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Original article

An analysis of the interaction between monetary and fiscal policies in Brazil

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Abstract:

This paper examines the interaction between monetary and fiscal policy rules in Brazil using quarterly data ranging from 2003 to 2017. Based on a New Keynesian macro model, a GMM system is applied and, as a robustness exercise, a Vector Autoregression (VAR) estimation is performed. Regarding the Taylor rule, there is evidence of the Brazilian central bank holding a dual mandate, i.e., seeking price stability without ignoring economic activity variables. Therefore, monetary policy seems to be countercyclical. As for the fiscal policy rule, the dynamics of economic activity leads to a decrease in the public sector borrowing requirement (PSBR) as a share of GDP, which is an indication of a countercyclical fiscal policy and coordination of economic policies. However, this may indicate only that GDP grows faster than PSBR, and not that the latter is decreasing. As a result, it is not possible to assure that the Brazilian fiscal policy is actually coordinated with the country´s monetary policy.

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The conduct of monetary policy has been motivating interesting debates among academic economists and policymakers, which were even intensified with the adoption of the inflation targeting (IT) system as a nominal anchor in many countries. In the IT regime, monetary policy can be considered effective as long as the target set for inflation is reached, with the minimum sacrifice ratio possible.

Fiscal policy until recently played a secondary role in several theoretical and empirical studies. However, in the aftermath of the 2008 global financial crisis, central banks and governments, including those of Brazil, were forced to coordinate the use of fiscal and monetary policies to prevent economic activity from plunging. In that specific period, lowering interest rates and finding ways of solving public debt were the main economic policy tools used.

This article aims to analyze the interaction between monetary and fiscal policies in Brazil, from the first quarter of 2003 until the fourth quarter of 2017. The study is based on a New Keynesian macroeconomic model, with an IS curve, a Phillips curve, a monetary rule (Taylor rule) and a fiscal rule. The econometric methodology applied is a system of equations estimated via Generalized Method of Moments (GMM). A Vector Autoregression (VAR) estimation is also performed as a robustness exercise in order to consider the presence of endogenous variables.

The main results show that Brazilian aggregate demand depends on its lagged economic activity, GDP growth expectations and real interest rate. As for the hybrid Phillips curve, expected future inflation and lagged inflation determine current inflation. The exchange rate influences inflation as well, creating some type of pass-through effect. Regarding the Taylor rule, expected inflation and GDP growth are also important in determining the country's interest rate rule. Thus, monetary policy seems to be countercyclical in Brazil. As for the fiscal policy rule, the lagged GDP leads to a decrease in the public sector borrowing requirement (PSBR) as a share of GDP, which is an indication of a countercyclical fiscal policy and coordination of economic policies. However, it should be noted that the variable PSBR in relation to GDP may indicate only that GDP grows faster than PSBR, and not that there is an effective decrease in public spending. Thus, it is not possible to assure that fiscal policy is actually coordinated with monetary policy in Brazil.

1. Literature review

Fiscal policy was slightly neglected in recent times. But that does not mean that there was no further scientific research in the area, especially researches related to the interaction between monetary and fiscal policies. In fact, Subacchi (2013) argued that monetary policy should be considered in a more coordinated and integrated framework, in which measures are consistent with fiscal policy and economic growth.

Sargent and Wallace's (1981) article is crucial to understand the importance of coordinating monetary and fiscal policies. According to the authors, there are basically two important regimes to be considered: *i*) monetary dominance regime, in which a passive fiscal policy is able to generate a primary surplus through the stabilization of the public debt/GDP ratio and an active monetary policy capable of controlling the price level; *ii*) fiscal dominance regime, in which fiscal policy is active and a primary surplus can be obtained independent of the public debt/GDP ratio dynamics. In this case, monetary authorities must print money to create seigniorage gains and, as a result, the ability to control inflation is lost.

Leeper (1991), Sims (1994), and Woodford (1995), amongst others, focused on the so-called fiscal theory of the price level, in which the role of fiscal policy is crucial for determining the price level. In fact, this theory can be described as non-Ricardian once the intertemporal budget constraint is satisfied only at a specific equilibrium price level, despite the possibility of multiple price levels consistent with a given equality between supply and demand for money, and with a given amount of money. There may even be some cases in which the equilibrium price level chosen cannot be dependent on money supply, due to fiscal factors (Walsh, 2003).

Blinder (1982) also contributed to the discussion by considering the interaction between policies as a game amongst institutions. Lambertini and Rovelli (2003) agreed with that vision and modelled the interaction between monetary and fiscal policies as a Nash equilibrium, in

which the two institutions (monetary and fiscal) define their policies, disregarding the action of the other. Their results showed that the non-simultaneous solution is preferred and that fiscal policy should take the leadership role, since it is revised less frequently.

Blake and Kirsanova (2011) presented a detailed analysis on the coordination between discretionary monetary and fiscal policies in an intertemporal general equilibrium model. Emphasis was given to non-cooperative interactions under a conservative monetary authority, which puts greater weight on inflation stabilization. According to the authors, the choice of a fiscal instrument is an important issue that should be accounted for. In addition, monetary leadership is relatively better if the monetary authority is conservative and puts greater weight on inflation.

Considering the interaction amongst fiscal and monetary policies in a two-country sticky price model, Lombardo and Sutherland (2003) claimed that fiscal cooperation welfare gains depend on actions from monetary authorities. In general, policy cooperation leads to higher welfare gains. However, when monetary authorities act as Nash players, policy cooperation may reduce welfare. Hallet et al. (2011) argued that, even if policymakers had idiosyncratic goals and a production target that was not socially optimal, such coordination could still improve social welfare because coordination would prevent the two policies from trying to offset each other's actions.

