6.50%) was brought about by cyclical and structural factors. The most important cyclical contributors were probably the domestic crisis between 2014 and 2016, the positive inflation dynamics and a credibility shock on the central bank. Between 2015 and 2016, GDP contracted 3.4% y-o-y on average, widely opening a negative output gap that was responded with rate cuts by the central bank. A positive supply shock on food products throughout 2017 coupled with the negative output gap brought down headline and core inflation measures, supporting the rate cuts.

Additionally, a new monetary authority took office in July 2016, and it was perceived as less prone to political pressure, helping anchor inflation expectations hence enabling the BCB to put the necessary cuts on track more effectively. The persistency of low inflation through a positive inertia and the wide output gap have certainly contributed to the further easing started past July, which also counted with looser monetary conditions abroad, since the central banks of the United States, Chile, Mexico, Peru, Indonesia, Korea, Russia, Turkey, and Euro Area, to name a few, also cut rates amid the Trade War and decelerating global growth.

Alongside those changes, some structural shifts made during the aforementioned easing cycle have played an important role. The substitution of the base rates for the BNDES's loans is one of them. In 2016, the administration substituted the TLJP, fixed in an ad hoc manner, for the TLP (Long Term Rate), associated to 5-year inflation-linked bond and thus more market related, reducing the subsidies that distorted Brazilian credit market. On top of that, BNDES's balance sheet has been reduced repeatedly, as the bank is repaying to the Treasury the capital injections the latter has done since the Global Financial Crisis. Both factors combined are reducing subsidized credit, as shown by Figure 7, allowing the central bank to deliver lower Selic levels without easing monetary conditions.

Figure 7 – Brazil: Earmarked Credit Outstanding (% change y-o-y, real)



Source – BCB, author's elaboration.

The renewed easing cycle of 2019 has also been met with structural changes, namely the approval of the Pension Reform, which the Senate's Independent Fiscal Institute (2019), in its Commentary Number 3, expects will save around R$ 630 billion. The reform should help tackle two problems of the Brazilian economy: 1) it would slow the pace of government expenditures growth, increasing public savings and helping build a fiscal anchor, and 2) it would generate incentives for the private sector to also increase its saving to sustain its consumption after retirement. Moreover, the government intends to deliver the central bank independence bill, which would further improve its credibility and effectiveness when it comes to anchoring inflation expectations.

With the above depicted factors, one may ask what has happened to neutral interest rates in Brazil. All of them (low inflation, low growth, low rates, lower rates abroad and the reforms path) point to a decrease in neutral rates. However, there are some counterbalances to those as well. Mainly the increasing government's debt and persistent fiscal deficit, but even the Pension Reform could generate upward pressures on neutral rates, via the investment resurge that is expected given the risk premium reduction - a risk the Central Bank itself has reckoned in the July 2019 minutes.[1]

The BCB (2019) has stated, in that same minute, that it has been "continuously reassessing" estimates of the neutral rates in Brazil given the current backdrop for rates, but "as the structural rate is not observable and economic activity and inflation depend on several other factors, estimates of this rate involve a high degree of uncertainty" (BCB, 2019, p. 4, author's traduction).The main goal of this monography will be to estimate the neutral rates for the Brazilian economy, assuming that the net effects of the recent determinants of monetary policy has been on the direction of neutral rates reduction. Following the estimation, we will analyze monetary policy in Brazil since the 2008 Crisis.

To do so, we will split this monography into five more sections besides this one. The second section will present a brief revision of past estimations of neutral rates for the Brazilian economy; the third, a background on neutral rates definition and estimation methodologies. The fourth will present the data used on the estimations and their results. With the results, the fifth section will present the monetary policy assessment. Finally, we will deliver the concluding remarks on the sixth section.

[1] The July 2019 minutes are available here: <https://www.bcb.gov.br/publicacoes/atascopom/31072019>

2 PREVIOUS ESTIMATIONS FOR BRAZIL

Neutral rates literature is vast and has been widely applied to Brazilian data. In this section, we present a brief revision of different estimates that many authors have done of Brazil's neutral interest rate throughout the years. We will split them into three groups. The first encompasses the estimations based on an IS curve, the second will be the estimations based on structural variables, and the third will revise the works based on the Kalman Filter. Chart 1 summarizes their findings. Details of the methodologies will come in the following sections.

Chart 1 – Revision of Past Neutral Rates Estimations

Methodology	Authors	Sample	Average
IS curve with output at 0	Nakane and Muinhos (2006)	1992-2002	11.11%
	Goldfajn and Bicalho (2011)	2002-2009	9.00%
	Gottlieb (2013)	2005-2010	7.33%
		2010-2012	5.31%
Model with Structural Variables	Goldfajn and Bicalho (2011)	1999-2008	10.00%
	Gottlieb (2013)	2005-2010	7.48%
		2011-2012	4.74%
	Moreira and Portugal (2019)	1999-2018	7.90%
Kalman Filter	Neto and Portugal (2009)	1999-2008	9.62%
	Ferreira and Mori (2012)	2002-2012	7.20%
	Gottlieb (2013)	2005-2010	6.62%
		2011-2012	5.22%
	Fonseca and Muinhos (2018)	2018	3.2%~3.8%
	Moreira and Portugal (2019)	1999-2018	6.40%

Source – Author's elaboration.

Nakane and Muinhos (2006) estimated neutral rates through different methodologies for different emerging economies, but our main focus here will be their estimation of the IS curve for Brazil, in which neutral rates are those that close the output gap. With the results, the authors concluded that Brazilian neutral rates were higher than the other emerging economies in the sample they studied. Goldfajn and Bicalho (2011) also estimated an IS curve and concluded that neutral rates estimations declined briskly after the Global Financial crisis. The IS curve estimations from Gottlieb (2013) pointed to a downward trend in neutral rates estimates as well.

The second methodology is the one that puts neutral interest rates as those reflecting the long term structural variables of an economy. Goldfajn and Bicalho (2011) and Gottlieb (2013) estimated similar models under that perspective and came to parallel conclusion and risks to their estimations. While both stated that their long term estimations of neutral rates were downward-sloped towards the end of their sample, they singled out the fact that the fiscal and credit policy put in course at that time by the government might bring upward pressures in the future. Moreira and Portugal (2019) also estimated a model based on structural variables, and came to the conclusion that political turmoil and inflation volatility during their samples played a major role in the upward swings of neutral rates estimations.

The final methodology is the one based on the Kalman Filter. The authors we presented in Chart 1 replicated the Laubach and Williams (2003) model or their updated version present in Holston, Laubach and Williams (2017). Barcellos Neto and Portugal (2009) replicated the Laubach and Williams model and found an upward trend for their neutral rates estimates in the sample they used. Ferreira and Mori (2012) and Gottlieb (2013) also estimated the model for alike samples and came to similar conclusions: that neutral rates were, this time, in a downward trend. Fonseca and Muinhos (2018) and Moreira and Portugal (2019) are the ones with the most recent estimations, and both have found a pronounced downward trend after the 2015-2016 Brazilian crisis. Moreira and Portugal (2019) used the Holston, Laubach and Williams updated version of the Laubach and Williams model.

Now that we have revised previous estimations of neutral rates in Brazil, we will proceed to more details on the definition and measurement of neutral rates.

3 DEFINING AND MEASURING NEUTRAL RATES

3.1 Defining

In the famous (and poetic) words of John Williams, “the natural rate (of interest) is an abstraction: like faith, it is only seen by its works” (WILLIAMS, 1931, p. 578). When it comes to seeing the “works” of neutral rates, one has to evaluate monetary policy, as its stance depends heavily on the deviation of real rates from its neutral value, as points the influential work of Taylor (1993). Under this perspective, if real rates are above their neutral value, we say monetary policy is restrictive. Conversely, if they are below, monetary policy is stimulative. Thus, neutral rates are associated with monetary policy at neither stimulative nor restrictive stance.

Definitions of neutral rates date back to a seminal work of Knut Wicksell: Interest and Prices (1936). There, he presented the meaning of neutral interest rates in at least three levels: “1) the rate of interest that equates savings and investments, 2) the marginal productivity of capital, and 3) the rate of interest that is consistent with aggregate price stability” (AMATO, 2005, p. 3). These different definitions are closely related as Amato (2005) points out, and one could say that the natural rate of interest is consistent with equilibrium and constant in the long term, with changes coming from technological progress throughout time, as stated by Gottlieb (2013).

The famous Wicksellian definition has influenced many works. For instance, Laubach and Williams use its long term perspective to define neutral rates as “the real short-term interest rate consistent with the economy operating at its full potential once transitory shocks to aggregate supply or demand have abated” (LAUBACH; WILLIAMS, 2016, p. 2). In other words, they prevail “after the economy has emerged from any cyclical fluctuation and is expanding at its trend rate” (LAUBACH; WILLIAMS, 2016, p. 2).

Other models, however, regardless of coming from the Wicksellian source, define neutral rates in a short term perspective. Woodford (2003) defines neutral rate as the one compatible with short term equilibrium in a model with rational expectations and flexible wages and prices. Rephrasing, it is the real interest rate in effect when output is at potential levels and inflation at its target, if one thinks of the model consisting of aggregate supply, aggregate demand and a Phillips curve. Through these lenses, the natural rate of interest changes frequently from period to period depending on a set of variables, following a long term trend that can change slowly, according to Gottlieb (2013).

It is important to single out, as did Laubach and Williams, that these views are not “competing or contradictory” (LAUBACH; WILLIAMS, 2016, p. 2); rather, both views are complementary. With that in mind, it is fair to assume that the neutral interest rate is dependent both on structural variables, which will determine the long term trend, and cyclical ones, which will shape short term fluctuations. Taking this into account, we will now present different methodologies to estimate neutral rates, which we will apply to the Brazilian data.

3.2 Measuring

Despite its somewhat simple definition, many questions arise when one proceeds to estimate neutral interest rates. The first of them being which measure of real interest rate extract the neutral value from. Many central banks have discussed which one is the most appropriate for policy making, broadly agreeing on the ex-ante measure, as it is paramount for investment decisions. Still, one could argue that the ex-post measure is also relevant, given its importance for current consumption decisions. In this work, we will use three different measures of real interest for the Brazilian economy. First, ex ante real rates, defined as the current monetary policy target rate (Selic) deflated by twelve-month-ahead inflation expectations; second, ex-post real rates, defined as Selic deflated by the current consumer price index (IPCA); and third, a market implied ex-ante real rate, defined as the interest rate on 360 days Pré/DI swaps deflated by twelve-month-ahead inflation expectations.

Also, one could argue about which methodology to use to estimate neutral rates. If the definition from Laubach and Williams (2016) is brought to the table, the first ones that come to mind are univariate statistical filters. The same authors discuss that, despite their a priori adequacy, univariate filters tend to be unreliable when inflation and economic activity are not stable, which certainly applies to Brazil. Additionally, classical problems of the filters arise, such as their tendency to overweigh the last observations, particularly in Brazil's recent environment, with the central bank putting in course another easing cycle.

In order to avoid those problems, we decided to take three different approaches when estimating neutral rates. The first will be a short term one, with the estimation of an IS equation; the second will be the estimation of an interest rate rule with a long term perspective; and the third will be a multivariate filter, using the Kalman filter a la Laubach-Williams (2003). In this work, our focus will be the recent neutral rates dynamics after the 2008 Global Financial Crisis. The details of the models come in the following subsections, and the results in the following section.

3.2.1 A Short Term View

Following Nakane and Muinhos (2006) and Gottlieb (2013), under this approach we define neutral interest rate as the one that closes the output gap, putting the economy at its potential – a definition close to Woodford's (2003). As Gottlieb points out, this is a higher frequency measure and more sensitive to the current outlook of the economy, given the short term nature of the estimation. In order to try and measure neutral rates, we will first estimate a simple IS equation as follows:

$$\tilde{y}_t = \beta_0 + \beta_1 \tilde{y}_{t-1} + \beta_2 r_t + \beta_3 spending_t + \beta_4 tradeflow_t + \epsilon_t \tag{1}$$

In Equation (1), $\tilde{y}_t$ is the output gap, r_t is the real rates measure, which will vary according to the three definitions presented above, $spending_t$ is the real yearly change on government spending, $tradeflow_t$ is the yearly change on the sum of world exports and imports, and ϵ_t is the stochastic error term. Once we estimate the model for each real interest rate definition, we calculate the neutral interest rate as the one that would make the output gap and its lags equal to zero ($\tilde{y}_t = \tilde{y}_{t-1} = 0$), by rearranging (1) into (2):

$$r_t^* = \frac{-\left(\beta_0 + \beta_3 spending_t + \beta_4 tradeflow_t\right)}{\beta_2} \tag{2}$$

3.2.2 A Long Term View

In this second way to measure neutral rates, we use the differences between short term and long term measurements presented in Bernhardsen and Gerdrup (2007) and Goldfajn and Bicalho (2011). The authors state that the long term equilibrium rate depends on structural variables and the fundamentals of the economy one wants to study, whereas the short term, as we mentioned before, is more sensitive to the economic cycle.

