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Fiscal rules and the effectiveness of monetary policy: Estimates for a large emerging economy*

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Contents

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monetary policy, fiscal policy, fiscal rules, public debt

JEL Codes
E31, H30, H63

Abstract · Resumo

This work evaluated the effect of fiscal policy on the effectiveness of monetary policy by the Central Bank of Brazil. Using monthly data from January–2003 to January–2020, a test was conducted to gauge how the cyclicality degree of the fiscal policy—in light of the variations in the public debt—affected the variability of the short-term real interest rate. To this goal, we extracted a fiscal response index from an unobservable state variable using the Kalman filter. Applying the cointegration method and GMM estimation, the results revealed that the smoothing and effectiveness of monetary policy depend on the degree of fiscal responsiveness to the level of public indebtedness.

1. Introduction

Following Kydland and Prescott (1977, 1982) and Prescott (1986), the evolution of research on monetary policy led to the creation of new dynamic models based on the optimizing behavior of agents. However, these models initially followed the

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**Data availability:* The data that support the findings of this study are openly available in the Series Generator System (SGS) of the Central Bank of Brazil, https://www3.bcb.gov.br/sgspub; Institute of Applied Economic Research (Ipea), http://www.ipeadata.gov.br/Default.aspx; and the Brazilian Institute of Geography and Statistics (IBGE), https://www.ibge.gov.br

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long tradition of abstracting fiscal policy by attempting to estimate the behavior of inflation in the economy.

The contributions made from new Keynesian models, especially after the Subprime crisis and the European public debt crisis, adopted the fiscal variable as a determinant for monetary policy. Authors such as Woodford (2001), Sims (2011), and Leeper and Leith (2016) highlighted the role of fiscal policy in helping to control inflation, showing that this is often the main macroeconomic sphere responsible for explosive inflation trajectories.

The first point of interest when discussing the relationship between macro dynamics and economic policy is monetary policy. Qualitative aspects of monetary policy influence agents both in the present and the expectational field, as demonstrated by authors such as Taylor (1993), Svensson (1997) and Clarida, Gali, and Gertler (1999).

Nevertheless, it is necessary to consider whether a Central Bank committed to price stability is a sufficient condition for controlling inflation and ensuring social welfare. The new theoretical developments have shown that it is not. Therefore, the second important point to analyze is the fiscal dimension, addressed here as a core theme for economic stability. Mishkin (2007) showed basic principles for policymakers operating in an inflation targeting regime, and one of these principles is that fiscal policy should be conducted in coordination with monetary policy, given the various interactions between the two.

In the traditional theoretical literature, there are two combinations of conducting monetary and fiscal policies: monetary dominance and fiscal dominance. The debate culminated in the most recent developments of the new Keynesian monetary theory: the Fiscal Theory of the Price Level (FTPL).

If fiscal policy is not aligned with the stabilization of the public debt through the necessary adjustments of primary surpluses, the public debt/GDP ratio can rise to an extreme point at which it is impossible for the government to hold all its debts. This scenario reduces credibility and reputation at the fiscal level, leading to an inefficient economic policy and reduced social welfare in the country, as a growing public debt tends to induce greater volatility in the stock market and pessimism regarding the solvency conditions of the public sector. Ultimately, such contexts lead to a significant and rapid devaluation of the domestic currency (Woodford, 2001; Blanchard, 2005).

The core motivation for this article was then to evaluate at which level fiscal policy, in terms of seeking the stability of public debt, allowed the Central Bank of Brazil (BCB) to rely more effectively on its main instrument, the short-term interest rate (the Selic rate). From a methodological viewpoint, the first step was to estimate a fiscal rule (or a fiscal reaction) for Brazil, built on the concept of fiscal rules in Bohn (1998, 2005). This step was taken using cointegration methods. In the second estimation step, using the Kalman filter, it was possible to obtain an unobservable time series for the response of the primary surplus to the public debt (%GDP)—in other words, for the cyclicality degree of the Brazilian fiscal policy—from the previously estimated fiscal rule. Finally, through the creation of a *fiscal response index*, it was possible to test its effect on a monetary policy reaction rule (a Taylor rule), enabling the testing of the hypothesis that an improvement in the component of fiscal response increases the effectiveness of the monetary policy.

The article is organized as follows. Section 2 includes a brief discussion of the theoretical scope, while section 3 provides a review of the related empirical literature. The database and methodological strategy are presented in section 4, along with an analysis of the results. Section 5 contains the conclusions, which are followed by references and appendices.

2. Theoretical scope: a brief discussion

2.1 Interactions between fiscal and monetary policy

In economies with Central Banks operating under inflation targeting regimes (ITR), the fiscal policy should be implemented in coordination with the monetary policy (Mishkin, 2007). Nevertheless, the inflation targeting regime cannot by itself guarantee fiscal discipline. Thus, governments can adopt irresponsible fiscal policies even under an ITR.

A monetary or fiscal policy can be classified as an active or a passive policy. According to Leeper (1991), an active policy is concerned with goals that are not necessarily in keeping with meeting the government's intertemporal budget constraints. Meanwhile, a passive policy is restricted by decisions regarding optimization by agents, the decisions of the active authority and budget constraints.

There are two different combinations for conducting monetary and fiscal policies. Sargent and Wallace (1981) pointed out monetary dominance and fiscal dominance. In terms of the specification of rules used by Leeper (1991), in the former combination, monetary policy is active (for instance, with a view to stabilizing inflation in the long term) and fiscal policy is passive (i.e. adapting to budget constraints). In the latter combination, monetary policy is passive and fiscal policy is active (without making the necessary adjustments in terms of primary surpluses for the public debt to remain stable).

In the former combination, the monetary policy seeks an inflation target, adjusting the real interest rate to achieve this target (the so-called Taylor's Principle), whereas the fiscal policy adjusts the primary surpluses to cover the change in the public debt. In the latter combination, the fiscal policy does not cover the shocks to the debt with public savings, defining the fiscal equilibria through exogenous objectives (e.g. political aims), while the monetary authority slightly adjusts the nominal interest rate to avoid impacts of higher fiscal expenditure with the payment of interest on the public debt. The first combination is known as a ricardian regime and the second one as a non-ricardian regime. In ricardian regimes, the monetary policy performs the role of nominal anchor, while in non-ricardian regimes such a role is attributed to fiscal policy.