There are also theoretical works, such as Benigno and Woodford (2003); Persson et al. (2006) and Schmitt-Grohe and Uribe (2006), in which a New Keynesian model is used to explain the role of effective coordination between monetary and fiscal policies. Following the New Keynesian framework, Muscatelli et al. (2004) presented a model for the USA and Germany and showed that such coordination depends on the type of shocks observed in the economy, and on assumptions made. Moreover, they argued that a counter-cyclical fiscal policy can reduce welfare if not well coordinated with monetary policy. Wyplosz (1999) made use of a panel data analysis for the European Union countries and found that monetary and fiscal policies acted as substitutes for each other during the period 1980-1997, even though there was certain monetary dominance. Aktas et al. (2010) analyzed the Turkish case and noticed that the country's fiscal dynamics had an important role in the effectiveness of monetary policy.

In the case of Brazil, Fialho and Portugal (2005) found that, for the period 1994-2003, monetary and fiscal policies acted as substitutes, although there was some monetary dominance. Rocha and Silva (2004) and Gadelha and Divino (2008) also found monetary dominance in the Brazilian case. However, Tanner and Ramos (2002) and Moreira et al. (2011) found results leading to fiscal dominance in Brazil.

Regarding the coordination of economic policy during the financial crisis, Mitreska et al. (2010) estimated a monetary/fiscal policy reaction function for a panel data of 61 developed and emerging countries, finding that advanced economies were more aggressive in output stabilization, compared to emerging economies. Gomes and Vieira (2014) analyzed a panel of 113 advanced and emerging economies. Their results showed that, after the 2008 financial crisis, both policies had to be used in some kind of coordinated manner.

Finally, it is important to highlight that, although we present a literature review focused on policy coordination, there are some studies that show the independent role of fiscal policy in providing stimulus for economic activity. For instance, Guajardo et al. (2011) concluded that fiscal consolidation has contractionary effects on private domestic demand and GDP. Fatás and Summers (2016) argued that, if the negative effects of fiscal consolidation are long lasting, countries may enter a negative cycle where attempts to reduce public debt are not effective

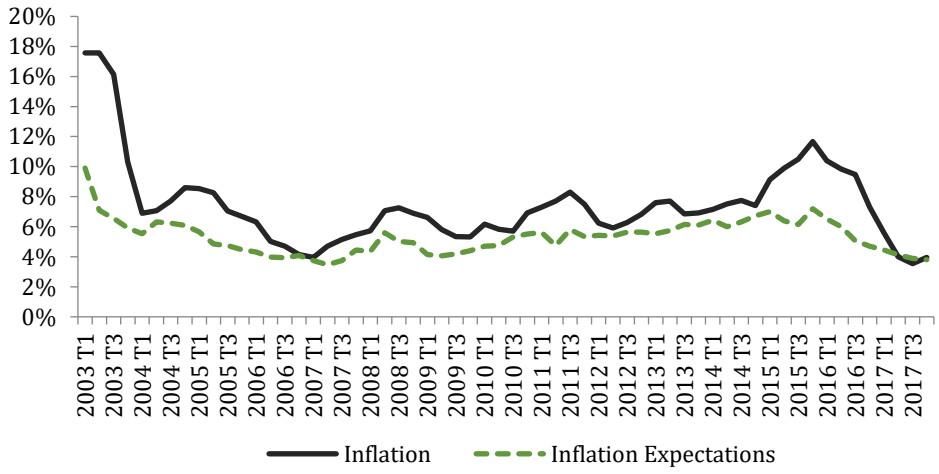
because of reductions in GDP. Jordá and Taylor (2016) showed that austerity is always an obstacle to growth, and especially in depressed economies.

2. A brief review of the conduct of monetary and fiscal policies in Brazil

After the failure of several inflation stabilization plans in Brazil, the 1994 Real Plan,[1] which was accompanied by a basic, but important, fiscal program, was successful in controlling inflation. In fact, after many frustrated attempts to stabilize the Brazilian economy during the 1980s and 1990s, Real Plan economists argued that the country's uncontrolled inflation rate was related to a general indexation of nominal contracts, and by a large public deficit. Economic stabilization was then developed in three phases: *i*) the government should adjust the short-term fiscal deficit; *ii*) monetary authorities should introduce a price index to stabilize relative prices; *iii*) a monetary reform should be implemented (Paula and Ferrari-Filho, 2003).

However, a speculative attack in 1998-99 led to the replacement of the exchange rate anchor by an inflation targeting regime, whose main objective was to control inflation. The next challenge happened some years later, in 2002, when Brazil was affected by a global economic slowdown, and by problems related to the country's presidential elections, when political uncertainty raised concerns about inflation stabilization.

Figure 1 – *Inflation and inflation expectations – IPCA* (*% 12-month*)



Sources: Central Bank of Brazil, available at: https://www.bcb.gov.br/ and IBGE, available at: https://www.ibge.gov.br/.

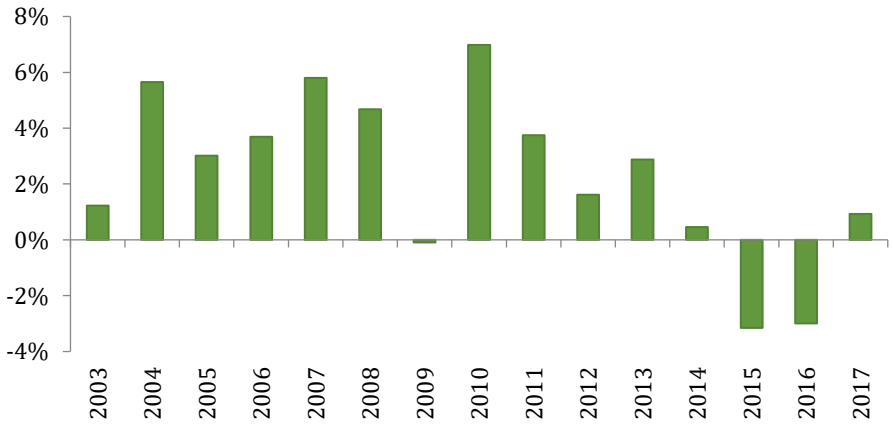
[1] The Real Plan was launched in 1994, in Brazil, aiming at ending hyperinflation, which plagued the country's economy for so many years. The plan, which is by far the largest price stabilization measure ever undertaken in Brazil, was based on an exchange rate anchor, restrictive monetary policy, more economic openness and some fiscal control. Due to internal and external crises, Brazil adopted a flexible exchange rate, in 1999, as well as an inflation targeting regime as its new nominal anchor.