In order to estimate the long-term neutral rate, we will proceed as Favero (2001), according to whom the current real interest rate (r_t) depends on its lagged value (r_{t-1}) and the long term neutral rates (r_t^*) (Equation (3)). The first component singles out the tendency monetary authorities bear to smoothen rates path and controls the inertia of rates decision; the second reflects neutral rates as a function of structural variables, in this case for the Brazilian economy (Equation (4)).

$$r_t = \alpha_1 r_{t-1} + (1 - \alpha_1) r_t^* + \epsilon_t \tag{3}$$

$$r_t^* = \alpha_2 debt_t + \alpha_3 credit_t + \alpha_4 deviation_t + \alpha_5 spread_t + \epsilon_t \tag{4}$$

The variables we elected to explain neutral rates are the following: $debt_t$ represents public sector's net debt as percentage of GDP, as a measure of fiscal conditions, with a positive expected parameter; $credit_t$ represents financial system's non-earmarked credit as a percentage of GDP, as a measure of credit conditions, with a negative expected parameter; $deviation_t$ represents the deviation from the yearly change on headline consumer price index to the center of the central bank's target, as a measure both of central bank's credibility and overall inflation behavior, with positive expected parameter ; $spread_t$

represents the spread between Brazil's and the USA's 10-year zero coupon government bonds yields, as a proxy both for external conditions and markets risk aversion, with a positive expected parameter; and ϵ_t are stochastic error terms. If we combine (3) and (4), we can estimate equation (5) through GMM, to avoid endogeneity problems, as Gottlieb (2013) remarks, that could arise if an explanatory variable is correlated to the error term.

$$r_t = \alpha_1 r_{t-1} + (1 - \alpha_1)(\alpha_2 debt_t + \alpha_3 credit_t + \alpha_4 deviation_t + \alpha_5 spread_t) + \epsilon_t \tag{5}$$

Instrumental variables in a GMM-estimated model should match two criteria: i) be correlated to the endogenous variables and ii) be orthogonal to the error vector. We chose as instruments the lagged values of the exogenous variables, as they possess an important inertial component and should therefore be correlated to the endogenous variables, matching criteria i). To test our credibility on instruments, we use the J test.

3.2.3 The Kalman Filter

Laubach and Williams's (2003) work is seminal and was widely replicated. In this work, we will use the updated version of the model presented by Holston, Laubach and Williams (2017) with Brazilian data. The authors use a New Keynesian framework of a Phillips curve relationship and an intertemporal IS equation to model dynamics between output gap, inflation and the real interest rate gap. They start from a neoclassical approach by modeling the relation between real rates and growth, according to Equation (6), which reflects household intertemporal utility maximization:

$$r = \frac{1}{\sigma} g_c + \theta \tag{6}$$

Where r is the real interest, σ is the intertemporal elasticity of substitution in consumption, g_c is the growth rate of per capita consumption and θ is the rate of time preference. The authors assumed the theoretical link between the neutral rate and the growth rate in Equation (6) to state the law of motion for the neutral rate, r_t^*, following Equation (7),

$$r_t^* = c g_t + z_t \tag{7}$$

Where g_t is the trend growth rate of the natural rate of output, and z_t captures other determinants of the neutral rate. Laubach and Williams (2003) estimated a σ that was very close to unity, yielding a c that was also very close to unity. This result was used in Holston, Laubach and Williams (2017) and will also be replicated here.[2] With that in mind, we can rewrite (7) as follows:

$$r_t^* = g_t + z_t \tag{8}$$

The authors obtain the identification of neutral interest rates by specifying a simple model to capture the short term dynamics between inflation, output and real interest rate. Aggregate demand appears in the form of a reduced IS equation (Equation (9)), in which the output gap appears as a function of its own lags, the real interest rate gap and a serially uncorrelated error. Aggregate supply is a Phillips curve (Equation (10)), where current inflation is a product of the average of its own lags, the lagged output gap measure and a serially uncorrelated error. Here lies the main difference between the original Laubach and Williams (2003) framework and Holston, Laubach and Williams (2017) re-specification: the former adds to the Phillips curve's right-hand side core import price inflation and lagged crude oil imported price inflation, as a measure of relative price shocks.

$$\tilde{y}_t = a_{y,1}\tilde{y}_{t-1} + a_{y,2}\tilde{y}_{t-2} + \frac{a_r}{2}\sum_{k=1}^{2}\left(r_{t-k} - r_{t-k}^*\right) + \epsilon_{\tilde{y},t} \tag{9}$$

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\pi_{t-2,4} + b_y \tilde{y}_{t-1} + \epsilon_{\pi,t} \tag{10}$$

In Equations (9) and (10), $\tilde{y}_t = 100 * (y_t - y_t^*), y_t$ and y_t^* are the logarithms of real GDP and the unobserved natural rate of output, r_t is the short-term real rates measure, π_t denotes consumer price inflation and $\pi_{t-2,4}$ stands for the average of its second to fourth lags. As Holston, Laubach and Williams (2017) single out, following Williams (2003), the presence of the stochastic terms $\epsilon_{\tilde{y},t}$ and $\epsilon_{\pi,t}$ allows transitory shocks to the output gap and inflation, whereas movements in r^* denote permanent shifts in the relation between real interest rate and the output gap.

The authors also specify log potential output as a random walk with a stochastic drift g, which itself also follows a random walk, as show Equations (11) and (12).

$$y_t^* = y_{t-1}^* + g_{t-1} + \epsilon_{y^*,t} \tag{11}$$

$$g_t = g_{t-1} + \epsilon_{g,t} \tag{12}$$

[2] Castro et al (2011), in Brazilian Central Bank's Working Paper n. 239, estimated a σ of 0.77 for the Brazilian economy.

Finally, the variable z_t is also defined as a random walk, in Equation (13).

$$z_t = z_{t-1} + \epsilon_{z,t} \tag{13}$$

As the determinants of the neutral interest rest are unobservable and the model is linear on them, the authors applied the Kalman Filter to estimate neutral interest rate (or alternatively the z component), the natural rate of output and its trend growth rate. Following Hamilton (1994), Equations (11) to (13) represent the transition equation in the state-space model required for the Kalman filter, whereas Equation (9) and (10) represent the measurement equations.

Laubach and Williams (2003) argue that, by merely running the Kalman filter, maximum likelihood estimations of standards deviations of z and g, σ_z and σ_g, respectively, are biased towards zero, owing to the pile-up problem discussed in Stock (1994). To overcome it, they propose the use of Stock and Watson's (1998) median unbiased estimators to estimate $\lambda_g \equiv \frac{\sigma_g}{\sigma_{y^*}}$ and $\lambda_z \equiv \frac{a_r \sigma_z}{\sigma_{\tilde{y}}}$. They impose those ratios when estimating the other parameters by maximum likelihood. The same is done in Holston, Laubach and Williams (2017), which is the model we will follow for Brazilian data.

The estimation process is threefold. In the first step, the authors apply the Kalman filter to estimate the output gap, omitting the real rate gap and assuming that g is constant. Then, Andrews and Ploeberger's (1994) Wald exponential test is done for a structural break with an unknown break date in the first difference of the preliminary estimations to obtain λ_g. The second step comes with the imposition of λ_g from the previous step and the inclusion of the real rate gap in the IS equation, assuming that z is constant. The same test is applied to obtain an estimate of λ_z. Finally, in the third step, the authors impose the values of λ_g and λ_z to estimate the remaining parameters by maximum likelihood following Harvey (1989). Throughout the estimation, Holston, Laubach and Williams (2017) imposed a negative slope for the IS curve and a positive one for the Phillips curve. Once this process is finished, we obtain the desired estimates of the unobservable variables.

With the methodologies defined, we will now proceed to explain the data used and estimate the models.

4 DATA AND ESTIMATION RESULTS

In this chapter, we will present the data used for the estimations and their results for each of the different methodologies presented in Section 3. This section starts defining the different measures of real interest rate. Then we proceed to the estimations of neutral rates: the univariate filters, the short term model, the long term model and the Kalman filter. Finally, we will decide which of the measures we will use to build an assessment of the Brazilian monetary policy since the subprime crisis.

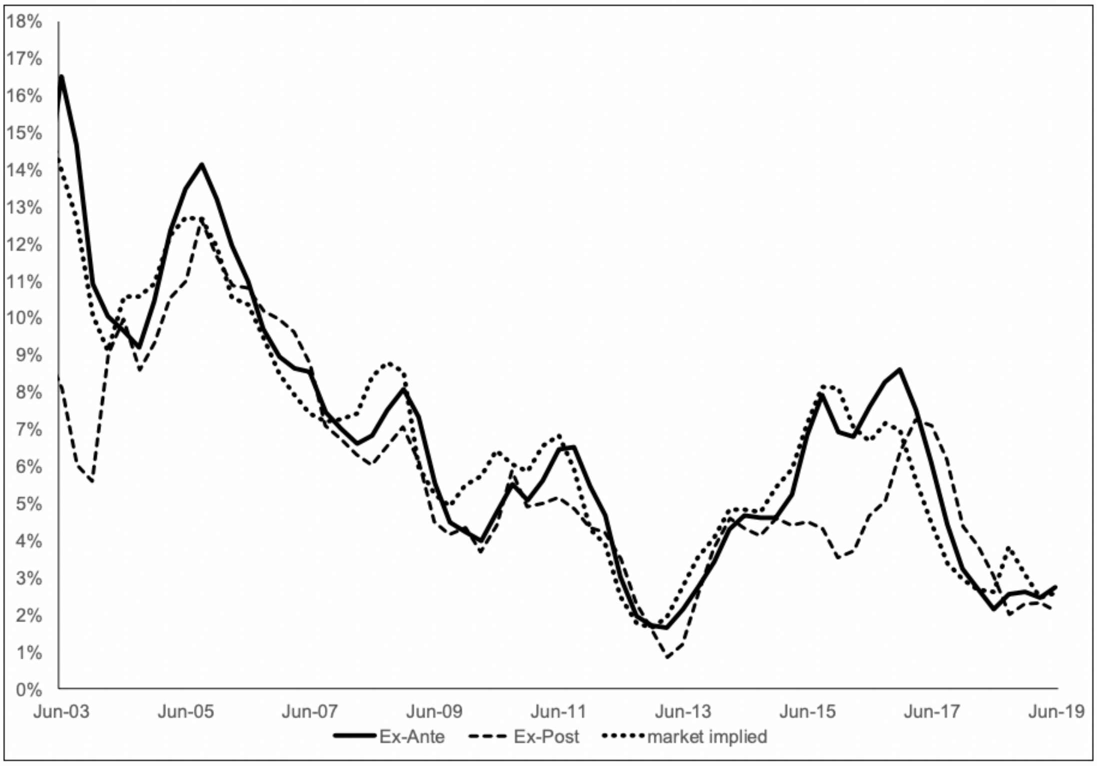
4.1 Rates Measures

As we mentioned in the previous section, we will use three different measures of real interest rates in the models for neutral rates estimation. We calculated them as follows:

$$r_{j,t} = \frac{1 + i_{j,t}}{1 + \pi_{j,t}} - 1 \tag{14}$$

In Equation (14), $r_{j,t}$ is the real rate measure, $i_{j,t}$ is the nominal rate measure and $\pi_{j,t}$ is the inflation measure. The index j indicates each of the different rates measure we mentioned on Section 3.2. If $j = a$, we will be talking about the real ex-ante interest rate ($r_{a,t}$), where $i_{a,t}$ is the nominal Selic rate, the BCB's target base rate, and $\pi_{a,t}$ is the twelve-month-ahead inflation expectations, from the BCB as well. If $j = p$, it is the real ex-post interest rate ($r_{p,t}$), where $i_{p,t} = i_{a,t}$ and $\pi_{p,t}$ is the year-over-year change in the consumer price index (IPCA) from IBGE (Brazilian Institute of Geography and Statistics). If j=m, it is the market implied real rate. This time, $i_{m,t}$ is the interest rate implied in the 360 days Pré/DI swap, which BCB discloses daily - we used the monthly average to calculate the measure. Also, $\pi_{m,t} = \pi_{a,t}$. Since the data are monthly disclosed, we first calculate the monthly real rates and then used the quarterly average for the models estimations. Figure 8 shows the different rates measure on a quarterly basis since 2002, when the central bank started disclosing inflation expectation measures.