However, there is another scenario for coordinating monetary and fiscal policies, given that the problem is not always so easy to identify. Woodford (2001) pointed out that the issue may be more subtle: it is possible that the policies are not inconsistent—in the sense that there is an equilibrium in which fiscal and monetary obligations can be maintained—, but the only possible equilibrium involves an inflationary or deflationary adjustment.

This is the basis for what is referred to in the literature as the Fiscal Theory of the Price Level (FTPL), in which, although the monetary authority is autonomous and performs its formal mandate, the fiscal policy could influence price levels in the economy. The conventional approach assumes that the government should alter its primary surplus due to debt shocks along the lines of a budget constraint.

However, from the viewpoint of the FTPL, a budget constraint is not considered a condition to be satisfied in all states of nature. For specific price levels, current and expected primary surpluses may be insufficient for the government's obligations. A budget constraint is thus viewed as an equilibrium condition. The price level becomes a corrector for the mismatch between the financial liability and public savings, which is not sustainable in the long run and, in the end, needs to be corrected via price level variation. In this respect, a context of continuous fiscal deterioration would be accompanied by inflationary pressures of a fiscal nature, even if the Central Bank is conducting monetary policy autonomously and is committed to the inflation target.

As demonstrated by Leeper and Leith (2016), the FTPL is not a substitute for the conventional theories of interaction between monetary and fiscal policies, but rather a complement. Its contribution is to fill some gaps on the fiscal side of the model while expanding the set of rules followed by the monetary and fiscal authorities. The theory reveals a richer set of equilibria that can arise when monetary and fiscal policies are intrinsically intertwined.

2.2 Solvency, reputation, and credibility in fiscal policy

Adopted by several countries since the 1990s, the inflation targeting regime (ITR) inspired a line of research on the credibility required for the success of the new regime. One of the variables to be considered when evaluating the efficiency of the monetary authority is the condition of public accounts. The central idea is the incapacity of the monetary authority to control inflation when faced with a persistent fiscal imbalance.

Pessimism in the midst of expectations of government solvency can contaminate inflation forecasts, leading the monetary authority to adjust its monetary policy instrument more aggressively than would occur in a more optimistic fiscal context. A lack of control over the growth of public debt leads to problems in diverse areas of a country's economy, entailing probable social losses. These problems include high short-term and long-term interest rates, volatility in the stock market, lower private investments, and less long-term growth, as well as sudden changes in output and price levels (including exchange rates). The solvency of the public debt can be defined in intertemporal terms as the characteristic of a certain public debt being sustainable, or not "exploding" in the long term. The solvency of the debt is a necessary condition for macroeconomic stability, especially in developing countries.

Having said this, how can one prove that a certain fiscal policy will ensure the sustainability of the public debt? Bohn (1998, 2005) suggested verifying a systematic relationship between the debt/GDP ratio and primary surplus equilibria in the form of equation (1), in which s_t is the primary surplus/GDP ratio, ρ and α are constants, d_t is the debt/GDP ratio, Z_t is a set of determinants of the primary surplus and ϵ_t and μ_t are the error terms:

$$s_t = \rho d_t + \alpha Z_t + \epsilon_t = \rho d_t + \mu_t; \tag{1}$$

$$\mu_t = \alpha Z_t + \epsilon_t. \tag{2}$$

In tests such as that of Bohn, a positive response is expected for the primary surplus/GDP ratio to increases in the debt/GDP ratio ($\rho > 0$), meaning that the fiscal authority reacts to positive shocks in the public debt by invariably increasing the primary surplus. Maintaining financial stability is then a long-term goal of the fiscal policy (Taylor, 2000).

Solvency, or the sustainability of the public debt, is necessarily accompanied by two other inseparable concepts: reputation and credibility (Montes & Tiberto, 2015). Reputation is a backward-looking variable related to fiscal authority, in other words, it is determined by past results or the achievement of fiscal targets. Given that reputation is a basic premise for the emergence of credibility, the former is necessary for the public to believe that the announced targets will be achieved successfully. Credibility is thus a forward-looking variable, related to the fiscal policy itself, demonstrating that the agents trust that targets and announced goals will be achieved in the future.

3. Evidence for a large emerging economy: The case of Brazil

Analyzing how the government reacts to variations in its level of indebtedness, Mello (2008) estimated a fiscal reaction function with monthly data for 1995 to 2004. For every definition used, the author found positive responses of the primary surplus to an increase in the public debt. The author found a weak and positive correlation between output and fiscal surplus, hinting at a countercyclical fiscal reaction in the Brazilian economy over that sample.

The behavior of the fiscal reaction function for Brazil was also the aim of study of Luporini (2015) and Campos and Cysne (2019). The work of Luporini suggested that the government's fiscal policy would have been sustainable in the sample (1991 to 2011). The author also showed that the fiscal policy remained more stable from the year 2000 onwards, albeit less responsive to the level of debt.

In turn, the findings of Campos and Cysne (2019) suggested a sustainable fiscal reaction until 2013, but when they limited the sample to 2014 to 2016, all the statistical methods pointed to an unsustainable fiscal reaction. The authors also found that the response of the primary deficit to the variations in the debt/GDP ratio diminished throughout the sample period.

Some studies have sought to understand the effects of attributes such as the reputation or credibility of economic policy on the Brazilian economy. Mendonça, Guimarães, and Souza (2009) showed that greater credibility requires smaller variations in interest rates to control inflation and also leads to lower interest rates.

Other authors have focused on the role of fiscal policy in facilitating the conducting of monetary policy. Mendonça and Silva (2008) revealed that management of the public debt is directly related to greater economic credibility, suggesting that lower debt indexation at the Selic rate promotes greater flexibility for the monetary authority to pursue price stability. Besides, analyzing 18 emerging economies (including Brazil from 1996 to 2008), A. Moreira and Rocha (2011) obtained results suggesting that the hypothesis that fiscal austerity reduces the domestic interest rate cannot be rejected.