Due to the events in 2002, uncertainty increased by the end of that year because economic agents did not know which monetary and fiscal policies the newly elected president would pursue. Therefore, there was a high exchange rate depreciation, as well as a considerable increase in inflation and inflation expectations. The new government reacted in 2003, together with the central bank's monetary policy committee, pursuing more restrictive monetary and fiscal policies. In this way, the credibility of the government was recovered, reducing inflation, stabilizing the exchange rate and controlling public debt (Bresser-Pereira and Gomes, 2008). In 2004, Brazil experienced considerable economic growth due to a large external adjustment between 1998 and 2004, caused by the effects of currency devaluation, by Chinese economic growth, which increased exported goods from Brazil, and by domestic distributive policies. Inflation also started a declining trend (figure 1).

In March 2006, after the substitution of the country's minister of finance, the conduct of monetary policy in Brazil began to change. The aim was to not only consider price stability but also to foster economic growth by raising public investment. Inflation started to pick up, easily reaching the upper limit of the target.

In fact, during the period 2003-2008, Brazilian economic growth was closely related to international economics and trade. Average annual GDP growth went from about 3% in 2003-2005 to about 5% in 2006-2008. Exchange rate depreciation and the world's economic growth boosted the Brazilian export sector, increasing exports in 2003. In the period 2006-2008, output growth was achieved with inflation control and lower interest rates, due to a significant increase in commodities before the beginning of the international financial crisis. Growth acceleration was accompanied by the accumulation of international reserves, reducing Brazil's external vulnerability and external inflationary pressures. On the fiscal side, there was a small reduction in the country's primary result, which in turn did not compromise the decline in the public-sector debt-to-GDP ratio (Barbosa and Souza, 2010).

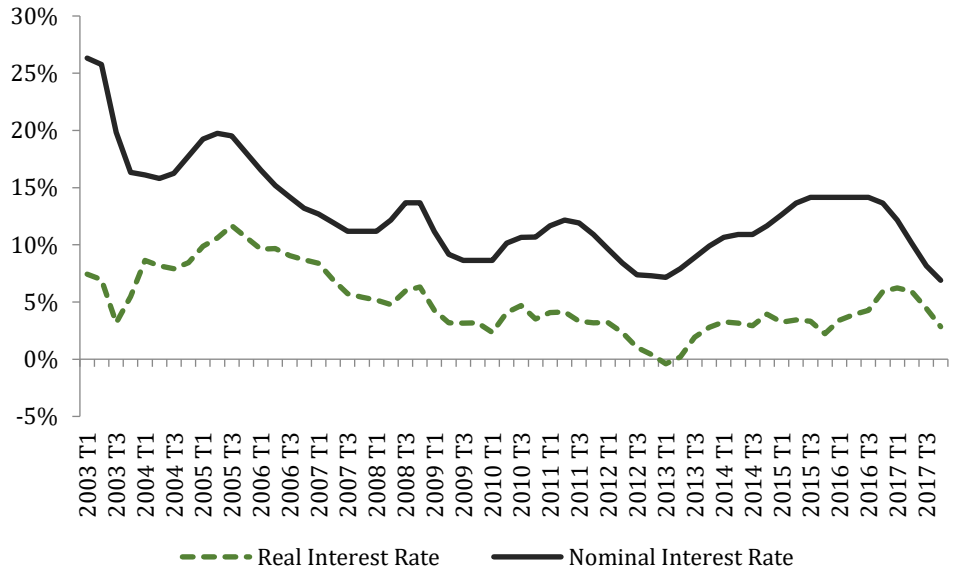
Figure 2 – *Gross Domestic Product* (*% p.a.*)



Source: IBGE, available at: https://www.ibge.gov.br/.

But Brazil was also hit by the global financial crisis in the second half of 2008. This is clearly seen in figure 2, which shows that the country's annual growth rate decreased considerably in 2009. Indeed, the global economic and financial crisis of 2008, which led to the fall in industrial production and GDP, forced the government to take action. On one hand, the benchmark Selic[2] interest rate was reduced (figure 3), and changes in reserve and capital requirements were made. On the other hand, the Federal Administration started to adopt an expansionary fiscal policy by increasing government spending and decreasing some federal taxes. In addition, in order to deal with a massive credit crunch, government-controlled banks helped to keep liquidity in the financial system.

Figure 3 – *Nominal interest rate and real interest rate – Selic* (*% p. a.*)



Source: Central Bank of Brazil, available at: https://www.bcb.gov.br/.

When president Dilma took power in the beginning of 2011, monetary policy started to be expansionary, with a considerable decrease of the benchmark Selic interest rate (figure 3). Fiscal policy also continued to be expansionary with measures aimed at keeping consumption booming, such as tax exemptions given to the automobile and durable goods sectors, as well as payroll tax exemptions given to several industrial and service sectors. In fact, the increased government expenses, without an increase in additional revenue, resulted in a greater budget deficit (figure 4).

[2] Selic is the Portuguese acronym for Special System for Settlement and Custody, which is the settlement system for most of the Brazilian government domestic securities. From a monetary and fiscal perspective, Selic is responsible for holding all public offerings (auctions) issued by the National Treasury and for open market operations conducted by the Central Bank. These operations generate the Selic rate, which is the Central Bank overnight interest rate. The Brazilian Monetary Policy Committee (COPOM) sets a target for this Selic rate.