Figure 8 – Brazil: Real Interest Rate (annual rate)

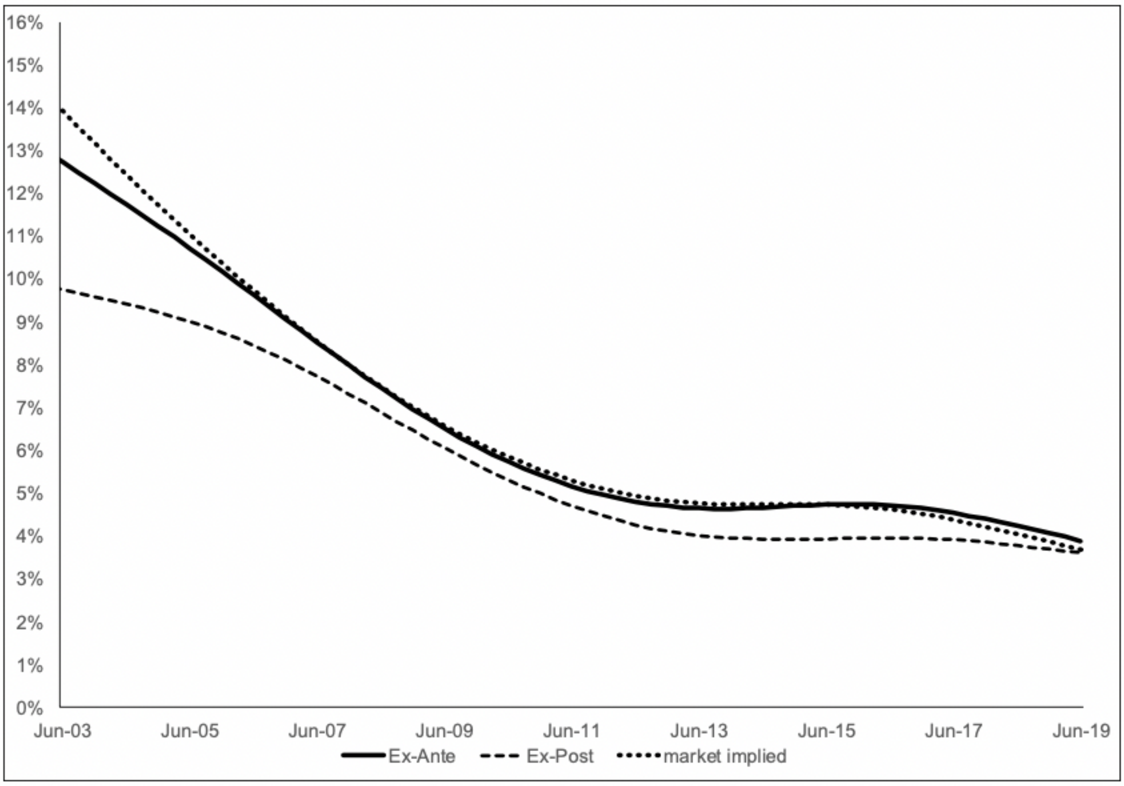


Source – BCB, IBGE, author's elaboration.

4.2 Univariate Filters

The immediate thought when estimating neutral interest rates, as we mentioned in Section 3.2, is to apply univariate filters to real interest rate measures. Despite the problems depicted in that section, we still see them as a valuable ball park, at least for an initial guess. We applied two different filters. The first one is the Hodrick-Prescott (1997) filter, with a parameter λ of 6400, as suggest Laubach and Williams (2003). The second is a full-sample asymmetric bandpass filter following Christiano-Fitzgerald (2003). Laubach and Williams (2003) recommend the use of a 60-quarter window bandpass filter, but we lack enough data in inflation expectations to do so for the ex-ante real rate, hence the choice for the full-sample filter. Figures 9 and 10 show the filters for each rate measure described in Section 4.1. Both filters show a downward trend in the neutral rates estimations, which is our underlying assumption, but the HP filter is less volatile and presents an even more pronounced trend.

Figure 9 – Brazil: Real Interest Rates after the HP Filter (annual rate)



Source – Author's elaboration.

Figure 10 – Brazil: Real Interest Rates after the Bandpass Filter (annual rate)

Source – Author's elaboration.

4.3 The Short Term Model

First, we have to recall Equation (1), which we now rewrite with the different rate measures in mind:

$$\tilde{y}_t = \beta_0 + \beta_1 \tilde{y}_{t-1} + \beta_2 r_{j,t} + \beta_3 spending_t + \beta_4 tradeflow_t + \epsilon_t \tag{15}$$

Having already defined the rate measures, we now proceed to define the other variables on the IS curve:

a) $\tilde{y}_t$ is the output gap calculated and disclosed quarterly by IPEA (Applied Economic Research Institute), based on the methodology developed by Souza-Júnior and Caetano (2013) and Souza-Júnior (2015);

b) $spending_t$ is the Central Government's total primary spending disclosed monthly by the Brazilian National Treasury. We deflated the values using headline consumer price index, which IBGE discloses monthly. We calculated the quarterly sum of real spending and the year-over-year percentage change of that sum was used in the estimation;

c) $tradeflow_t$ is the year-over-year percentage change in the quarterly sum of total world exports and imports disclosed monthly by the International Monetary Fund.

We estimate the three IS equations through ordinary least squares, from the first quarter of 2009 to the second quarter of 2019. We chose this sample to avoid the structural break represented by the global financial crisis of 2008. In doing so, the model presented better results. Table 1 summarizes the results for each specification:

Table 1 – IS Curves Estimation

Dependent variable: $\tilde{y}_t$			
Sample: 2009Q1 – 2019Q2			
Parameters	Rates definition		
	Ex-Ante	Ex-Post	Market Implied
β_0	0.004	0.002	0.003
	*(1.72)**	*(0.57)*	*(0.94)*
$\tilde{y}_{t-1}$	0.83	0.84	0.86
	*(15.39)****	*(14.48)****	(15.69)***
$r_{j,t}$	-0.18	-0.15	-0.15
	*(-2.75)****	*(-1.71)**	(2.15)**
$spending_t$	0.02	0.03	0.02
	*(2.43)***	*(2.56)****	*(2.52)***
$tradeflow_t$	0.03	0.04	0.03
	*(2.03)***	*(2.24)***	*(2.30)***
$\overline{R^2}$	0.89	0.88	0.89
Prob. LW Test	0.80	0.55	0.87
Log-Likelihood	145.84	143.51	144.41

Source – Author's elaboration.

Note – t statistics in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%

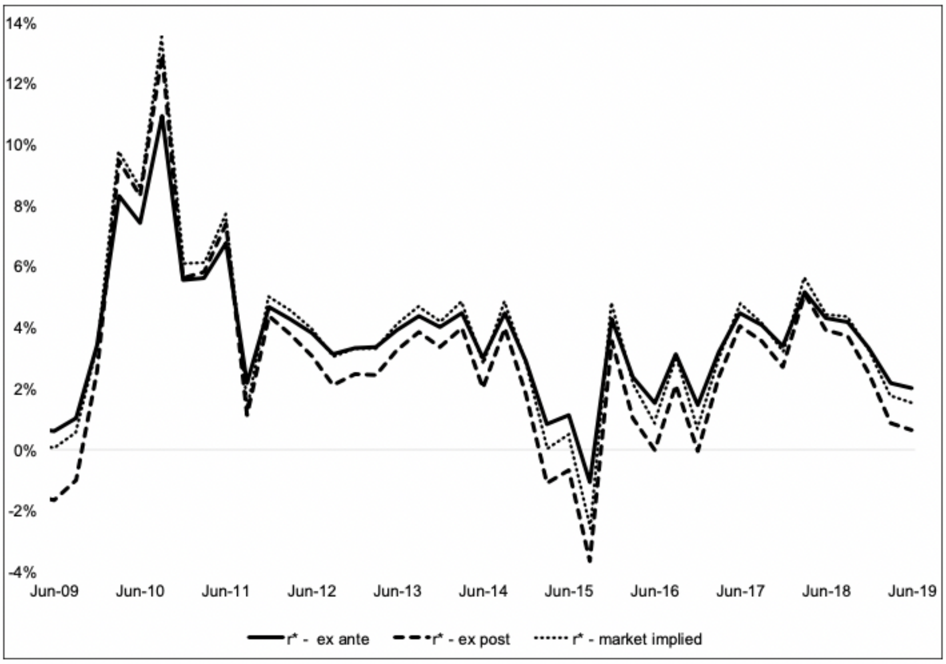
All estimated parameters delivered the expected signs. The ones associated with real interest rate are all negative and significant, as theory implies. The ones for $spending_t$ are also positive and significant, meaning that an increase in government spending widens (closes) the output gut if it is positive (negative). The same rationale applies to $tradeflow_t$, whose parameters are positive and significant as well.

With the estimations results at hand, we calculate the real short term neutral rates, following equation (2), which we rewrite as follows:

$$r^*_{j,t} = \frac{-\left(\beta_0 + \beta_3 spending_t + \beta_4 tradeflow_t\right)}{\beta_2} \tag{16}$$

Figure 11 shows the result of the estimation for the three real interest rates measure. There is no surprise that the different measures yielded similar results, given the nature of neutral interest rates. Changes and levels are approximate, as one would expect. However, the best model specification came when the ex-ante real measure was used. It counts with higher t-statistics, higher R^2 and higher log-likelihood. It will be the one used in the monetary policy assessment section. Additionally, we performed the Breusch-Godfrey Serial Correlation LM-Test in the residuals, and we did not reject the null hypothesis of no first order autocorrelation in any of the models we estimated.

Figure 11 – Brazil: Short Term Neutral Interest Rates (annual rate)



Source – Author's estimation.

4.4 The Long Term Model

As we did for the short term approach, we will rewrite Equation (5) taking into account the different interest rate measures, which we will estimate via GMM.

$$r_{j,t} = \alpha_1 r_{j,t-1} + (1-\alpha_1)(\alpha_2 debt_t + \alpha_3 credit_t + \alpha_4 deviation_t + \alpha_5 spread_t) + \epsilon_t \quad (17)$$

Before the estimation, we define the data:

a) $debt_t$ stands for the public sector's net debt as percentage of GDP, disclosed monthly by BCB. We aggregated them into quarterly data by using each quarter's end-of-period result, since debt is a stock, and not a flow;

b) $credit_t$ is the non-earmarked credit outstanding as a percentage of GDP, disclosed once again monthly by the central bank. We aggregated it using the quarter's end-of-period outstanding divided by the last twelve-month sum of monthly GDP, once again from BCB;

c) $deviation_t$ stands for the deviation from the yearly change on the consumer price index from IBGE to the central bank's target inflation in the current year. We calculated it as follows:

$$deviation_t = \frac{1+\pi_t}{1+\pi^*} - 1 \tag{18}$$

In (18), π_t is the yearly change of IPCA and π^* is the target inflation.

d) $spread_t$ is the spread between 10-year zero coupon bonds yield issued by the Brazilian and American governments, which we obtained in Trading Economics. The spread was calculated as below:

$$spread_t = \frac{1+\gamma_t}{1+\gamma_t^*} - 1 \tag{19}$$

In (19), γ_t is the Brazilian yield and γ_t^* is the American one. We used the quarterly average of the daily data in the estimations.

Now that we have defined all the data used in the long term model, we will estimate it. As discussed in Section 3.2.2, the estimation will be done through GMM to avoid endogeneity. We used as instruments for the GMM estimation the first to fourth lags of the independent variables a-d). Table 2 presents the estimation results for all three models.

Table 2 – Interest Rate Rule Estimation[3]

Dependent variable: $r_{j,t}$			
Sample: 2009Q1 – 2019Q2			
Parameters	Rates definition		
	Ex-Ante	Ex-Post	Market Implied
$r_{j,t-1}$	0.66	0.75	0.51
	*(15.16)****	*(10.28)****	*(9.86)****
$debt_t$	0.05	0.03	0.006
	*(2.45)***	*(1.18)*	(0.47)
$credit_t$	-0.11	-0.14	-0.08
	*(-1.67)**	*(-1.33)*	(-1.84)*
$deviation_t$	0.98	0.36	0.38
	*(4.96)****	*(0.69)*	(2.74)***
$spread_t$	0.48	0.64	0.73
	*(2.93)****	*(1.84)**	(5.33)***
$\overline{R^2}$	0.88	0.72	0.82
J-statistic	6.41	7.61	7.52
Prob.(J-statistic)	0.89	0.81	0.82

Source – Author's elaboration.