Furthermore Montes and Tiberto (2015) studied the correlation between the management of the Brazilian public debt and country risk, showing that a better reputation reduced the risk and increased economic stability. Thus, the opposite also tends to be the case: with a poor reputation, non-compliance with fiscal targets raises the cost of public indebtedness (considering the movement of implicit interest rates in public bonds) and the fiscal situation of the country deteriorates along with the macroeconomic scenario.

Continuing on the subject of interaction between monetary and fiscal policies, but focusing on coordinating the policies, Blanchard (2005), T. B. S. Moreira and Carvalho (2013) and R. R. Moreira (2017) found signs of an active fiscal policy, i.e., an insolvent fiscal policy in the long-term in Brazil.

4. Empirical analysis

4.1 Brief outline of the fiscal context

Using Brazil's general government gross debt, Figure 1 shows a falling trajectory regarding GDP up to the year 2008. The country emerged from a tense period of elections in 2002, during which the uncertainty generated by the so-called Lula-risk led to an exchange rate overshooting, resulting in the high debt/GDP ratio in the early sample period due to a significant part of the debt being indexed to the exchange rate.

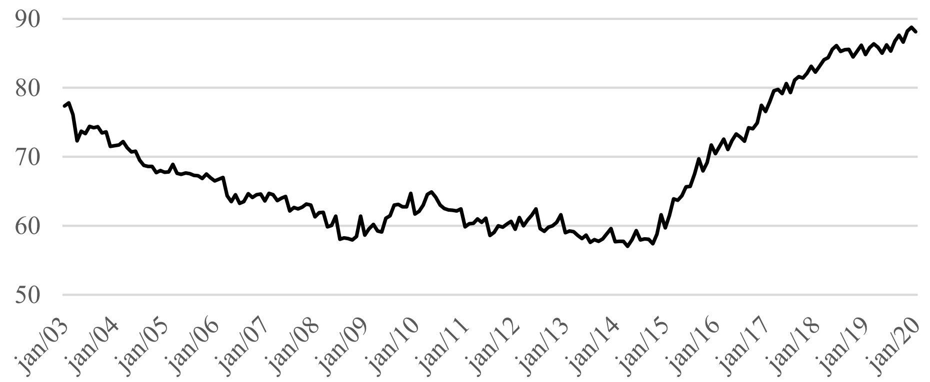
The subsequent reduction in the debt/GDP ratio up to 2008 was due to (i) the expressive increase in the Brazilian GDP over the period and (ii) the achievement of recurring primary surpluses. From 2014, in Dilma Rousseff's presidential administration, a crisis of confidence related to the growing insolvency risk of the Brazilian government explains the trajectory of increasing debt/GDP. In turn, Temer's administration, which began in 2016, resumed the bases of the macroeconomic tripod and thus a cycle of fiscal adjustment. At this time, the creation of a ceiling for the growth of nominal expenditures by the federal government (Constitutional Amendment No. 95 of 2016) may be highlighted, considered as a basic condition for a return to economic stability. In January 2020, according to the methodology of the series used here, the gross debt was 88.18 % of Brazil's GDP.

Figure 2 presents the evolution of the *need for financing of the public sector* (NFPS) in the primary concept, i.e., excluding from the calculation the government's financial revenues and expenditure. The expressive reduction in the primary surplus after 2011 illustrates the lack of control over public accounts during Rousseff's administration, which intensified after the 2014 presidential election with the recurrence of primary deficits.

The fiscal deterioration can also be viewed in Figure 3, which shows that the average maturity and average duration of public bonds issued by the National Treasury have reduced since 2015, while the gross debt has grown. The explanation for this process is that it is due to fears of the unsustainability of the Brazilian public debt: given that there is a default risk, agents demand higher interest rates for long-term bonds, which forces the issuer (the National Treasury of Brazil) to work with bonds with shorter maturity.

4.2 Data for estimation

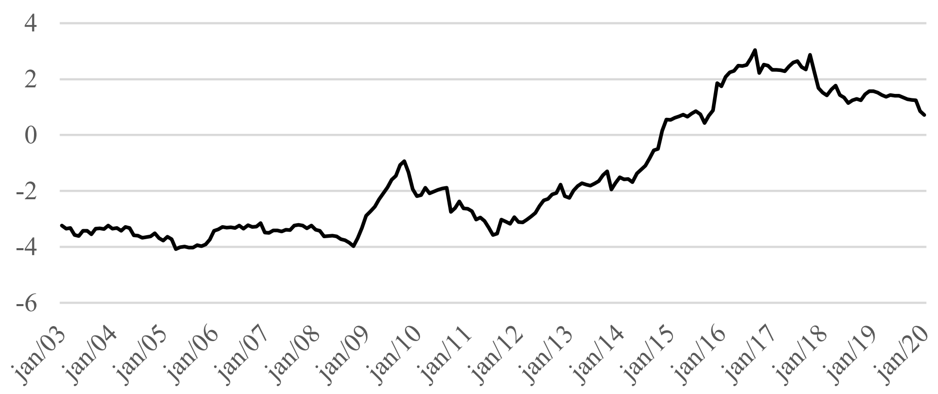
Our time sample covers the period from January 2003 to January 2020. The time series were collected from the Series Generator System (SGS) of the Central Bank of Brazil, the Institute of Applied Economic Research (Ipea) and the Brazilian Institute of Geography and Statistics (IBGE). The variables used in different stages of the work were:



Note: The BCB's operations with government bonds are included, enabling better monitoring of the debt situation in relation to the net debt concept; debts of state-owned companies are not included.

Source: Prepared by the authors. Data obtained from the Time Series Management System of the BCB.