The situation was aggravated by a corruption scandal at the government-controlled oil company Petrobras ("Operation Car Wash"[3]), and by the use of some discretionary accounting conventions (creative accounting) to present better fiscal accounts. In fact, there was a change of an accounting rule in the Budgetary Guidelines Law in 2009, allowing the accounts of state-owned companies, including Petrobras, to not be considered for the purpose of calculating Brazil's primary results. Such action caused perverse consequences, such as creating conditions for the manipulation of the government's financial results, artificially inflating the country's primary surplus, and reducing the transparency of government accounts. This undermined public confidence and reduced short-term incentives for the government to ensure the financial integrity of Petrobras. The pursuit of costly public policies through Petrobras generated rising expenses (including corruption), which didn't appear in federal government records (Salama and Pargendler, 2016). Even with the use of creative accounting, Brazil's fiscal accounts started to worsen after 2012 and, after the presidential election, in the second semester of 2014, the Brazilian Court of Auditors and Accounts ordered the federal administration to correct its fiscal accounts; this made public debt increase considerably from the beginning of 2015. The result was a growing public sector borrowing requirement as a share of GDP, from 2011 onwards in 2016 (figure 4).

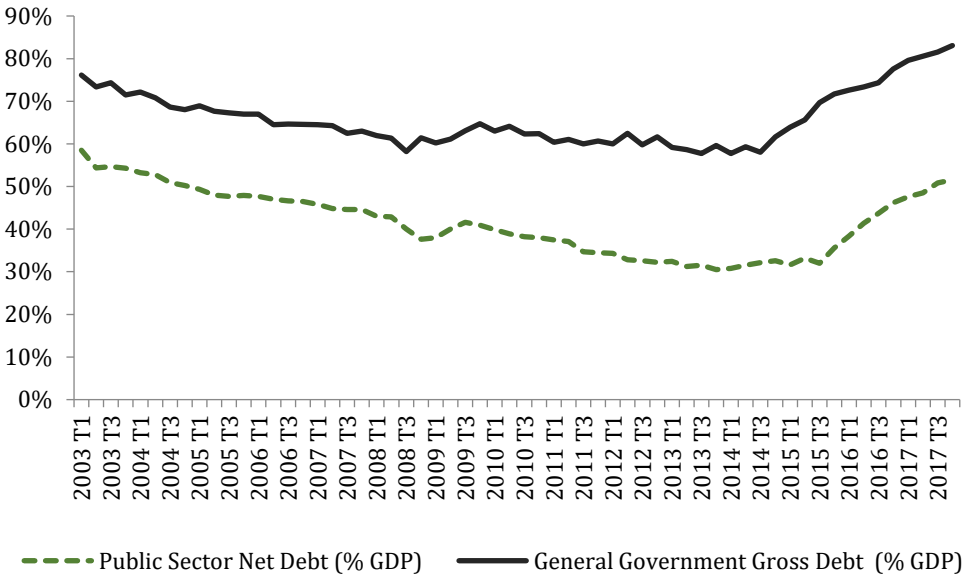
Figure 4 – *Primary public sector borrowing requirement* (*% GDP*)

Source: Central Bank of Brazil, available at: https://www.bcb.gov.br/.

[3] Operation Car Wash was launched in March 2014 by Brazilian law enforcement officials, with the purpose of stopping a large scheme of money laundering and bribery involving Petrobras, large contractors, and politicians.

When one looks at figure 4, one can clearly see a negative primary public sector borrowing requirement (as a percent of GDP), especially from 2003 to 2014, which meant a primary budget surplus during the whole period. This path contributed to a downward trend in the country's public sector net debt between 2003 and 2014. However, the Brazilian general government gross debt decreased until 2008, but started increasing from then on, due to a rise in the central bank's repurchase agreement operations and to public financial transfers, mainly to the national development bank (BNDES). It should be noted that the increase in both net and gross debts, seen at the end of the period analyzed, is mainly related to a large budget deficit (figure 5).

Figure 5 – *Public sector net debt and general government gross debt* (*% of GDP*)



Source: Central Bank of Brazil, available at: https://www.bcb.gov.br/.

3. Estimated model

The empirical assessment is based on a small structural macroeconomic model built by Muscatelli et al. (2004)[4]. The authors estimate monetary and fiscal policy rules together with two structural equations: an IS curve and a Phillips curve.

The hybrid Phillips curve, as proposed by Galí and Gertler (1999), shows that inflation depends on a convex combination of the expected inflation ($E_t\pi_{t+1}$) and lagged inflation (π_{t-1}). The lagged term inserts inflation persistence and shows that there are costs in case of disinflation.

[4] For more information on the model, refer to the work of Muscatelli et al. (2004).

$$\hat{\pi}_t = \alpha_1 \hat{\pi}_{t-1} + \alpha_2 E_t \hat{\pi}_{t+1} + \alpha_3 \hat{s}_t \quad (1)$$

where $\hat{s}_t$ is the percentage change from steady-state marginal cost. This variable is the percentage change of the labor income share and will be called 'wages' in this work, which reflects the percentage change from steady state of labor income participation.

Given the monetary policy rule, the nominal interest rate (i_t) follows a traditional forward-looking Taylor rule:

$$\hat{\imath}_t = \emptyset_0 + \emptyset_1 E_t \hat{\pi}_{t+q} + \sum_{i=0}^{m} \emptyset_{2i}\, \hat{y}_t + \emptyset_3 \hat{\imath}_{t-1} \quad (2)$$

where y_t is the output and the rule allows for interest rate smoothing, if $\emptyset_3 \neq 0$.

With regard to fiscal policy, Muscatelli et al. (2004) establish a backward-looking fiscal rule, which captures a realistic response of fiscal policy to macroeconomic variables. Such a response is possible because of the frequency at which fiscal policy is determined, and because of the presence of automatic stabilizers. The authors estimate separate models for government spending (g_t) and tax revenue (τ_t). In each case, both variables respond to output (y_t) and to a stabilization mechanism that captures the impact of the lagged budget deficit to GDP (dp) ratio.

$$\hat{g}_t = \sum_{i=1}^{m} \delta_{1i}\, \hat{g}_{t-i} + \sum_{i=1}^{m} \delta_{2i}\, \hat{y}_{t-i} + \psi_1 (dp)_{t-k} \quad (3)$$

$$\hat{\tau}_t = \sum_{i=1}^{m} \varphi_{1i}\, \hat{\tau}_{t-i} + \sum_{i=0}^{m} \varphi_{2i}\, \hat{y}_{t-i} + \psi_2 (dp)_{t-k} \quad (4)$$

For this model to be empirically estimated, some simplifications and adaptations to the Brazilian case must be made. The first one is to consider the evolution of the country´s public debt through a nominal government budget constraint, such as:

$$B_t = (1 + R_{t-1}) B_{t-1} + G_{t-1} - \tau Y_{t-1} \quad (5)$$

where B_t is the nominal debt, which depends on the lagged debt (B_{t-1}), real interest payments ($R_t B_t$), government spending (G_{t-1}) and tax revenues (τY_{t-1}). It is assumed that the tax revenues occur exogenously by means of automatic stabilizers (τ).