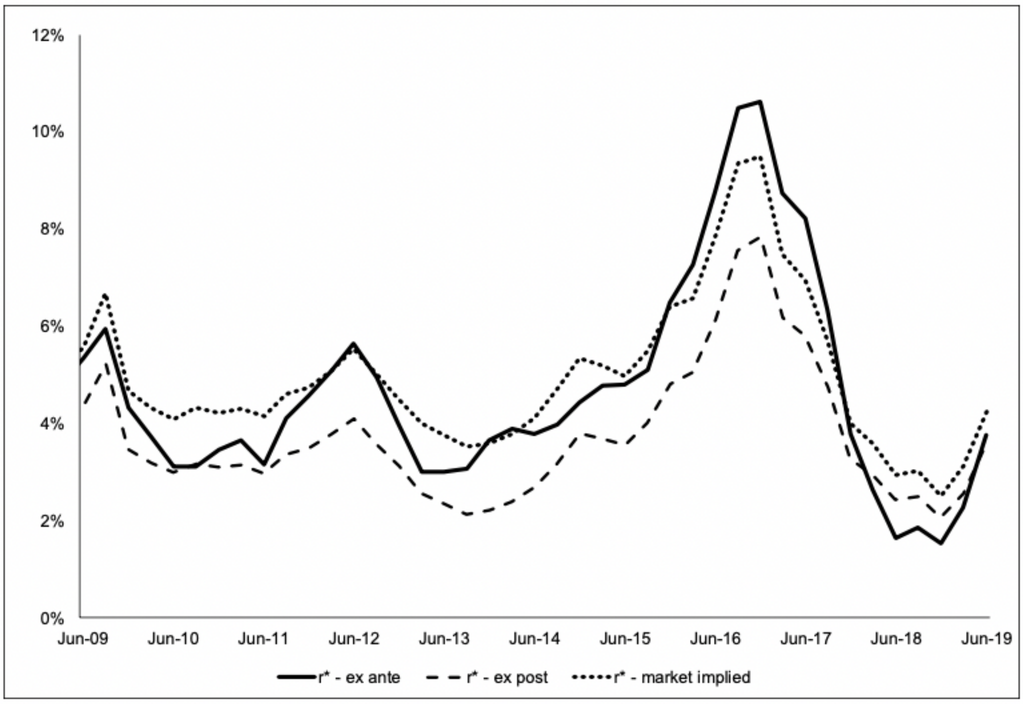
Note – Instruments: debt (-1 to -4); credit (-1 to -4); deviation (-1 to -4); spread (-1 to -4). t statistics in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.

All parameters presented the expected signs. When $debt_t$, $deviation_t$ and $spread_t$ increase, neutral rates estimates increase as well, owing either to higher government indebtedness, higher inflation deanchoring, higher risk perception or a combination of all of them. When $credit_t$ increases, however, neutral rate estimates decrease. This, as Goldfajn and Bicalho (2011) discuss, would be a result of higher market forces penetration in the credit outstanding, if compared to earmarked credit. This would increase monetary policy effectiveness and help reduce neutral rates. Applying the J test in the three models yields a positive result: we do not reject the validity of the instruments in any of the models.

With the estimations done, we proceed to calculate the long term neutral rates estimates. Figure 12 presents the estimations for all three measure of real rates.

[3] We could not implement proper tests for serial autocorrelation in the residuals. We recommend cautiousness when analyzing the parameters.

Figure 12 – Brazil: Long Term Neutral Interest Rates (annual rate)



Source – Author's estimation.

Once again, as expected, all estimations produced similar results in level and trajectory. However, the model with ex-ante real rates presented better overall p-values, J statistic and adjusted R^2, and will be used to assess Monetary Policy.

4.5 The Kalman Filter

First, as we did for the other methodologies, we will rewrite Equations (9) to (13) taking into account the different rates measures defined in Section 4.1:

$$\tilde{y}_t = a_{y,1}\tilde{y}_{t-1} + a_{y,2}\tilde{y}_{t-2} + \frac{a_r}{2}\sum_{k=1}^{2}\left(r_{j,t-k} - r^*_{j,t-k}\right) + \epsilon_{\tilde{y},t} \tag{20}$$

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\pi_{t-2,4} + b_y \tilde{y}_{t-1} + \epsilon_{\pi,t} \tag{21}$$

$$y^*_t = y^*_{t-1} + g_{t-1} + \epsilon_{y^*,t} \tag{22}$$

$$g_t = g_{t-1} + \epsilon_{g,t} \tag{23}$$

$$z_t = z_{t-1} + \epsilon_{z,t} \tag{24}$$

As we defined in Section 3.2.3, following the notation of Hamilton (1994), Equations (20) and (21) are the measurement (or observation) equations and Equations (22) to (24) are the transition (or state) equations. The estimation was done using the R code written by Holston, Laubach and Williams (2017), which is available at the New York Federal Reserve website.[4] The variables necessary for the estimation with this code are four. First, the logarithm of real seasonally adjusted GDP, for which we used GDP data from IBGE, rebased to make 2000=100. Second, the inflation measure. The authors recommend the use of core inflation since this is the one which the FED targets. For Brazil, however, we used headline inflation (IPCA, measured by IBGE), as this is the one BCB targets. We used the yearly change in the quarterly average index. Third, the nominal interest rate, for which we used the quarterly average of the targeted Selic. Finally, for inflation expectations, we used the quarterly average of twelve-month ahead inflation expectations disclosed by BCB. The authors originally used the four-quarter average of past inflation as a proxy for the expectations measure. As BCB discloses the expectations measure itself, we decided to use it.

The estimation of the model with Brazilian data was rather challenging and we had to adapt the code to some of its idiosyncrasies. First, the model for the USA uses more than 50 years of data, given the structural nature of neutral rates. Taking into account the lack of inflation expectations data previously to 2001 and that the model uses four lags previous to the sample start, we started our estimation in the first quarter of 2003, in order to make the dataset as long as possible.

The second problem was identified by Moreira and Portugal (2019). Originally, Holston, Laubach and Williams (2017) impose the following restrictions when estimating Equations (20) to (24): $a_r \leq -0.025$ and $b_y \geq 0.025$, in order to facilitate convergence. Moreira and Portugal noticed that, when imposing this constraints to Brazilian data, especially the Philips curve one, variance estimation becomes biased towards zero, bringing back the pile-up problem, despite the sequential estimation proposed by Holston, Laubach and Williams. To avoid it, they imposed a much tougher constraint to the estimation: $b_y \geq 0.25$. Here, we proceed as they do.

The third and final alteration refers to the initial guess of the unobservable variables vector - the vector ξ_0 in Hamilton's (1994) notation. In the original code, the authors use a Hodrick-Prescott (1997) filter with $\lambda = 36000$ to estimate the initial potential GDP. Regardless of how close they seemed, we decided to use IPEA's quarterly estimates based on the methodology developed by Souza-Júnior and Caetano (2013) and Souza-Júnior (2015), owing to the fact that the latter incorporates a production function when estimating potential output, rather than only using a univariate filter, which present some problems, as we have discussed.

4 The code is available here: <https://www.newyorkfed.org/research/policy/rstar>

Table 3 presents the result of the Holston, Laubach and Williams (2017) estimation for each rates measures. Figure 13 presents the estimation of neutral interest rates for each rate measure as well.

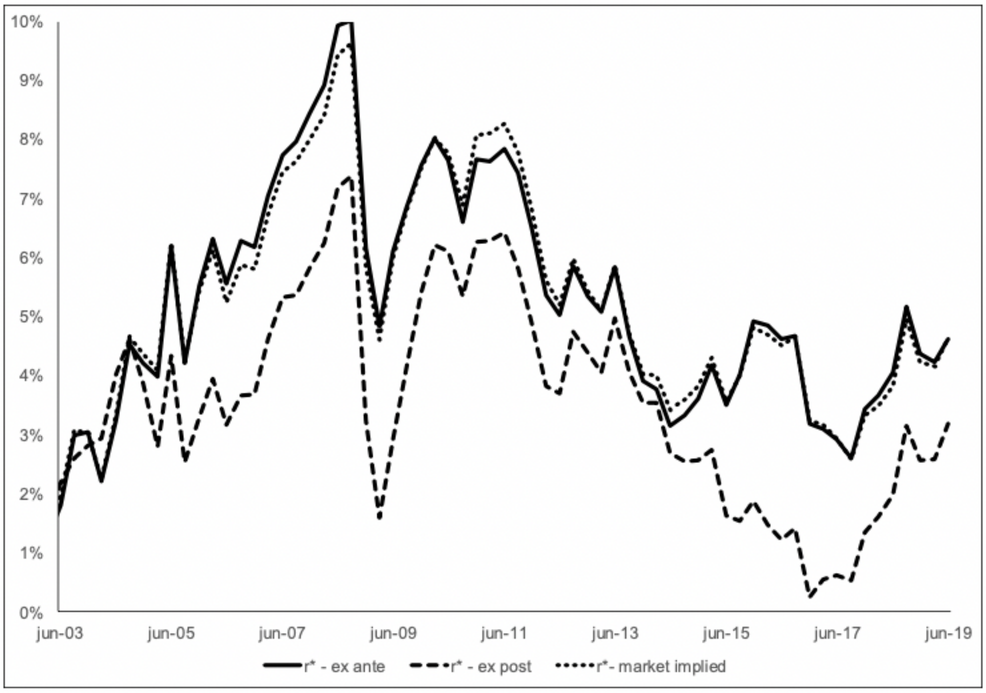
Table 3 – Holston, Laubach and Williams (2017) Model Estimation[5]

Sample: 2003Q1 – 2019Q2			
Parameters	Rates definition		
	Ex-Ante	Ex-Post	Market Implied
λ_g	0.21	0.21	0.21
λ_z	0.12	0.04	0.11
Σa_y	0.26	0.47	0.33
a_r	-0.03	-0.002	-0.03
	(1.09)	*(1.04)*	(1.05)
b_π	0.99	1.09	1.04
	(7.04)	*(6.08)*	*(7.41)*
b_y	2.75	10.59	2.57
	(1.08)	*(1.59)*	*(1.14)*
σ_y	0.13	0.02	0.13
σ_π	0.47	0.50	0.49
σ_{y^*}	1.01	1.05	1.01
σ_g	0.21	0.22	0.21
σ_z	0.02	0.001	0.02
$\sigma_{r^*} = \sqrt{\sigma_g^2 + \sigma_z^2}$	0.21	0.22	0.22
	Standard Errors (sample average)		
r^*	2.44	2.49	2.45
g	1.32	1.38	1.31
y^*	0.28	0.12	0.29

Source – Author's estimation.

5 Estimation results for the other unobservable variables are in the appendix. We could not implement proper tests for serial autocorrelation in the residuals. We recommend cautiousness when analyzing the parameters.

Figure 13 – Brazil: Neutral Interest Rate via Kalman Filter (annual rate)



Source – Author's estimation.

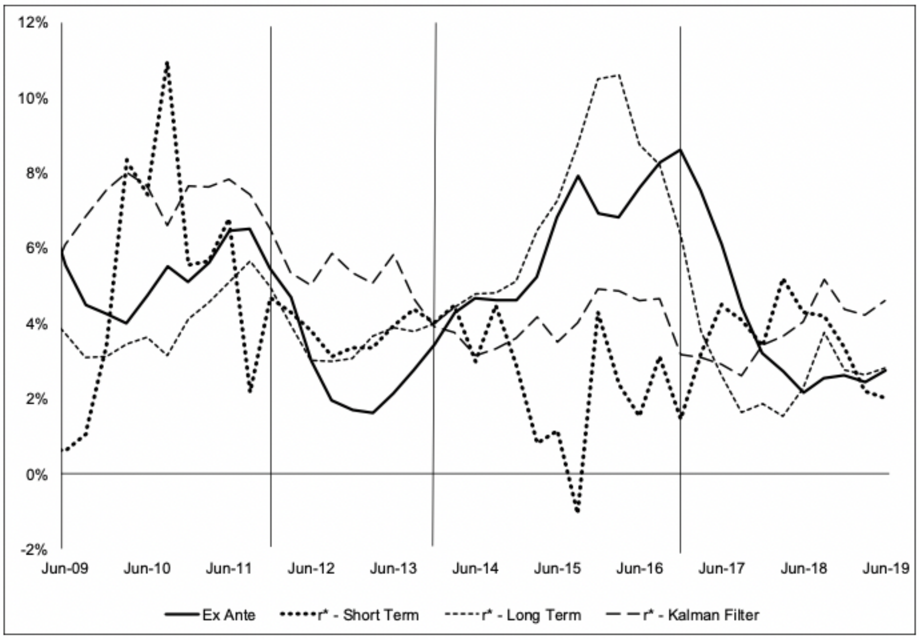
Regardless of the fact that the parameters were broadly statistically significant, there were some significant changes when it came to the levels of the neutral rates estimations. They started very similarly in 2003, then moved away very significantly from 2004 until the end of the financial crisis of 2008, became similar again by 2012 and 2013, then separated again by 2015. We believe this happened because of the difference between ex-ante and ex-post real rates measures. In 2004 and 2015, inflation was above its expected level, yielding higher ex-ante than ex-post real rates and probably leading the Kalman filter algorithm to underestimate neutral rates when that was the case. This probably contributed to the level discrepancy between the estimates, notwithstanding the similar trajectory.

All three specifications yielded parameters with good t-statistics. Still, we decided also to adopt the model with ex-ante real rates when assessing monetary policy, given the lower standard errors and variation estimated for neutral rates.