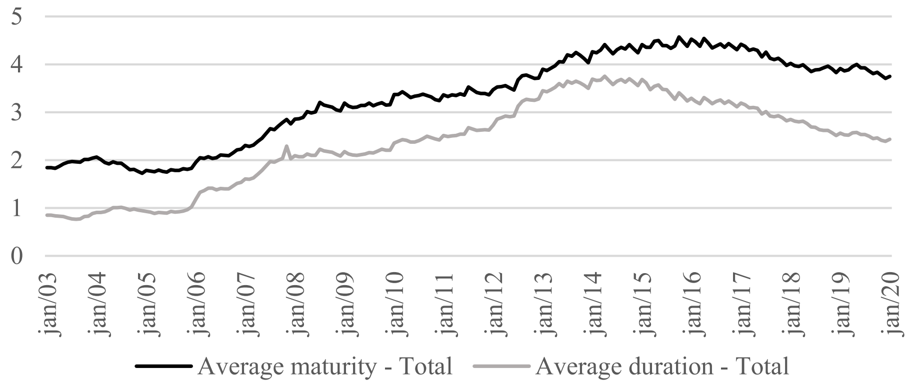
Figure 1. Evolution of general government gross debt as % of GDP between 2003 and 2020



Note: Flow accumulated over 12 months, primary results without currency devaluation, total for the consolidated public sector.

Source: Prepared by the authors. Data obtained from the Time Series Management System of the BCB.

Figure 2. Public Sector Financing Needs in % GDP from 2003 to 2020



Note: Coupon-indexed securities may have a longer maturity and shorter duration, as they are sensitive to interest rates
Source: Prepared by the authors. Data obtained from the Time Series Management System of the BCB.

Figure 3. Average maturity and average duration (in years) of government bonds from 2003 to 2020

PS_t The primary surplus of the government (%GDP), i.e., excluding government's revenues and expenditure with interest, represented by the NFPS (Need for Financing of the Public Sector) series; the total value accumulated in 12 months for the consolidated public sector was used.

DEB_t The general government gross debt (%GDP).

$E[PS]_t$ The expected primary surplus (%GDP) for the end of the following year, using the median expectation at the close of each month.

$SELIC_t$ The short-term real interest rate, represented by the historical annualized series of the Selic Over, which is the basic interest rate in the interbank market at the end of each day, subtracted from the expected inflation for 12 months ahead; the daily Selic rate was used to compose the monthly historical series at the close of each month.

$IPCA_t$ The monthly consumer inflation, using data from the seasonally adjusted, *Broad Consumer Price Index* (or *Índice de Preços ao Consumidor Amplo* in portuguese, IPCA).

$E[IPCA_t]$ The accumulated consumer inflation expectation for 12 months ahead of the IPCA, at the close of each month.

$IBCBR_t$ The total output of the Brazilian economy, represented by the seasonally adjusted IBC-Br index of the Central bank; the use of the IBC-Br as a proxy of GDP is necessary because it allows for a monthly measure of the GDP.

$EXCH_t$ The real exchange rate for the US dollar at the end of the period, deflated by the IPA-DI, index with a monthly basis of June 1994.

For purposes of robustness in some estimations, the *Monthly Industrial Research —Physical Production* (PIM-PF) series of the IBGE was also used, with seasonal adjustment, as a proxy for GDP, replacing the IBC-Br. The significance of a dummy variable ($DUMMY\_F_t$) was also tested to identify a potential change in conducting fiscal policy from the end of 2014 onwards. The descriptive statistics of the variables are presented in Table 1.

Table 1. Descriptive statistics of the variables

VARIABLES	MEAN	MEDIAN	MAXIMUM	MINIMUM	S.D.
PS_t	1.469	2.180	4.080	-3.040	2.215
DEB_t	67.872	64.520	88.780	57.030	9.039
$E[PS]_t$	2.009	2.800	4.300	-2.210	2.189
$SELIC_t$	6.972	6.620	19.180	0.450	4.001
$IPCA_t$	0.469	0.430	2.200	-0.270	0.307
$E[IPCA]_t$	5.189	5.230	11.560	3.330	1.231
$IBCBR_t$	130.237	135.710	148.660	99.030	13.773
$EXCH_t$	72.222	71.790	122.830	48.910	15.208
$PIMPF_t$	92.811	91.300	105.000	77.500	7.223

4.3 Methodological strategy

The first step with the time series is to identify their order of integration. We used unit root tests (the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP)), as well as the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) stationarity test. Along with the initial estimation, (using the Ordinary Least Squares method), the existence of a long-term relationship among the variables was then analyzed, using the cointegration method, based on the definition of Campbell and Perron (1991). It can be said that a group of time series are cointegrated if at least one linear combination of these variables is stationary. Moreover, with the existence of a long-term relationship, it is possible to work with level variables without the risk of incurring spurious regressions.

The concept developed by Campbell and Perron (1991) corresponds to a stochastic cointegration. Here the linear combinations that eliminate the unit roots are permitted to have a linear trend other than zero. This cointegration concept does not require all the data series to be integrated in the first order, with some series allowed to be I(0). In practice, according to the authors, researchers are commonly faced with vectors from series containing variables I(0) and I(1).

The second step of the study involved obtaining an unobservable time series for the response of the primary result to the public debt (%GDP) from a fiscal reaction rule, using the Kalman filter. This filter is an efficient recursive estimation algorithm in which an observation variable can be used to estimate a state variable, which in turn is not observable. The Kalman filter can be used efficiently in state-space models that allow the estimation of the parameters of a linear model at each instant of time. In accordance with Harvey (2003), the state-space model can be represented by two equations. The first is the observation equation, given by

$$s_t = \mathbf{b}_t'\boldsymbol{\alpha}_t + \mu_t, \qquad t = 1, 2, \ldots, T, \tag{3}$$

with s_t being a series over time, $\mathbf{b}_t$ a $m \times 1$ vector, $\boldsymbol{\alpha}_t$ is the state vector $m \times 1$, and μ_t is the white noise residual term with a zero mean and variance σ_μ^2. The second equation, known as the transition equation, shows how the state variables are generated:

$$\boldsymbol{\alpha}_t = \boldsymbol{\Gamma}_t\boldsymbol{\alpha}_{t-1} + \boldsymbol{\eta}_t, \tag{4}$$

with $\boldsymbol{\Gamma}_t$ being the transition matrix $m \times m$ and $\boldsymbol{\eta}_t$ being a residual white noise vector $m \times 1$ with a zero mean and covariance matrix $\mathbf{Q}_t$. The residual terms μ_t and $\boldsymbol{\eta}_t$ satisfy $E(\mu_t\eta_s) = 0_{m\times 1}$ for $t, s = 1, 2, \ldots, T$. The initial state vector $\boldsymbol{\alpha}_0$ has a mean of a_0 and covariance matrix $\mathbf{P}_0$, so that $E(\mu\alpha_0) = 0_{m\times 1}$ and $E(\eta_t\alpha_0') = 0_{m\times m}$ for $t, s = 1, 2, \ldots, T$.