As in Kirsanova et al. (2005), the debt equation can be log linearized and thus represented as follows:

$$b_t = (1 + r_0) b_{t-1} + r_{t-1} b_0 + g_{t-1} - \tau y_{t-1} \quad (6)$$

where b_t is the nominal debt, r_t is the real interest rate, g_t is the government spending (G_{t-1}), τy_{t-1} is the tax revenue.

Thus, the New Keynesian IS curve will be adapted to the following format:

$$y_t = \beta_1 y_{t-1} + \beta_2 E_t y_{t+1} - \beta_3 r_t + \beta_4 g_t + \beta_5 g_{t-1} \quad (7)$$

The public spending equation can be described as:

$$g_t = \rho_1 g_{t-1} + \rho_2 y_{t-1} + \rho_3 div_{t-1} \quad (8)$$

As for the exchange rate (e_t), we follow Minella et al. (2003) and express a monetary Taylor rule as:

$$i_t = \lambda_0 + \lambda_1 E_t \pi_{t+1} + \lambda_2\, y_{t-1} + \lambda_3\, i_{t-1} + \lambda_{34}\, e_{t-1} \quad (9)$$

Given these adaptations, we assume only one lag and one lead for the variables. Moreover, we exclude the tax revenue equation and consider only the equation related to the ratio of the government's primary deficit to GDP. Thus, the estimated equations are as follows:

$$y_t = \beta_1 y_{t-1} + \beta_2 E_t y_{t+1} - \beta_3 r_t + \beta_4 g_t + \beta_5 g_{t-1} \quad (10)$$

$$\pi_t = \beta_6 \pi_{t-1} + \beta_7 E_t \pi_{t+1} + \beta_8 s_t + \beta_9 e_{t-1} \quad (11)$$

$$i_t = \beta_{10} + \beta_{11} E_t \pi_{t+1} - \beta_{12} y_{t-1} + \beta_{13} i_{t-1} + \beta_{14} e_{t-1} \quad (12)$$

$$g_t = \beta_{15} g_{t-1} + \beta_{16} y_{t-1} + \beta_{17}\, div_{t-1} \quad (13)$$

where: y_t = output; r_t = real interest rate; g_t = government spending; π_t = inflation; e_t = exchange rate; E_t = expectations term; i_t = nominal interest rate; div_t = public sector net debt; s_t = wages.

4. Econometric methodology, data and descriptive statistics

The econometric methodology consists of a GMM system estimation, which is a time-series system of equations estimated via Generalized Method of Moments (GMM), as proposed by Hansen (1982). As a robustness exercise, a Vector Autoregression[5] (VAR) estimation is also performed to account for the possible presence of endogenous variables.

An important feature of the GMM methodology is that it allows for more moment conditions than parameters to be estimated, that is, the parameters can be overidentified. In this situation, the idea is to consider each of the moments according to the variance and obtain a quadratic function which can be minimized (Bueno, 2008). In fact, the GMM estimation assumes that the disturbances in the equations are not related to the set of instrumental variables, causing a selection of estimates of parameters, so that the correlation between the instruments and the errors is as close to zero as possible. Moreover, by making use of GMM with instrumental variables, the estimators are consistent, under the assumptions of homoscedasticity and no serial correlation of errors. Endogeneity is also accounted for because we take the variables in their own lagged terms as instrumental variables. Therefore, there is no endogeneity bias.

The GMM estimation is made through the equalization of the sample moments to population moments, which is similar to the vector of moment conditions $m(y_t, \theta)$ to zero:

$$\overline{m}\,(y_t, \theta) = \frac{1}{T}\sum_{t=1}^{T} m(y_t, \theta) = 0 \quad (14)$$

where $\overline{m}$ is the vector of moment conditions (population moments) and T is the sample size. In general, there are more moment conditions than parameters (overidentified system), and, therefore, there are several solutions. In order to achieve a unique solution, it is necessary to define a criterion function:

$$J(\theta) = \overline{m}(\theta)' \, W \overline{m}(\theta) \quad (15)$$

The idea is to minimize $J(\theta)$, with W being a positive-defined matrix weighting. Thus, we reach an asymptotically efficient solution estimation when this matrix is:

$$W^* = \left\{ \lim_{t \to \infty} Var\,(\sqrt{T}\,\overline{w}(\theta)) \right\}^{-1} = \Omega(\theta)^{-1} \quad (16)$$

where $\Omega(\theta)$ is the variance-covariance matrix of the model parameters (Laurini and Hotta, 2009). Finally, the following quadratic form has to be minimized in order to find the efficient GMM estimator:

[5] See Hamilton (1994), Fuller (1996) and Martin et al. (2012) for more information about VAR.

$$\hat{\theta} = arg \min_{\theta} \overline{m}\,(\theta)' \hat{\Omega}\,(\theta^*) \bar{g}\,(\theta) \quad (17)$$

After describing the econometric methodology, we now turn to the description of data used in the article, emphasizing some of their basic descriptive statistics. The period of analysis ranges from the first quarter of 2003 to the fourth quarter of 2017. The data sources are the central bank of Brazil and the Brazilian Institute of Geography and Statistics (IBGE).