5 MONETARY POLICY ASSESSMENT

In possession of the neutral interest rates estimations through different methodologies, we will now focus on an assessment of monetary policy since the global financial crisis. But first we need to take a step back and look into the comparison between the different rates measures within the same methodology and, as we argued in the previous section, the ex-ante measure yielded the best models. This is in line with most of the literature we presented here, which use the ex-ante real rate measure in the majority of times. With that in mind, we present all three measures of neutral interest rates in Figure 14, alongside the ex-ante measure itself.

Figure 14 – Brazil: Real Interest Rates (annual rate)



Source – BCB, author's estimation.

We will divide the period following the subprime crisis up until now into four sub periods. One between 2009 and 2011, the other comprising 2012 until 2013, another from 2014 to 2016 and the final one from 2017 until the second quarter of 2019. Table 4 compares the averages of the three measures in this period. In the next paragraphs, we will analyze monetary policy in each of these periods.

Table 4 – Brazil: Neutral Rates Estimates (annual rate, period average)

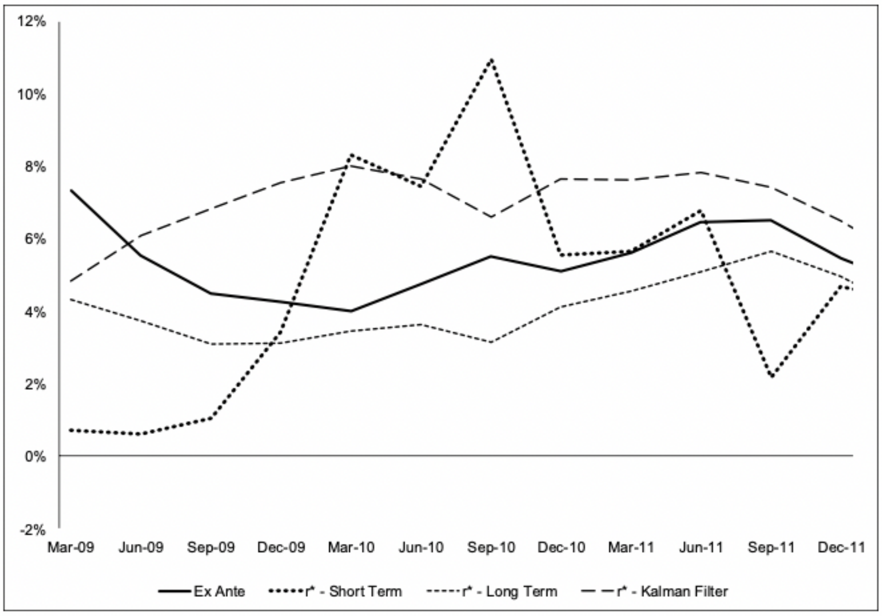
	Short Term	Long Term	Kalman Filter
2009-2011	4.8%	4.1%	7.1%
2012-2013	3.8%	3.5%	5.1%
2014-2016	2.4%	7.2%	4.0%
2017-Now	3.6%	2.6%	3.8%

Source – Author's estimation.

5.1 2009-2011: Recovering

The analysis of the first period will consist of two different moments: the first is 2009, right after the crisis, and the second is 2010-2011, when Brazil recovered. Figure 15 shows real ex-ante and neutral interest rates during the period.

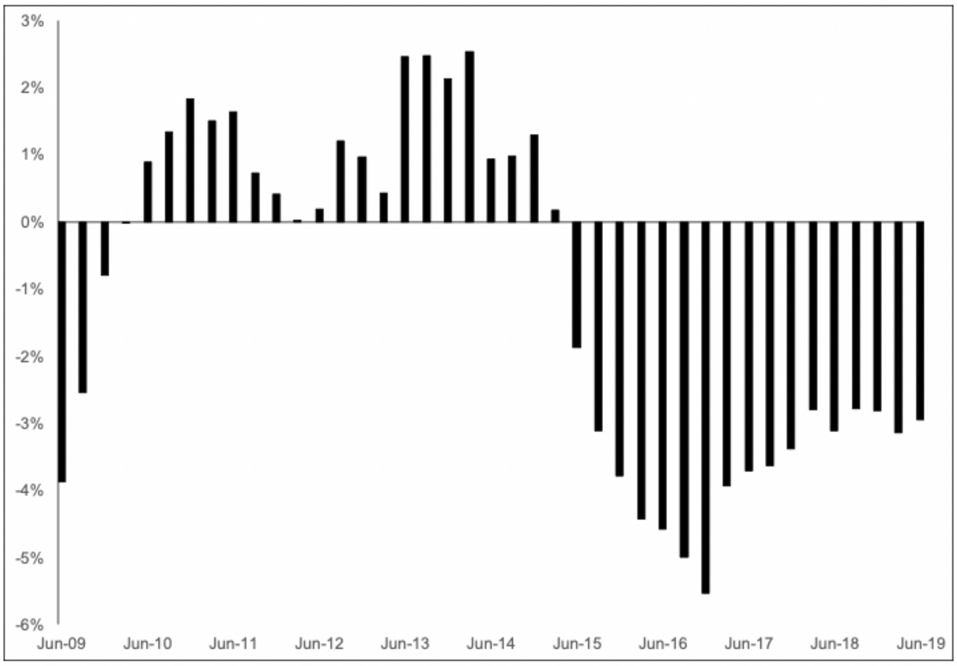
Figure 15 – Brazil: Real Interest Rates during 2009-2011 (annual rate)



Source – BCB, author's estimation.

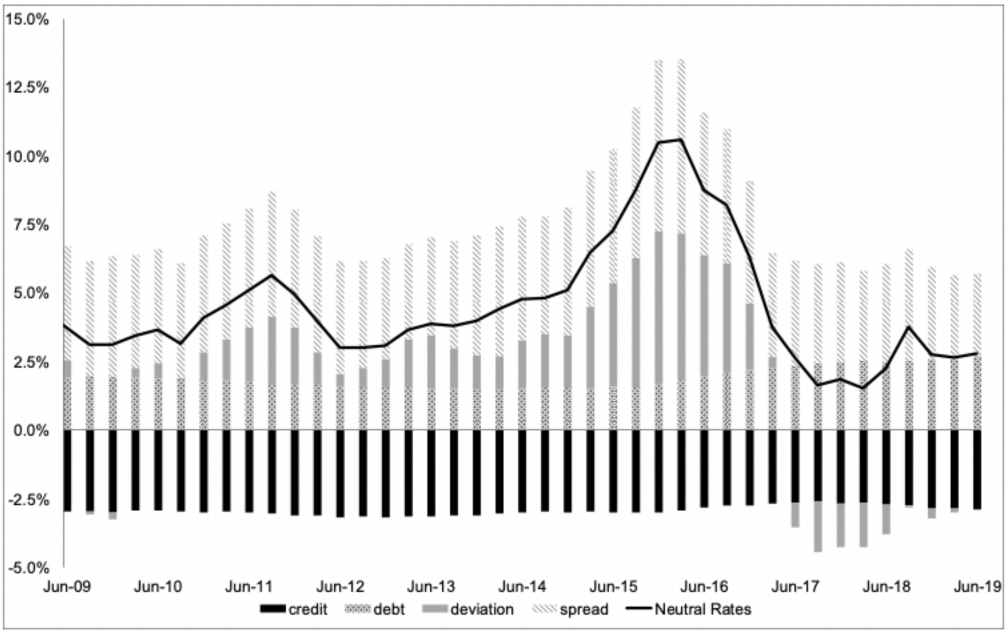
The immediate aftermath of the global financial crisis was a period of negative output gaps in most economies worldwide. In Brazil it was not different, as we can see in Figure 16, and it certainly took a toll on neutral rates estimations. First, the short term one fell not only due to the negative output gap, which would require lower interest rates to close, but also due to a contraction of its determinants according to our IS equation: world trade flow dropped materially in 2009 (-22.1% on average), which was more than enough to offset the average 8.5% expansion in government spending that same year, hence the contraction of neutral rates. The long term measure also fell during 2009 - a product of a decrease in the spread measures at a first moment, followed by a decrease in inflation deviation and net debt, as one can see in Figure 17, which shows the contribution to the long term neutral rates. The HLW model results also fell sharply during the crisis in 2009, as we saw in Figure 13, but went back to previous levels quickly in 2009.

Figure 16 – Brazil: Output Gap (%)



Source – IPEA, author's elaboration.

Figure 17 – Brazil: Contributions to Long Term NIR (p.p.)



Source – Author's estimation.

Globally, as the work of Holston, Laubach and Williams (2017) point out, neutral rates estimates also fell, which, coupled with an economy in recession, led the Federal Reserve, the European Central Bank and Bank of Japan, to name a few, to engage in an easing cycle that encompassed not only interest rates targets at low levels never seen before but also large quantitative easing programs. In a scenario of decreasing neutral rates estimates, negative output gap and easier monetary policy abroad, the Brazilian Central Bank (BCB) engaged in its own easing cycle, bringing down Selic from 13.75% in December 2008 to 8.75% in September 2009. The BCB's decisions were communicated in a somewhat dovish orientation.[6] The necessity of additional monetary stimuli during the year was often called and backed up by the good behavior of inflation in the communication of BCB.

In 2010, things started to change and we face the first neutral rates conundrum in the recent years. The conundrum is represented by the decoupling of short term and long term neutral rates measure: whereas the former materially edged up between 2010 and 2011, the latter only slightly went up, and became below the short term measure in almost all quarters, as did the Kalman filter estimations.

To better understand this apparent enigma, we will have to recall the determinants of each measure. Under the short term perspective - more sensitive to cyclical components - the rapid upsurge can be explained by the quick recovery the Brazilian economy posted in 2010, when GDP expanded 7.5% y-o-y, according to IBGE (the Brazilian statistical

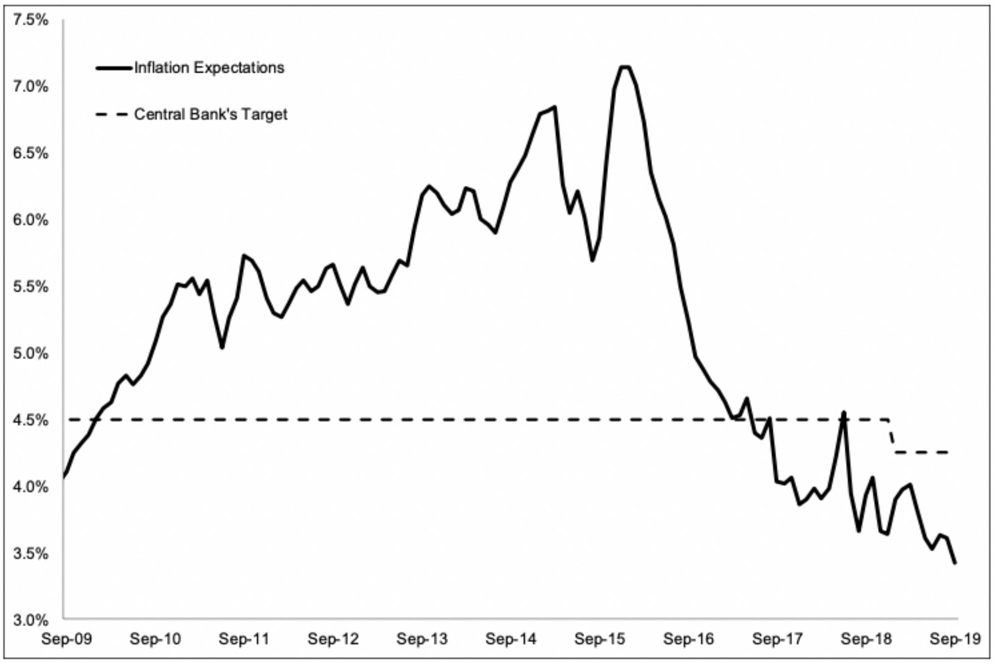
[6] In the January 2009 communique, available here: <https://www.bcb.gov.br/detalhenoticia/15900/nota>, authorities highlighted they started an easing cycle that would not harm the inflation target.

bureau). Glancing at the IS curve determinants, both world trade flow and government spending expanded briskly in 2010 - 22.3% y-o-y and 16.3% y-o-y, respectively -, even though the caveat of a low comparison base for the former is important. All this led to an economy that went rapidly above its potential, as evidenced by the positive output gap measured by IPEA.

The long term measure stayed around the 3.5% handle during 2010, as inflation, spreads and non-earmarked credit's contribution became steady in the process. Kalman filters estimates also were stable in 2010, around the 7.5% handle, greater than the other estimations. And here the conundrum materializes, as monetary policy was stimulative in the short term and in the Kalman filter definition of neutral rates while, at the same time, it was contractionary if the long term definition is to be adopted.

Taking the monetary authority's standpoint, in 2010 the economy recovered to and above its potential levels and prospective inflation scenario started to worry, as one can see with inflation expectations going above the target in Figure 18. In this scenario, the central bank decided to start a hiking cycle to normalize the past monetary stimulus, and took rates from 8.75% in March 2010 to 10.75% at the year-end and then to 12.50% in July 2011. In 2011, the contractionary effects materialized and we can see the output gap closing especially in the third and fourth quarters, considering the lags for the monetary policy pass through.