In this work, equation (3) represents a fiscal reaction rule, with s_t being the primary surplus as a proportion of GDP. Using the fiscal reaction rule in a state-space model, it was possible to extract the response series from the primary result in relation to the public debt, or the time fiscal response.

Finally, the effect of fiscal response on the conduction of monetary policy was analyzed using an estimation obtained through the *Generalized Method of Moments* (GMM), which is robust to avoid possible problems of heteroskedasticity, autocorrelation and endogeneity in the estimation. The GMM uses instrumental variables to eliminate endogeneity and requires a set of specified moments for the model, these moments being functions of the parameters of the models and the data.

To satisfy the hypothesis of exogeneity of the instruments, the set of chosen instruments was lagged for the period $t - 1$ or earlier. An overidentification analysis of the instruments was then performed with the J statistic test to guarantee the correct specification of the instrumental variables.

4.4 Results and discussion

Estimation of the fiscal response for the Brazilian economy

The results of the tests for the order of integration of the time series[1] are presented in tables 2 and 3.

[1] The lags for the ADF test were determined based on the Akaike information criterion (AIC); for the PP and KPSS tests, the bandwidth selection used the Newey-West method (Bartlett kernel).

Table 2. Unit root test – variables in level

VARIABLES	ADF	PP	KPSS
PS_t	-2.059	-1.207	0.232***
DEB_t	0.795	0.826	0.415***
$E[PS]_t$	-2.864	-2.351	0.258***
$SELIC_t$	-3.896**	-1.678*	0.240***
$IPCA_t$	-8.701***	-8.644***	0.147**
$E[IPCA]_t$	-3.731***	-5.211***	0.212**
$IBCBR_t$	-2.082*	-2.311	0.412***
$EXCH_t$	-1.943	-2.971**	0.411***
$PIMPF_t$	-2.036	-2.115	0.381*

Note: For the ADF and PP tests: (***) rejects the null hypothesis of the unit root at the level of 1%, (**) rejects the null hypothesis at the level of 5%, (*) rejects the null hypothesis at the level of 10%; For the KPSS test: (***) rejects the stationarity null hypothesis at the level of 1%, (**) rejects the stationarity null hypothesis at the level of 5%, (*) rejects the stationarity null hypothesis at the level of 10%.

Table 3. Unit root tests – variables in first difference

VARIABLES	ADF	PP	KPSS
$D(PS_t)$	-3.574***	-13.012***	0.133
$D(DEB_t)$	-2.133**	-19.029***	0.064
$D(E[PS]_t)$	-2.944***	-11.716***	0.134
$D(IBCBR_t)$	-8.274***	-13.744***	0.072
$D(EXCH_t)$	-5.610***	-11.774***	0.070
$D(PIMPF_t)$	-16.385***	-16.353***	0.245

Note: For the ADF and PP tests: (***) rejects the unit root null hypothesis at the level of 1%, (**) rejects the null hypothesis at the level of 5%, (*) rejects the null hypothesis at the level of 10%; for the KPSS test: (***) rejects the stationarity null hypothesis at the level of 1%, (**) rejects the stationarity null hypothesis at the level of 5%, (*) rejects the stationarity null hypothesis at the level of 10%.

It was verified that the variable of interest for the estimation of a fiscal rule (the primary surplus) and four of the six variables initially viewed as explanatory (based on the fiscal rule literature) were integrated in the first order, I(1).

Thus, different specifications of fiscal rule or reaction for Brazil were estimated by OLS with *Newey–West* correction, as shown in Table 4. The ADF test on the residuals can be understood as an initial cointegration test. For the last three specifications, it was decided that the $PIMPF_t$ series would be used to replace the $IBCBR_t$ as a robustness analysis. A dummy variable was also tested to investigate a change in how fiscal policy was conducted from late 2014 onwards. After this date, the public debt began an increasing trajectory and recurring primary deficits were observed. For periods before November 2014, the dummy assumed a value equal to 0, and for later periods equal to 1.

All specifications indicated the fiscal policy was countercyclical, i.e., despite being relatively low in relation to their standard deviation, the positive coefficients statistically significant at 1% for the gross debt suggest the existence of a counter-

Table 4. Specifications of fiscal reaction rules

OLS Estimation: PS_t						
Explanatory variables	Specifications					
	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 1.5	Model 1.6
c	-1.538** (0.624) [-2.464]	-1.540** (0.622) [-2.475]	-0.738*** (0.448) [-1.645]	-2.750*** (0.598) [-4.594]	-2.724*** (0.589) [-4.622]	-1.792*** (0.470) [-3.814]
PS_{t-1}	0.909*** (0.040) [22.347]	0.908*** (0.039) [22.842]	0.963*** (0.027) [35.578]	0.878*** (0.037) [23.525]	0.877*** (0.037) [23.724]	0.969*** (0.021) [45.438]
DEB_{t-1}	0.015*** (0.004) [3.817]	0.015*** (0.004) [3.817]	0.010*** (0.003) [3.112]	0.021*** (0.003) [5.518]	0.020*** (0.003) [5.529]	0.015*** (0.003) [4.318]
$E[PS]_{t-1}$	0.076** (0.037) [2.056]	0.078** (0.034) [2.253]	-	0.100*** (0.029) [3.387]	0.102*** (0.028) [3.604]	-
$IBCBR_{t-1}$	0.004 (0.002) [1.602]	0.004* (0.002) [1.628]	0.001 (0.001) [0.574]	-	-	-
$IPCA_{t-1}$	0.011 (0.047) [0.242]	-	0.031 (0.046) [0.680]	0.025 (0.042) [0.611]	-	0.047 (0.043) [1.094]
$PIMPF_{t-1}$	-	-	-	0.014*** (0.003) [3.923]	0.014*** (0.003) [3.927]	0.009*** (0.002) [3.255]
$DUMMY\_F_t$	-0.337*** (0.115) [-2.919]	-0.333*** (0.120) [-2.777]	-0.317** (0.125) [-2.536]	-0.304*** (0.108) [-2.806]	-0.296*** (0.111) [-2.661]	-0.284*** (0.121) [-2.340]
Adjusted R^2	0.990	0.990	0.990	0.991	0.991	0.990
AIC	-0.222	-0.289	-0.207	-0.180	-0.302	-0.249
ADF test	-4.942***	-4.969***	-5.200***	-4.762***	-4.813***	-4.848***
LM (p-value)	0.413	0.382	0.468	0.378	0.238	0.000