- Gross Domestic Product (y): accumulated growth rate over the past four quarters;
- GDP expectations ($E_t y_{t+1}$): expectation data collected from the Central Bank Expectations System (quarter-over-quarter);
- Nominal interest rate (i): Selic nominal interest rate (% annualized). It is the average rate weighted by the volume of one-day operations guaranteed by federal government securities. It is the benchmark rate used as reference by the monetary policy;
- Real interest rate (r): Selic nominal interest rate (% annualized – IPCA deflated);
- 12-month IPCA inflation rate (π) on a quarterly basis;
- Inflation expectations ($E_t \pi_{t+1}$): expected in 12 months on quarterly basis;
- Real effective exchange rate (e): obtained from the Bank for International Settlements (quarter-over-quarter);
- Public sector net debt (div): (%) of GDP;
- Primary public sector borrowing needs – PSBR (g): (%) of GDP. This variable was calculated from the monthly variation of the Brazilian net fiscal debt, excluding nominal interest expenses, and including interest income related to international reserves.
- Wages (s): real minimum wage growth (12-month accumulated on a quarterly basis).

Table 1 – *Descriptive statistics (1Q2003 – 4Q2017)*

	Mean	**Median**	**Maximum**	**Minimum**	**Std. deviation**
GDP (% change)	2.47	3.00	7.50	–4.60	3.08
GDP expectations (% change)	1.97	2.38	8.10	–5.76	2.89
Real interest rate (%)	5.02	4.20	11.67	–0.40	2.80
Nominal interest rate (%)	12.84	12.04	26.30	6.90	4.13
Inflation (%)	7.44	6.97	17.57	3.54	2.83
Inflation expectations (%)	5.33	5.40	9.90	3.47	1.13
Real exchange rate (% change)	0.98	0.96	1.42	0.74	0.14
Public sector net debt (% GDP)	41.62	41.15	58.50	30.50	7.65
Primary PSBR (% GDP)	–1.81	–2.68	3.05	–3.99	2.11
Wages (% change)	4.36	3.19	13.50	–6.27	4.37

Sources: Central Bank of Brazil, available at: https://www.bcb.gov.br/ and IBGE, available at: https://www.ibge.gov.br/

Table 1 reports the descriptive statistics of the series. For instance, Brazilian GDP had an average growth rate of 2.47%, and a 3.08 standard deviation. This considerable variability may be due to several factors, including the 2008-2009 crisis. GDP expectations averaged 1.97%, with a median of 2.38%.

The country's real interest rate presented an average of 5.02% and a median of 4.2%. As for the nominal interest rate, the data show an average of 12.84%, with a maximum rate of 26.3% and a minimum of 6.9%. There is no doubt that these interest rate percentages are extremely high when compared to those of most developed countries. IPCA inflation marked an average of 7.44%, with a maximum and a minimum of 17.57%, and 3.54%, respectively. With regard to inflation expectations, the average was 5.33%, which is lower than actual inflation.

5. Results

5.1. Model estimation – GMM System

The first step is to examine the variables' order of integration, via ADF and KPSS unit root tests. Table 2 shows the results of both tests for the variables in level. Both ADF and KPSS tests indicate that, at the usual significance levels, real exchange rate, inflation expectations and wages are integrated of order zero: I(0).

As in the unit root test for Brazil's public net debt, the null hypothesis was not rejected for: GDP expectations, inflation, primary PSBR, GDP, nominal interest rate and real interest rate. In this case, as variables in level are not integrated of order zero, the first difference of these series was taken, and the unit root test was applied again. Table 3 shows these results and indicates that the transformed variables are integrated of order zero, at the usual significance levels.

With regard to the GMM system estimation, four regressions were performed (table 4). Systems 1 and 2 did not include a dummy for the 2008 financial crisis. As for the instruments used in the estimations (table A1 in the online appendix), the procedure adopted is to use lags of the own variables as instruments (systems 1 and 3: 2 lags; systems 2 and 4: 3 lags).[6] In addition, systems 3 and 4 include a dummy for the 2008 financial crisis. In order to verify the validity of the instruments, a series of Hansen *J*-tests of overidentification is used.[7]

The estimation results for the four systems, containing all equations (IS curve, Phillips curve, monetary policy rule, and fiscal policy rule) are reported in table 4. With respect to the IS curve, estimations show that the lagged product is statistically significant in two of the four systems and GDP expectations are statistically significant in all systems. This result indicates that Brazil's GDP depends on the lagged output as well as on future expectations related to output growth, both with a positive sign. This means that a larger lagged GDP leads to an increase in economic activity, indicating a positive inertia in the production of Brazilian economy.

[6] It is important to point out that the limitation of this empirical work may be due to the small number of observations.

[7] Under the null hypothesis that the instruments are valid, the *J*-test statistic is chi-squared distributed in the number of over-identifying restrictions.