Figure 18 – Brazil: Twelve-Month Ahead Inflation Expectation (% change y-o-y)



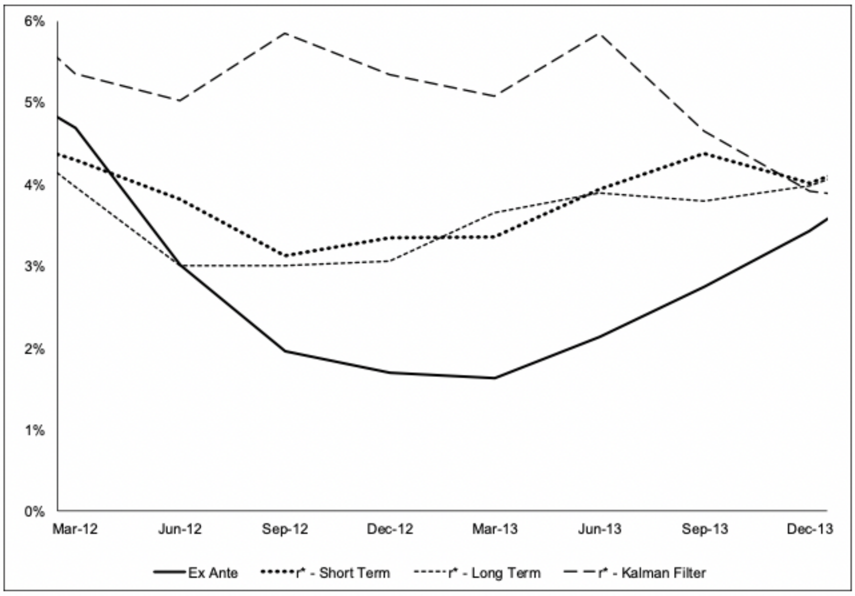
Source – BCB, author's elaboration.

With all that in mind, we head towards the end of 2011 with all three neutral rates measures at close levels and monetary policy close to a neutral stance. The latter did not last long.

5.2 2012-2013: Heating

First and foremost, we present the real interest rates measures during the period in Figure 19.

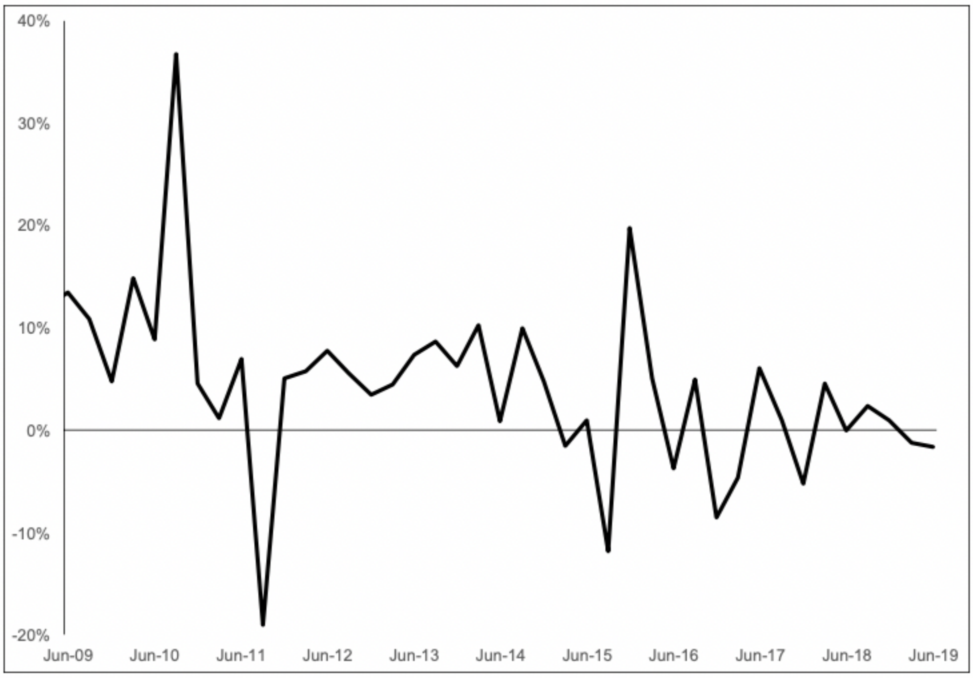
Figure 19 – Brazil: Real Interest Rates during 2012 and 2013 (annual rate)



Source – BCB, author's estimation.

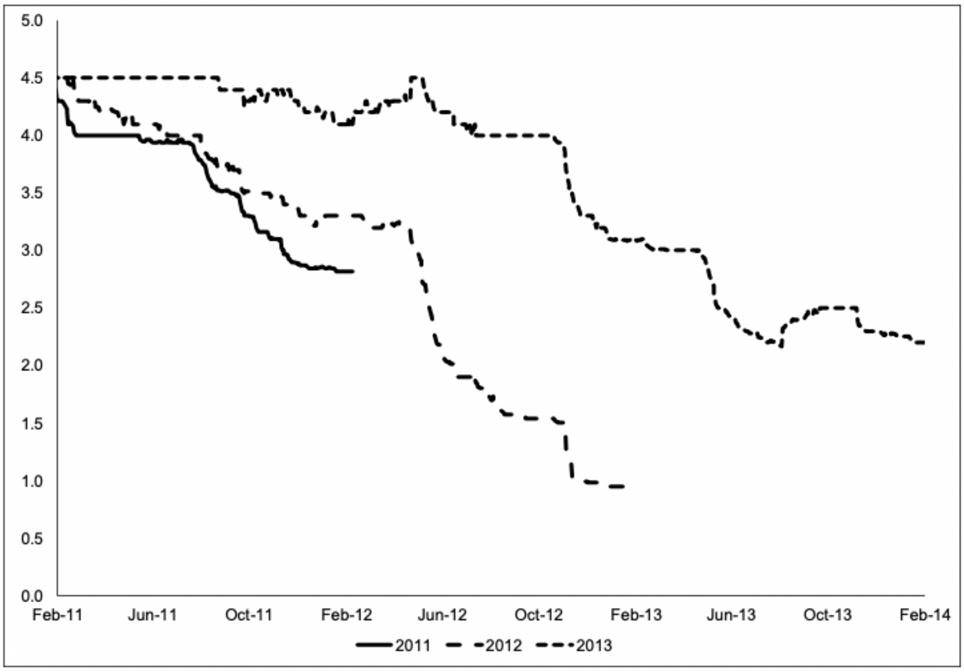
To better understand the 2012 to 2013 window, one has to bear in mind what the new government appointed in 2011 had on its hands when it came to economic performance. After strong growth numbers in 2010 and an upsurge in government spending that helped elect the new president (see Figure 20, with the yearly change on government spending), market participants started forecasting slower growth (see Figure 21, with Focus forecast for GDP). Still, government members decided they wanted to keep up the numbers and maintain the economy above its potential, turning a blind eye to the inflation expectations that were away from target. The first of the measures aimed at keeping the economy heated was the abrupt Selic cut on the August 2011 monetary policy meeting - a move that Bolle (2016) and many market participants saw as improper, in light of the increasing inflation expectations environment and the already above potential economy (see Figures 18 and 16).

Figure 20 – Brazil: Real Government Spending (% change y-o-y)



Source – National Treasury, author's elaboration.

Figure 21 – Brazil: Median GDP Expectations for 2011, 2012, 2013 (% change)



Source – BCB, author's elaboration.

The BCB brought Selic from 12.50% in August 2011 to 7.25% in March 2013, thus keeping real rates on stimulative grounds for the whole period. Neutral rates estimations were relatively stable in the period, hovering around the 3.8% handle. The short term measure faced downward pressures from decelerating trade flows (1.5% y-o-y on average, versus an 8.9% average on the previous period), but spending growth was able to offset it and keep neutral rates broadly unchanged. The long term measure also presented a steady behavior near 3.5%, owing to its determinants being controlled as well, as we can see in Figure 17. Kalman filter estimations were also relatively stable around 5.0% in the period, yielding an even more stimulative monetary policy.

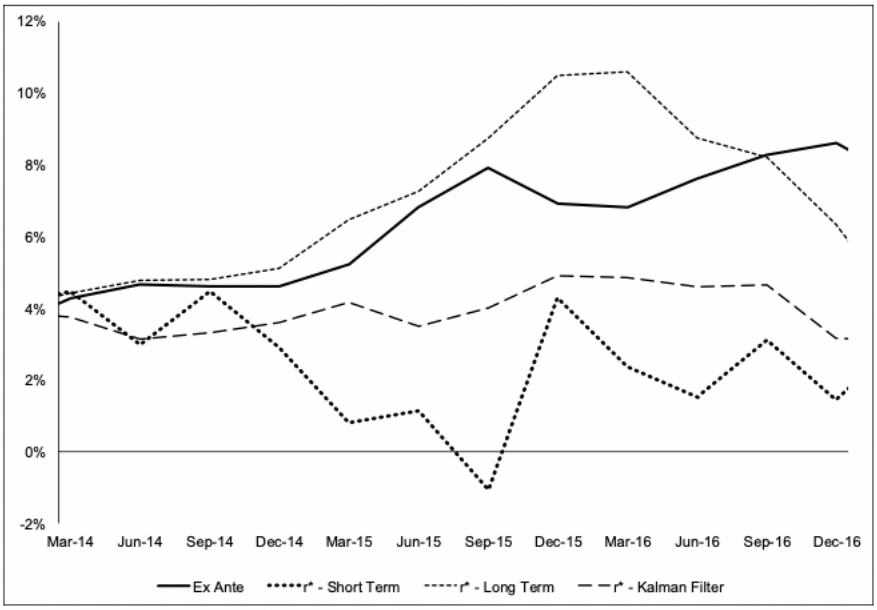
The monetary policy was not the only stimulus that government added to the Brazilian economy and the measures adopted during this period are key to understand the next. The so called "*Nova Matriz Econômica*" was a range of policies aimed at heating the economy that encompassed earmarked credit expansion, tax exemptions, increasing government spending, price controls – especially in energy tariffs –, and, among other initiatives, protectionism. The result, as Bolle (2016) defends, was a set of distortions that unmatched supply and demand and put the Brazilian economy in a worrisome path. Fiscal and external accounts started deteriorating and inflation was even more a concern to Brazil watchers.

The mild hiking cycle started in 2013 as a product of accelerating inflation was not enough to take away the monetary stimulus in that year, but rates closed it at an almost neutral stance. However, the consequences of the economic packages aforementioned to monetary policy will materialize in the next period.

5.3 2014-2016: Cooling

This period is marked by the second interest conundrum. The riddle this time is the opposite from the one of 2010: monetary policy was contractionary using the short term and Kalman filter estimations of neutral rates, but was stimulative looking to the long term rates, as we can see in Figure 22, with the rates measures between 2014 and 2016. In this period, the central bank proceeded the hiking cycle started in 2013 and brought rates from 7.25% in March 2013 to 14.25% in July 2015, where they stayed for nine consecutive meetings.

Figure 22 – Brazil: Real Interest Rates during 2014-2016 (annual rate)

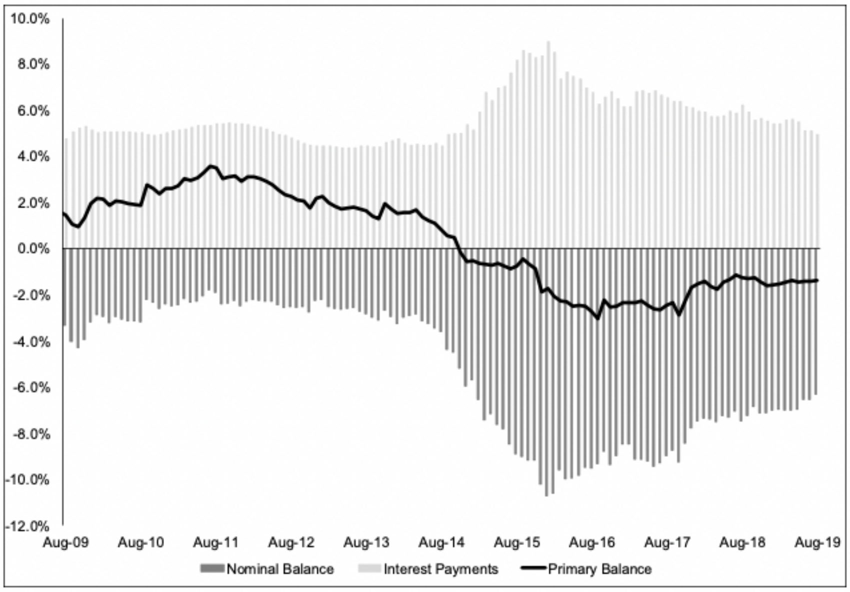


Source – BCB, author's estimation.