Note: ( ) for standard errors and [ ] for t-statistics. ADF test on the residuals of the regressions.
* significant at 10%; ** significant at 5%; *** significant at 1%.

cyclical rule for fiscal policy in Brazil from 2003 to 2020. Such a relationship is essential to guarantee a sustainable trajectory of the public debt, which, in turn, aids the active role of the monetary authority by not generating inflationary pressures.

The result for DEB_t is in keeping with the works of Mello (2008), Luporini (2015) and Campos and Cysne (2019). However, for the latter two most recent works, two considerations are relevant. Luporini indicated that the fiscal response would have been weaker in the final years of the sample and Campos and Cysne restricted their sample to 2014 to 2016 and found an unsustainable trajectory of the Brazilian public debt. In our estimations, the coefficients for $DUMMY\_F_t$ were significant in all the regressions. Therefore, the estimated fiscal rules showed that a structural change was made in how fiscal policy was conducted beginning in late 2014.

In turn, the coefficient for the lagged primary surplus was significant in all the specifications, signaling the existence of a strong inertial component, varying from 0.877 to 0.969. The result for this coefficient is related to the natural rigidity observed in fiscal policy and enhanced in Brazil.

The positive coefficients for the expected primary surplus show that a higher expected surplus at $t - 1$ is translated into a higher current surplus, with the coefficients varying between 0.076 and 0.078. This result reflects the economic agents' anticipation regarding the future behavior of the primary result.

Model 1.2 is one of the three that used the $IBCBR_t$, and is the only specification with all the regressors as significant, along with the best *Akaike information criterion*.[2] Thus, it was used as the baseline model into the second empirical step, i.e. the extraction of the time-varying fiscal reaction.[3]

In order to perform a robustness checking of the long-term relationship between the variables, a cointegration test was applied. With Model 1.2 having a dummy variable, it was decided to include it as an exogenous variable in the cointegration test. Details of the *cointegration test* as a robustness analysis are provided in Appendix A.

The Trace and Maximum Eigenvalue tests indicated the existence of a long-term relationship between the variables, confirming that using level variables in the fiscal rule did not incur a spurious estimation. The estimation of the normalized cointegrated equation (long-term equilibrium relationship) confirmed a countercyclical fiscal policy in the long-term. With the confirmation of the long-term relationship, the Kalman filter was then applied, along with the parameters of Model 1.2, to extract a time series for the fiscal response, the *FR* time series.

[2] A higher sum of squares error (SSE) results in a higher AIC. However, the criterion penalizes the addition of parameters, as models with more variables tend to have a lower SSE. Therefore, a lower AIC indicates a model with a better fit.

[3] The function of the fiscal reaction (Model 1.2) thus assumed the following form: $\widehat{PS}_t = -1{,}540 + (0.908)PS_{t-1} + (0.015)DEB_{t-1} + (0.078)E[PS]_{t-1} + (0.004)IBCBR_{t-1} + (-0.333)DUMMY\_F_t$.

Effects on the effectiveness of the Monetary Policy

The parameters of Model 1.2 were used in a state-space model estimated using the Kalman filter. Defining DEB_{t-1} as a regressor with recursive coefficients, when extracting the (unobservable) state series, the result was the relationship between the primary surplus and the public debt, or specifically the response of PS_t to the variations of DEB_{t-1}.

Given that the Kalman filter is a recursive process, the first observations of the *FR* series were characterized by greater variance (which is normal in such a statistical filtering procedure), so that a decision was made to work with a reduced sample in the final stage of the work: January 2004 to January 2020. The *FR* series was linearized from the beginning of the reduced sample.[4] Figure 4 shows the behavior of the time-varying fiscal response over this reduced sample. The decreasing path of *FR* since 2012 is consistent with the deterioration of fiscal policy over Dilma Rousseff's administration and it is in keeping with the previously presented data: lower primary surpluses in the presence of an increasing gross debt as a percentage of GDP.

Therefore, to test the hypothesis of effects of the fiscal response on the effectiveness of monetary policy in Brazil, a reaction rule with a fiscal component was estimated for the Central Bank:

$$D(SELIC_t) = \beta_1 + \beta_2 D(SELIC_{t-1}) + \beta_3\,(E[IPCA]_{t-1}) + \beta_3 IBCBR\_GAP_{t-1} + D(EXCH_{t-2}) + \beta_3 FR_{t-1}. \quad (5)$$

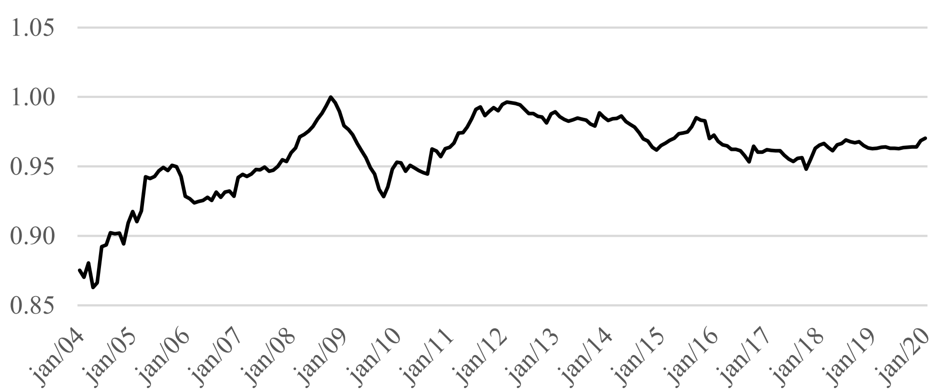


Figure 4. Fiscal response (*FR*) index: January 2004 to January 2020

[4]The linearization was based on the observation of the highest value in the series: in October 2008, the value observed was 0.007429. The formula used for the linearization was $FR_t = (value\ extracted_t)/0.007429$.