Table 2 – *Unit root tests: series in levels*

Series	ADF (H_0: Unit root)							KPSS (H_0: Stationary)						
	Test stat.	Lags	Intercept/ Trend	Critical values			Reject H_0 ?	Test stat.	Band width	Intercept/ Trend	Critical values			Reject H_0 ?
				1%	5%	10%					1%	5%	10%	
Real exchange rate	–4.57	2	I/T	–4.12	–3.49	–3.17	Yes	0.06	3	I/T	0.21	0.14	0.11	No
	–2.20	4	I	–3.55	–2.91	–2.59	No	0.29	3	I	0.73	0.46	0.34	No
	–0.40	4	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–
Public sector net debt	1.57	0	I/T	–4.12	–3.48	–3.17	No	0.20	6	I/T	0.21	0.14	0.11	Yes/No
	–1.44	2	I	–3.55	–2.91	–2.59	No	0.52	6	I	0.73	0.46	0.34	Yes/No
	–0.12	1	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–
Inflation expectations	–4.51	0	I/T	–4.12	–3.48	–3.17	Yes	0.15	5	I/T	0.21	0.14	0.11	Yes/No
	–4.40	0	I	–3.54	–2.91	–2.59	Yes	0.15	5	I	0.73	0.46	0.34	No
	–2.15	0	´–	–2.60	–1.94	–1.61	Yes/No	´–	–	´–	–	–	–	–
GDP expectation	–2.73	3	I/T	–4.13	–3.49	–3.17	No	0.17	5	I/T	0.21	0.14	0.11	Yes/No
	–1.60	3	I	–3.55	–2.91	–2.59	No	0.54	5	I	0.73	0.46	0.34	Yes/No
	–1.29	3	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–
Inflation	–2.21	3	I/T	–4.13	–3.49	–3.17	No	0.15	5	I/T	0.21	0.14	0.11	Yes/No
	–5.40	1	I	–3.54	–2.91	–2.59	Yes	0.18	5	I	0.73	0.46	0.34	No
	–2.30	1	´–	–2.60	–1.94	–1.61	Yes/No	´–	–	´–	–	–	–	–
Wages	–4.63	0	I/T	–4.12	–3.48	–3.17	Yes	0.09	3	I/T	0.21	0.14	0.11	No
	–3.89	0	I	–3.54	–2.91	–2.59	Yes	0.40	4	I	0.73	0.46	0.34	Yes/No
	–2.28	0	´–	–2.60	–1.94	–1.61	Yes/No	´–	–	´–	–	–	–	–
Primary PSBR	–1.80	0	I/T	–4.12	–3.48	–3.17	No	0.19	6	I/T	0.21	0.14	0.11	Yes/No
	–0.005	0	I	–3.54	–2.91	–2.59	No	0.76	6	I	0.73	0.46	0.34	Yes
	–1.03	0	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–
GDP	–1.99	6	I/T	–4.14	–3.49	–3.17	No	0.16	5	I/T	0.21	0.14	0.11	Yes/No
	–0.87	6	I	–3.56	–2.91	–2.59	No	0.57	5	I	0.73	0.46	0.34	Yes/No
	–1.10	6	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–
Nominal interest rate	–1.17	2	I/T	–4.12	–3.49	–3.17	No	0.21	5	I/T	0.21	0.14	0.11	Yes
	–1.10	2	I	–3.55	–2.91	–2.59	No	0.64	5	I	0.73	0.46	0.34	Yes/No
	–1.01	2	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–
Real interest rate	–2.02	0	I/T	–4.12	–3.48	–3.17	No	0.15	5	I/T	0.21	0.14	0.11	Yes/No
	–1.57	0	I	–3.54	–2.91	–2.59	No	0.56	6	I	0.73	0.46	0.34	Yes/No
	–1.22	0	´–	–2.60	–1.94	–1.61	No	´–	–	´–	–	–	–	–

Regarding the Brazilian real interest rate, the coefficient was statistically significant in four systems, with an expected sign, indicating that a higher interest rate reduces investment and GDP, consequently. Concerning the current and lagged values of public spending, the former is statistically significant in two of the four systems estimated, with a negative sign, whereas the latter is not statistically significant in any system. The negative sign of government spending may be related to the fact that some government expenditures, such as social security, have no effect on GDP, while subsidies have a negative effect on GDP. But this issue will be explored in more depth later in this article.

Table 3 – *Unit root tests: variables in first difference*

Series	ADF (H_0: Unit root)							KPSS (H_0: Stationary)						
	Test stat.	Lags	Intercept/ Trend	Critical values			Reject H_0 ?	Test stat.	Band width	Intercept/ Trend	Critical values			Reject H_0 ?
				1%	5%	10%					1%	5%	10%	
Public sector net debt	–6.28	0	I/T	–4.12	–3.48	–3.17	Yes	0.15	3	I/T	0.21	0.14	0.11	Yes/No
	–5.20	0	I	–3.54	–2.91	–2.59	Yes	0.69	5	I	0.73	0.46	0.34	Yes/No
	–5.27	0	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–	–	–	–	–
GDP expectation	–6.21	2	I/T	–4.13	–3.49	–3.17	Yes	0.04	3	I/T	0.21	0.14	0.11	No
	–6.23	2	I	–3.55	–2.91	–2.59	Yes	0.04	3	I	0.73	0.46	0.34	No
	–6.29	2	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–	–	–	–	–
Inflation	–4.34	0	I/T	–4.12	–3.48	–3.17	Yes	0.14	2	I/T	0.21	0.14	0.11	Yes/No
	–4.26	0	I	–3.54	–2.91	–2.59	Yes	0.22	2	I	0.73	0.46	0.34	No
	–4.20	0	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–	–	–	–	–
Primary PSBR	–6.32	0	I/T	–4.12	–3.48	–3.17	Yes	0.05	2	I/T	0.21	0.14	0.11	No
	–6.30	0	I	–3.54	–2.91	–2.59	Yes	0.17	3	I	0.73	0.46	0.34	No
	–6.14	0	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–	–	–	–	–
GDP	–4.11	5	I/T	–4.14	–3.49	–3.17	Yes/No	0.04	3	I/T	0.21	0.14	0.11	No
	–4.19	5	I	–3.56	–2.91	–2.59	Yes	0.04	3	I	0.73	0.46	0.34	No
	–4.16	5	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–	–	–	–	–
Nominal interest rate	–6.19	1	I/T	–4.12	–3.49	–3.17	Yes	0.08	3	I/T	0.21	0.14	0.11	No
	–6.59	1	I	–3.55	–2.91	–2.59	Yes	0.17	3	I	0.73	0.46	0.34	No
	–6.64	1	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–	–	–	–	–
Real interest rate	–3.97	3	I/T	–4.12	–3.48	–3.17	Yes/No	0.06	2	I/T	0.21	0.14	0.11	No
	–3.99	3	I	–3.55	–2.91	–2.59	Yes	0.06	2	I	0.73	0.46	0.34	No
	–4.00	3	´–	–2.60	–1.94	–1.61	Yes	´–	–	´–				–

As for the Phillips curve, the results reported in table 4 show that there still is inflation inertia in Brazil, since the lagged inflation coefficient is statistically significant in all estimations made, with values from 0.42 to 0.77. The coefficients for expected inflation show that inflation in Brazil also has a forward-looking perspective. This means that a hybrid Phillips curve can be a good indication for the Brazilian case.[8] The exchange rate coefficient is statistically significant in three of the four systems estimated, but with a sign different than expected. As for the coefficients related to wages, there is statistical significance in three of the systems estimated, signaling that higher wages lead to higher inflation.