In 2014, the Brazilian economy posted clear signs it was cooling, with GDP closing the year with a meager 0.5% expansion according to IBGE and the output gap was in a downward-sloped path. With that said, short term neutral rates were still stable, being held by solid trade flow numbers and spending growth. From the fourth quarter onwards, things started to change. With the economy entering and remaining in recession, trade flows contracting by 7.8% on average in the period and the government putting in course some sort of fiscal adjustment in the beginning of 2015 (spending growth decelerated to 0.7% on average between 2015 and 2016), short term neutral interest rates collapsed. The Kalman filter also showed a downside slope following the beginning of the crisis. In normal conditions, one could argue that the right thing to do was to bring interest rates down to close the negative output gap, but we believe the long term determinants of neutral rates prevented the central bank from doing so.

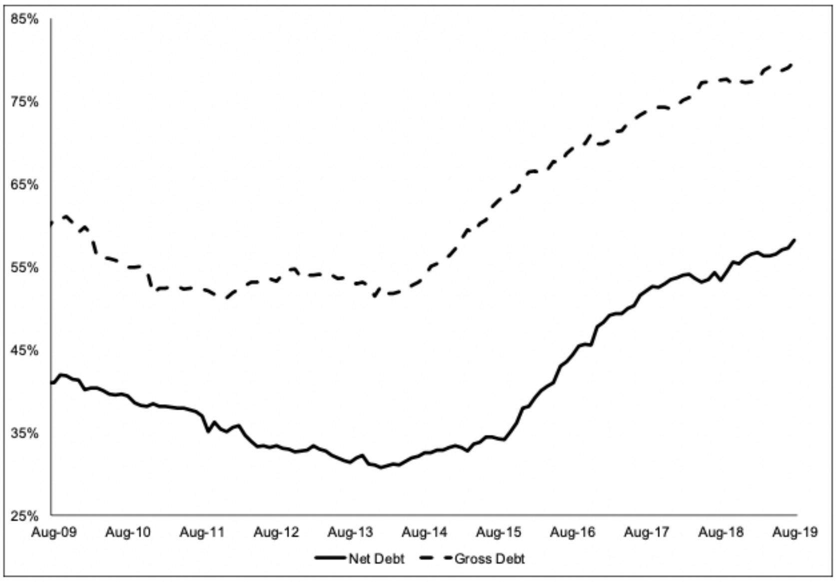
When looking back at Figure 17, one can see that the contributions of debt, spread and deviation all increased in 2015 and 2016. With fiscal accounts deteriorating, as showed by Figure 23, which unveils the increasing public sector's budget deficits, government indebtedness increased materially, both in gross and net terms, as one can see in Figure 24. Additionally, with the political turmoil around former president's impeachment process, spread mushroomed to its highest levels of the period we analyzed here, as portrays Figure 25. The final hit came from the inflation upsurge stemmed from the liberalization of energy prices in 2015, which led inflation to breach target, as presented in Figure 26, also contributing to the uptick in long term neutral interest rate estimates.

Figure 23 – Brazil: Fiscal Balance (12-month sum, as % of GDP)



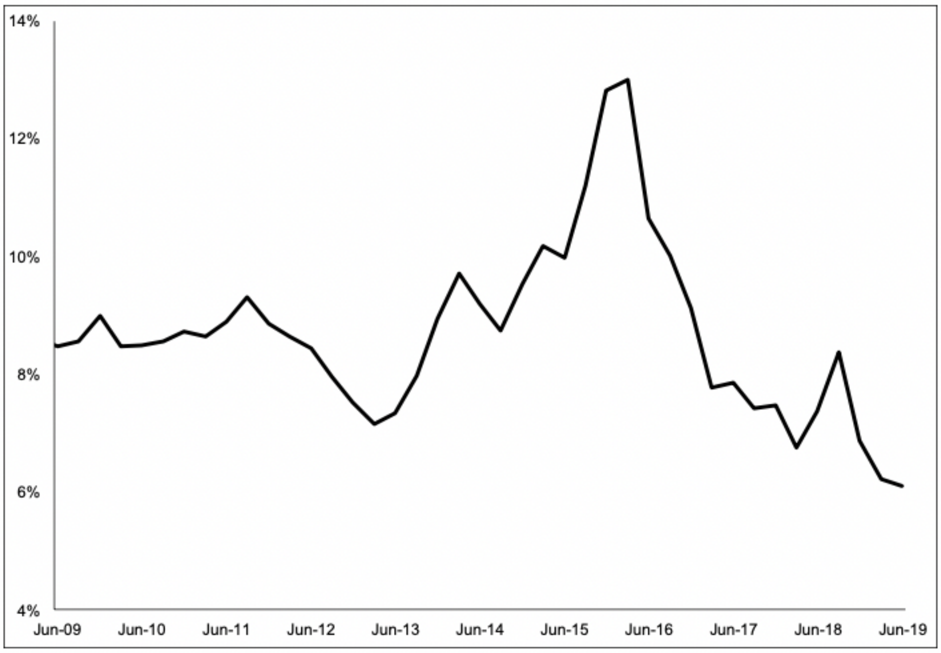
Source – BCB, author's elaboration.

Figure 24 – Brazil: Government Debt (as % of GDP)



Source – BCB, author's elaboration.

Figure 25 – Brazil: Spread between Brazil and USA's 10-year government bonds yield (p.p)



Source – Trading Economics, author's elaboration.

Figure 26 – Headline Inflation (% change y-o-y)

Source – IBGE, BCB, author's elaboration.

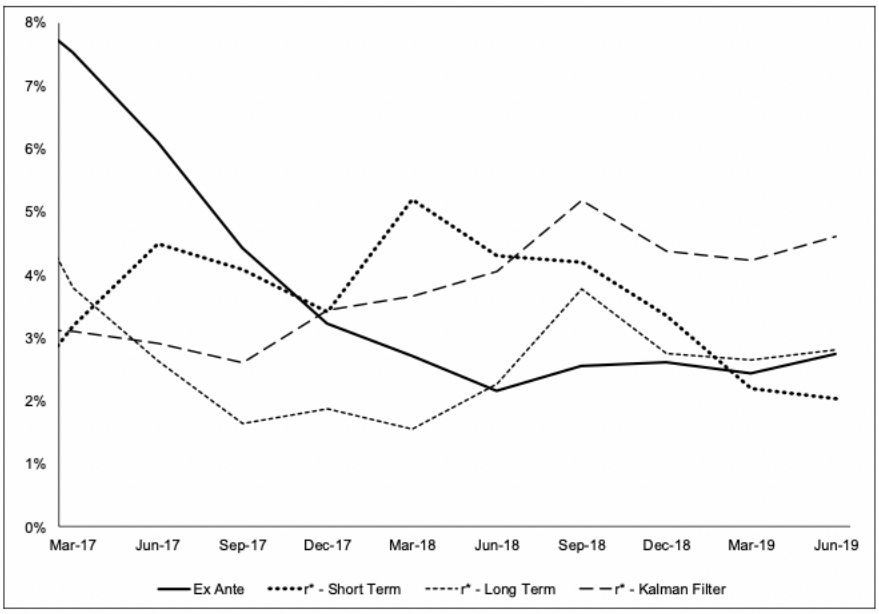
The result was an economy in recession that could not use a powerful tool to fight it: monetary policy. Real rates levels were broadly contractionary if compared to short term and the Kalman filter, but were expansionary in the long term measure. The crisis had many factors, but the persistency of contractionary monetary policy during the crisis was certainly one of them. Also, this puzzle might be one of the factors to explain why many market participants, Bolle (2016) included, started suspecting of fiscal dominance in Brazil during the 2015-2016 biennium.

The year of 2016 closed with the second year of GDP contraction (-3.4% on average, according to IBGE), inflation above target and a conundrum in the conduct of monetary policy. The new monetary authority that took office in July 2016 had many challenges ahead.

5.4 2017-2019: Lingering

When the new monetary authority took office, long term neutral rates estimations were already normalizing, with decreasing contributions from spread and inflation. As a result, it delivered two timid 25 bases points cuts on Selic and it ended 2016 at 13.75%. The easing cycle became more aggressive in March 2017 and brought down base rates to 6.50% in March 2018, concomitant with a sharp decline in long term neutral rates estimations. We can see this movement in Figure 27. Behind the aforementioned reduction, we see the signs of improvement in structural variables in the period.

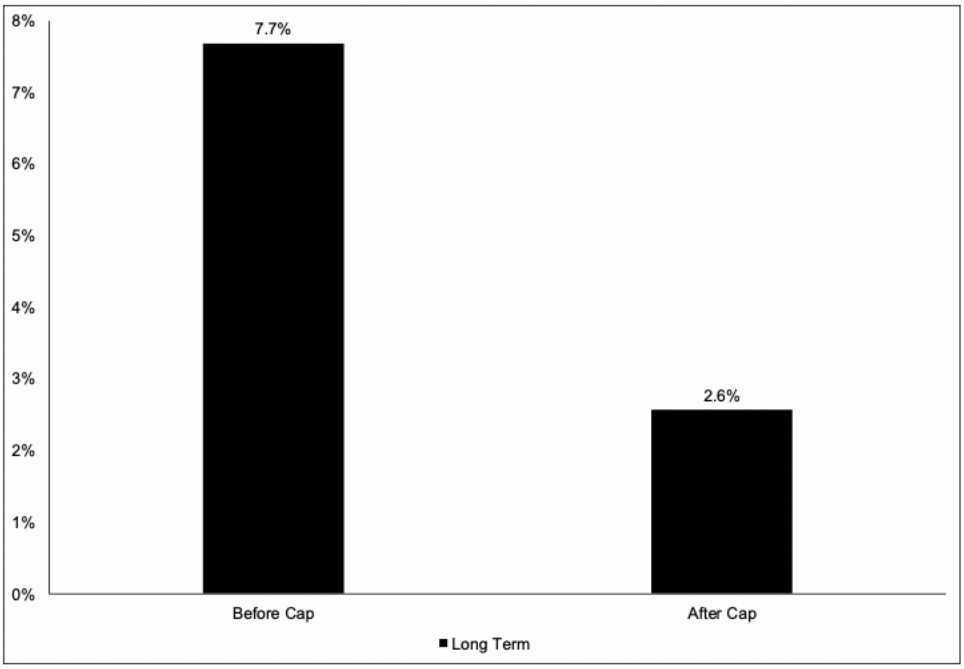
Figure 27 – Brazil: Real Interest Rates during 2017-2019 (annual rate)



Source – BCB, author's elaboration.

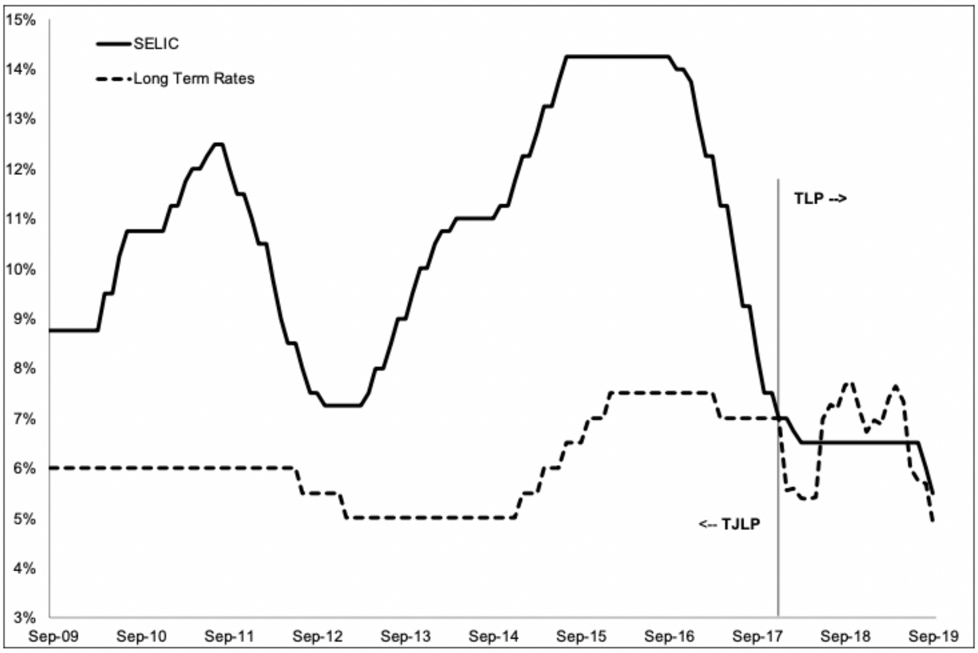
The government that took office after the impeachment process was perceived as more market friendly. It delivered two important measures that helped reduce risk-premium and improve monetary policy effectiveness. The first of them, and the one we see as paramount to the long term interest rate reduction, was the approval of the spending cap constitutional amendment in December 2016. Figure 28 shows the average of long term neutral rates 10 quarters before and after the approval of the spending cap. The second is the creation of the Long Term Rate (*TLP - Taxa de Longo Prazo*), in substitution to the Long Term Interest Rate (*TJLP - Taxa de Juros de Longo Prazo*), in July 2017. TLP took the role of base rates for the Government's development bank (BNDES) and is more sensitive to market movements, as it is linked to the five-year inflation-indexed government bond (NTN-B). TJLP, on the other hand, was defined in an ad hoc manner, and was kept persistently below Selic, as shows Figure 29. This contributes to the central bank's role in the sense that it increases its effectiveness, as more credit is sensitive to market forces.