Equation (5) is a modified reaction rule for monetary policy. There are several recent works with estimates of monetary policy reactions for Brazil, including Barbosa, Camêlo, and João (2016) and R. R. Moreira and Monte (2020).

For greater adherence of the empirical exercise to economic theory, it was decided to use the deviation of the total output of the Brazilian economy in relation to potential output, i.e., the *output gap*, as an explanatory variable for the real interest rate. To this end, we used the Hodrick–Prescott's statistical filter (HP), to extract a cycle level. The output gap, by definition of its construction process via the HP filter, is of a stationary nature. Furthermore, the expected inflation change was also used as a regressor, capturing the *forward-looking* component of the monetary policy (Clarida et al., 1999; R. R. Moreira & Monte, 2020), as well as a potential effect of the real exchange rate change on the real Selic rate.

The use of the reduced sample made it necessary to repeat the unit root tests for the variables. These tests can be found in Appendix B. The monetary policy's reaction rule was estimated by the GMM (Table 5). The coefficient for the lagged real interest rate was significant in all the specifications, indicating the existence of an inertial component in the variation of the real interest rate. In other words, the estimation captured considerable smoothing behavior of the Central Bank of Brazil with its monetary policy instrument, with coefficients between 0.76 and 1.01 at 1 % of statistical significance.

The literature on monetary policy under inflation targeting regimes indicates the importance of gradualism, whether allowing for anchoring expectations, through gradualism itself being a channel for controlling inflation or to avoid errors of monetary policy intensity. High gradualism could indicate greater facility for anchoring expectations and given its effects on consumption and savings decisions, it contributes to a more stable macroeconomic environment.

In turn, it was observed that the Central Bank of Brazil reacts to changes in inflation expectations by increasing the variation of the Selic in real terms, corroborating the forward-looking behavior expected from a monetary policy under an inflation targeting regime. In all the specifications, the related coefficient is statistically significant at 1 %.

Most importantly, in all regressions the coefficient for the FR_t variable remained negative and significant at 1 % (except for the last specification, at 10 %), with results between −1.19 and −1.72, thereby validating the central hypothesis of this work: *the rise in the fiscal response index, i.e., a greater response from the fiscal authority in terms of primary surpluses with regard to the public debt/GDP is related to lower variations in the short-term real interest rate*. It reveals a gain in the smoothing and effectiveness of the monetary policy in a context of fiscal consolidation.

Assuming that the Central Bank of Brazil is committed to achieving inflation targets, this means that a poorer fiscal response is followed by less effectiveness of real Selic changes for the purpose of controlling inflation, thus requiring stronger

Table 5. Estimation of the effect of the fiscal response in a monetary reaction rule

GMM Estimation: $D(SELIC)_t$				
Explanatory Variables	Specifications			
	Model 2.1	Model 2.2	Model 2.3	Model 2.4
c	1.306*	1.167***	1.847***	1.277*
	(0.731)	(0.628)	(0.757)	(0.715)
	[1.785]	[2.664]	[2.438]	[1.784]
$D(SELIC)_{t-1}$	0.766***	1.017***	0.843***	0.862***
	(0.086)	(0.155)	(0.064)	(0.073)
	[8.855]	[6.529]	[13.035]	[11.788]
$D(E[IPCA]_{t-1})$	0.828***	1.227***	0.880***	1.136***
	(0.177)	(0.276)	(0.240)	(0.239)
	[4.671]	[4.437]	[3.652]	[4.742]
$IBCBR\_GAP_{t-1}$	0.028**	-0.017		
	(0.001)	(0.019)		
	[2.006]	[-0.931]		
$D(EXCH)_{t-2}$	0.001		0.031	
	(0.002)		(0.056)	
	[0.055]		[1.175]	
FR_{t-1}	-1.359***	-1.720***	-1.191***	-1.320*
	(0.757)	(0.655)	(0.785)	(0.746)
	[-1.795]	[-2.626]	[-2.436]	[-1.768]
Adjusted R^2	0.381	0.342	0.373	0.346
J stat (p-value)	0.339	0.405	0.404	0.261

Note: ( ) for standard errors and [ ] for t-statistics. Instruments: constant, $D(SELIC)$ (−3 to −6), $D(E[IPCA])$ (−2 to −6), $IBCBR_GAP$ (−3 to −6), $D(EXCH)$ (−3 to −7), FR (−2 to −6);
* significant at 10%; ** significant at 5%; *** significant at 1%.

volatility of interest rates over time. The evidence then denotes a loss of flexibility and effectiveness, and so an increase in monetary uncertainty, as a consequence of worsening fiscal management in the country.

The contribution of the fiscal field regarding a more effective monetary policy instrument necessarily involves the following consideration. The high level of fiscal rigidity naturally reduces capacity to respond to shocks in the public debt. Avoiding an unsustainable debt trajectory inevitably appears to include reducing the compulsory expenditure of the Brazilian state. This situation is corroborated by an analysis from the *Independent Fiscal Institution* (IFI), which is connected to the Federal Senate of Brazil. In a 2020 publication (Senado Federal, 2020), it was highlighted that there is a relationship between complying with primary result goals and the compression of discretionary public spending. An expansionist fiscal authority, with a continued reduction in *FR*, requires a monetary authority with a more conservative profile to achieve macroeconomic stability. Based on our estimates, the short-term interest rate in real terms needs to be more volatile for inflation to meet the pre-set target.

5. Concluding remarks

This work evaluated and tested the hypothesis that the degree of cyclicality of the fiscal response to the public debt/GDP ratio affects the dynamic of the real interest rate, thereby influencing the flexibility, smoothing and effectiveness of monetary policy in Brazil. A monetary authority committed to price stability is not a sufficient condition to ensure inflationary control and economic welfare. This work contributed to the literature on the interaction between fiscal and monetary policy by finding an inverse relationship between the cyclicality of primary surpluses regarding public indebtedness and the variability of the real interest rate in the country.

More specifically, using monthly data from January 2003 to January 2020, the study found evidence that a better response from the fiscal authority to changes in the debt/GDP ratio results in a lower variation of the Selic rate in real terms, which may be considered a more effective monetary policy under a regime in which the Central Bank is committed to inflation targeting. The fiscal response notably deteriorated in Brazil beginning in 2014, corroborating previous studies (R. R. Moreira, 2017; Campos & Cysne, 2019). Since then, it was possible to observe a concomitant relationship between the fiscal decline of the Brazilian government and non-achievement of inflation targets. Our results reveal that a return to a fiscal consolidation in the country could help to achieve lower variability in real interest rates, thus greater macroeconomic stability and consumer inflation stability without the Central Bank having to make aggressive adjustments to the Selic rate. A recommendation for future research advances is to use the empirical strategy of the current study for a group of emerging and/or developed countries with panel data methods. Characteristics that distinguish both groups, such as sovereign risk premiums, can be controlled when performing the estimation.

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Appendix A. Cointegration test

Table 6. Identification of optimal lag for unrestricted VAR

Lag	AIC	SIC	HQ
0	17.224	17.358	17.278
1	5.275	5.675*	5.437*
2	5.179	5.846	5.449
3	5.151*	6.085	5.529
4	5.242	6.442	5.728
5	5.322	6.788	5.915
6	5.213	6.946	5.914
7	5.171	7.171	5.981
8	5.242	7.509	6.160

Note: * indicates the optimal lag in accordance with the information criterion.

Table 7. Optimal specification of the Johansen cointegration test (1 lag)

Data trend	None	None	Linear	Linear	Quadratic
Rank or	No intercept	Intercept	Intercept	Intercept	Intercept
No. of CEs	No trend	No trend	No trend	Trend	Trend
	Akaike information criterion by rank (lines) and model (columns)				
0	5.445	5.445	5.405	5.405	5.441
1	5.346	5.333	5.291	5.206	5.234
2	5.327	5.323	5.280	5.204*	5.223
3	5.354	5.336	5.331	5.243	5.252
4	5.431	5.408	5.408	5.324	5.324
	Schwarz information criterion by rank (lines) and model (columns)				
0	5.445	5.445	5.470	5.470	5.571
1	5.476	5.479	5.486	5.417*	5.494
2	5.587	5.616	5.605	5.562	5.613
3	5.744	5.775	5.787	5.747	5.773
4	5.951	5.993	5.993	5.975	5.975

Note: * indicates the most parsimonious specification.

Table 8. Trace and Maximum Eigenvalue Tests

Trace Test				
No. of cointegrations	Eigenvalue	Trace Statistic	Critical value 0.05	p-value**
None *	0.249	88.382	63.876	0.000
Up to 1	0.086	29.830	42.915	0.512
Up to 2	0.048	11.450	25.872	0.848
Up to 3	0.006	1.403	12.517	0.993
Maximum Eigenvalue Test				
No. of cointegrations	Eigenvalue	Max-Eigen Stat	Critical value 0.05	p-value**
None *	0.249	58.552	32.118	0.000
Up to 1	0.086	18.376	25.823	0.349
Up to 2	0.048	10.050	19.387	0.613
Up to 3	0.006	1.403	12.517	0.993

Note: * indicates rejection of the hypothesis at 5%; ** MacKinnon–Haug–Michelis (1999) p-value.

Table 9. Estimation of the cointegrated equation (long-run equilibrium relationship)

Cointegrated Equation	
$PS(-1)$	1.000
$DEB(-1)$	-0.578***
	(0.077)
	[-7.487]
$E[PS](-1)$	0.493
	(0.468)
	[1.051]
$IBCBR(-1)$	-0.502***
	(0.096)
	[-5.207]
C	85.274

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 10. Estimation of Error Correction Model (short-run relationship)

Error Correction Model	D(PS)	D(DEB)	D(E[PS])	D(IBCBR)
Short-run coefficients	-0.040***	0.157***	-0.030***	-0.057
	(0.006)	(0.035)	(0.006)	(0.035)
	[-5.909]	[4.385]	[-4.659]	[-1.584]

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix B. Unit root tests for the reduced sample

Table 11. Unit root tests, second step of the analysis – variables in level

VARIABLES	ADF	PP	KPSS
$SELIC_t$	-2.596	-1.498	0.193**
$E[IPCA]_t$	-1.039	-0.984	0.206
$IBCBR\_GAP_t$	-4.162***	-3.872***	0.035
$EXCH_t$	-2.290	-2.128	0.369*
FR_t	-3.348**	-3.217**	0.322***

Note: For the ADF and PP tests: (***) rejects the unit root null hypothesis at the level of 1%, (**) rejects the null hypothesis at the level of 5%, (*) rejects the null hypothesis at the level of 10%; for the KPSS test: (***) rejects the stationarity null hypothesis at the level of 1%, (**) rejects the stationarity null hypothesis at the level of 5%, (*) rejects the stationarity null hypothesis at the level of 10%.

Table 12. Unit root tests, second step of the analysis – variables in first difference

VARIABLES	ADF	PP	KPSS
$D(SELIC_t)$	-5.504***	-8.084***	0.058
$D(E[IPCA]_t)$	-11.283***	-12.263***	0.108
$D(EXCH_t)$	-5.322***	-11.294***	0.075