Figure 28 – Brazil: Long Term Neutral Rates (annual rate, average)



Source – author's estimation.

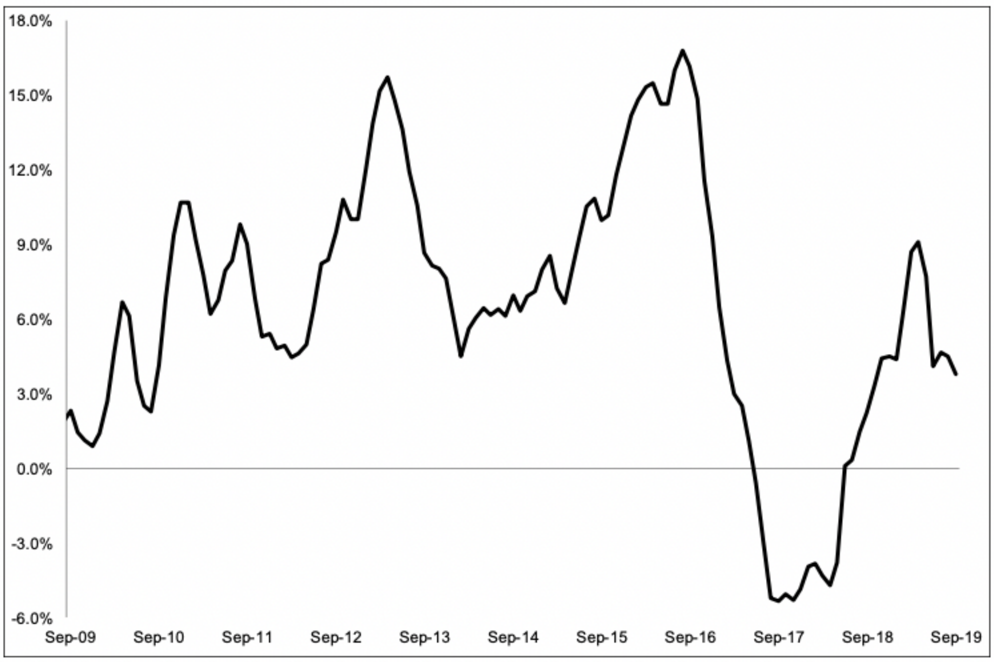
Figure 29 – Brazil: Selic, TLP and TJLP (annual rate)



Source – BCB, BNDES, author's elaboration.

Additionally, a positive supply shock in food inflation, portrayed in Figure 30, delivered downside surprises on inflation, bringing it below the target range in 2017 and helping it stay within range since then.

Figure 30 – Brazil: Food Inflation (% change y-o-y)



Source – IBGE, author's elaboration.

Upward pressures are also present. Figure 31 shows that non-earmarked credit until 2019 was decreasing, which hampered monetary policy effectiveness and contributed to higher long term neutral rates. Additionally, fiscal challenges, regardless of the spending cap, have not yet been fully surpassed and government indebtedness continues to soar. Combined, these two variables preclude a sharper decrease in long term neutral rates and continue to be an impediment to monetary policy.

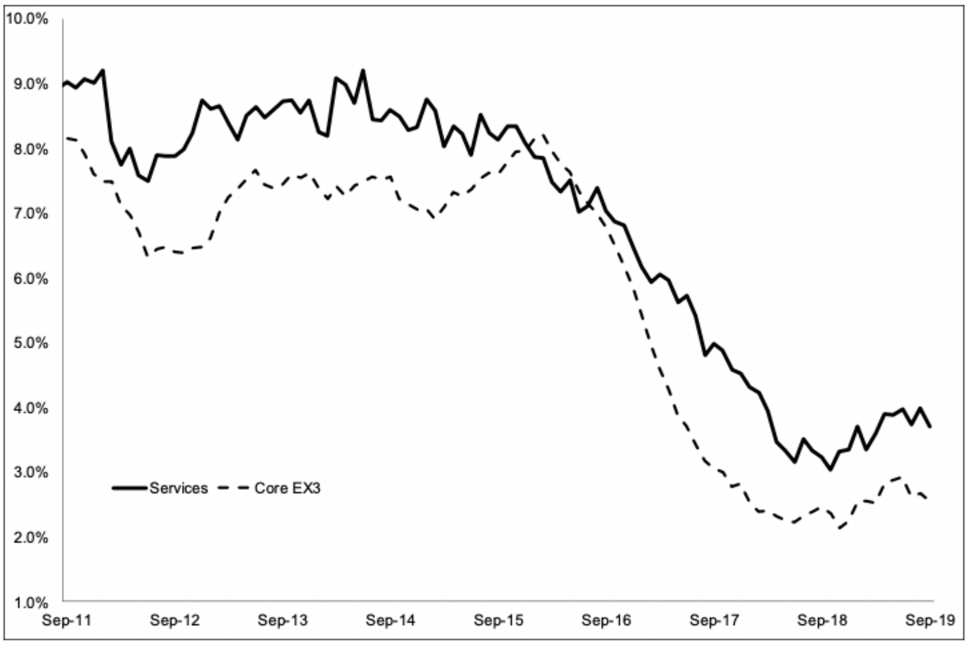
Figure 31 – Brazil: Non-Earmarked Credit (as % of GDP)

Source – BCB, author's elaboration.

Recently, the dynamics for short term and Kalman filter estimates have been similar. With the economy still below potential, estimations were skewed to the downside during the crisis, but went up again when the economy started to recover in 2017, albeit mildly. Continued cuts since then on government spending can also explain the downfalls on short term estimations and, more recently, trade flows subsided amid trade tensions between the USA and China and decelerating global growth, and also yielded negative contributions to short term neutral rates.

In July 2019, the monetary authority began a new easing cycle after ten on hold meetings, bringing rates down to 5.00% in the October 2019 meeting. This came in an environment of sluggish economic recovery, downside surprises in inflation and easier monetary conditions abroad with many central banks worldwide cutting interest rates. Moreover, domestically, short and long term neutral rates estimations pointed to monetary policy close to neutral until the second quarter. With that in mind, and thinking of the still wide negative output gap and well behaved inflation measures, especially services and the EX3[7] core (as shown in Figure 32), a scenario in which the central bank engages in further rates cut is plausible. On top of that, the Pension Reform was approved by the senate, which could not only contribute to the reduction of risk perception, but also - and mainly - to the fulfillment of a sustainable fiscal anchor, coupled with the spending cap.

Figure 32 – Core and Services Inflation (% change y-o-y)



Source – IBGE, author's elaboration.

Having estimated neutral rates through different methodologies and analyzed monetary policy since the Global financial crisis, we will now proceed to the final remarks.

7 The EX3 core measure comprises core services and core industrial goods. Core measures are detailed here: <https://www.bcb.gov.br/conteudo/relatorioinflacao/EstudosEspeciais/Novas_medidas_nucleo_inflacao.pdf>

6 CONCLUSION

This work aimed at estimating neutral interest rates for the Brazilian economy and studying its short and long term determinants, as well as presenting the results of the Kalman filter. When doing so, we found relevant information concerning what drove neutral rates estimations in the years after the global financial crisis.

The short term model provided useful insights to understand the roles of fiscal policy and the global economy. If government spending increases, the output gap closes (widens) if the starting point is negative (positive), and neutral rates estimations increases. If the global economy is heated, and trade flows ascend, the same rationale applies. Also, when faced with deep and prolonged recessions, like the one in Brazil during 2015 and 2016, neutral rates estimations collapsed below zero. This is in line with the notion that the higher (lower) the output gap, the higher (lower) the neutral rates required to close it.

The long term model was useful to gauge the impact of structural variables on neutral rates estimations. We found evidence that inflation deviation from its target, government indebtedness and risk perception all contribute to higher neutral rates, whereas the presence of non-earmarked credit reduces it. This singles out the importance of market forces to drive credit market, instead of earmarked credit at subsidized rates. Moreover, when comparing the short and long term measures, we were able to find two conundrums, of opposite nature, whose determinants provided worthwhile insights to understand monetary policy.

Importantly, when confronting the short and long term models, one perceives the uncertainty regarding neutral rates estimations, as we have seen that they do not always possess the same movement or levels. The duality sometimes seen in the movement of neutral rates estimations can also be transported to the assessment of lower neutral rates. While reductions in the short term estimations were often associated with negative downturns in the Brazilian economy, long term rates reduction came mainly when the Brazilian economy delivered positive outcomes when it came to structural variables, in the form of close-to-target inflation or lower risk perception, for example.

The Kalman filter estimation, of more dynamic nature, worked as the global tendency around which traveled the short and long term estimations. When confronted with periods of crisis, in 2008-9 and 2015-16, estimations also dropped materially, but went back to their normal values more rapidly than the other models.

Gazing at the estimation results, we were able to find evidence that neutral rates estimations are declining in Brazil after the global financial crisis in general, but more remarkably after the 2015-16 crisis period. Short term estimates took a toll from the negative output gap and are now going slowly back up, but still at low levels if compared to the aftermath of the 2008 Crisis. Kalman filter estimates, albeit at higher levels, are also showing signs of a slow reduction in the past years. We saw the steepest decline, however, in the long term estimation, after the structural reforms in 2016 and 2017, namely the spending cap amendment and the creation of TLP. This reduction also counted on a positive inertia from inflation measures after food deflation in 2017, as we argued. Upside risks stem from the soaring debt measures and a credit market that struggles to recover.

Adopting the hypothesis that neutral rates are declining, and we have evidence to do so, if one looks at the more recent behavior of neutral rates, especially in the short and long term models, we see that Brazilian monetary policy was close to a neutral stance until the second quarter of 2019. Confronting the estimations with the current backdrop of the Brazilian economy - low growth and low inflation -, we believe that there is room for more monetary easing from the central bank, bringing Selic down from its current 5.00% level, a move that market participants are already forecasting.

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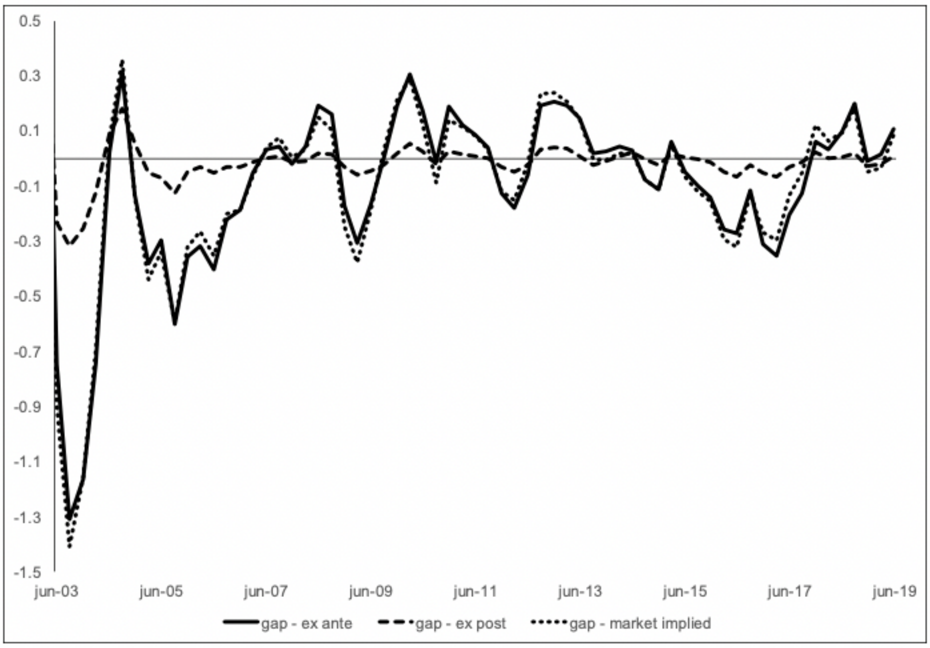
APPENDIX A – OTHER KALMAN FILTER RESULTS

Below we present the estimation outputs of the other unobservable variables in the Holston, Laubach and Williams (2017) model: g_t, the trend growth rate of the natural rate of output, and $\tilde{y}_t$, the output gap.

Figure A.1 – Trend Growth Rate Estimations (annual rate)

Source – Author's elaboration.

Figure A.2 – Output Gap Estimations (%)



Source – Author’s elaboration.