The monetary policy rule represents the central bank's reaction function (Taylor rule). The estimation results show that the coefficient estimated for inflation expectations is statistically significant in all systems and GDP is statistically significant in three of the four systems estimated, and both with positive signs. The Brazilian central bank seems to react to inflationary processes and to output growth above (or below) its potential, which can be interpreted as having dual mandate objectives, i.e., monetary authorities in Brazil seem to pursue price stability without neglecting economic activity variables, such as GDP and unemployment. Moreover, this result marks the countercyclical character of monetary policy, i.e., the benchmark Selic interest rate rises when the output gap closes faster than expected. As

[8] We applied the long-run restriction in the Phillips curve by making $\beta_6 + \beta_7 = 1$ in equation 11.

for the coefficients related to the exchange rate, two systems are statistically significant, corroborating some importance of this variable in the country's monetary policy conduct. The lagged nominal interest rate, related to interest rate smoothing, shows statistical significance in only one estimation performed. Finally, the inclusion of the dummy to capture the effects of the 2008 financial crisis shows statistical significance only in system 4.

Table 4 – *GMM System estimation results*

		System 1	**System 2**	**System 3**	**System 4**
IS curve y_t	$\beta_1 y_{t-1}$	0.337	0.324**	0.366	–0.541**
		(0.243)	(0.052)	(0.397)	(0.190)
	$\beta_2 E_t y_{t+1}$	0.731**	1.653**	0.724**	1.763**
		(0.137)	(0.048)	(0.231)	(0.169)
	$\beta_3 r_t$	–0.849*	–0.444**	–0.726	–0.061
		(0.484)	(0.167)	(0.658)	(0.052)
	$\beta_4 g_t$	–1.412	–0.801**	–0.845	–0.798
		(0.952)	(0.255)	(1.728)	(0.995)
	$\beta_5 g_{t-1}$	0.640	0.124	0.012	0.528
		(1.261)	(0.203)	(1.906)	(0.800)
	Dummy	–	–	–0.389	–3.439**
				(3.228)	(1.733)
Phillips curve π_t	$\beta_6 \pi_{t-1}$	0.771**	0.632**	0.592**	0.423**
		(0.116)	(0.047)	(0.265)	(0.054)
	$\beta_7 E_t \pi_{t+1}$	0.229	0.368	0.408	0.577
		(----)	(----)	(----)	(----)
	$\beta_8 s_t$	0.096**	0.077**	0.076	0.068
		(0.044)	(0.016)	(0.056)	(0.045)
	$\beta_9 e_{t-1}$	–1.684**	–2.25**	–2.666	0.746**
		(0.540)	(0.282)	(1.706)	(0.195)
	Dummy	–	–	1.182	–0.840**
				(3.319)	(0.276)
Monetary policy rule i_t	β_{10}	3.886**	–2.443**	–5.888*	–5.212**
		(0.680)	(0.340)	(3.550)	(2.176)
	$\beta_{11} E_t \pi_{t+1}$	0.525**	0.679**	1.516*	1.402**
		(0.127)	(0.054)	(0.836)	(0.257)
	$\beta_{12} y_{t-1}$	0.343**	0.265**	0.930	0.461**
		(0.122)	(0.040)	(0.654)	(0.063)
	$\beta_{13} i_{t-1}$	0.105	0.179**	–0.091	0.904**
		(0.115)	(0.040)	(0.420)	(0.043)
	$\beta_{14} e_{t-1}$	1.027	–1.193**	–2.674	–3.544
		(0.716)	(0.400)	(2.769)	(2.694)
	Dummy	–	–	4.889	5.347**
				(3.910)	(1.436)
Fiscal policy rule G_t	$\beta_{15} g_{t-1}$	0.718	0.339*	1.218	1.027*
		(0.504)	(0.107)	(1.443)	(0.080)
	$\beta_{16} y_{t-1}$	–0.003	–0.140**	0.027	–0.032
		(0.120)	(0.023)	(0.189)	(0.003)
	$\beta_{17} div_{t-1}$	0.009	–0.045*	0.037	0.003
		(0.062)	(0.027)	(0.103)	(0.003)
	Dummy	–	–	–0.438	0.906**
				(1.366)	(0.256)
J-statistics		0.102	0.233	0.030	0.236

Note: statistical significance 5% (**); statistical significance 10% (*).

As for the analyses of the fiscal policy rule equation, the coefficient related to the lagged public spending, represented by primary PSBR (% GDP), is statistically significant in two systems, and with a positive sign. It means that, at least in this case, an inertial process in public spending might occur in Brazil. This can be an indication of some type of fiscal dominance in the Brazilian economy, as expenses are always being followed by higher expenses in the next period. As for the lagged public debt, it is only statistically significant at 10%, in one model (system 2). In the case of economic activity, measured by the lagged output, it is statistically significant, with a negative sign, in one model that did not include the dummy variable. This shows a countercyclical fiscal policy.

However, it must be emphasized that the variable "primary public sector borrowing needs" is a percentage ratio to GDP. This means that we can argue only that GDP growth is higher than the government's financing needs, but it is not possible to say that an effective reduction of public spending is occurring. Therefore, although there is indication of some coordination of economic policies in Brazil, the restriction imposed by the variable "primary public sector borrowing needs" makes it hard to say that fiscal policy is coordinated with monetary policy.

5.2. VAR estimation

As mentioned previously, we estimated a VAR system to account for possible cases of endogeneity. Based on the VAR results, we then ran generalized impulse response functions, as in Pesaran and Shin (1998), to circumvent the typical ordering problem found in this type of exercise. The variables used in the estimation were as follows: GDP expectations (*EXPPIB*), GDP (*PIB*), nominal interest rate (*SELICN*), primary public sector borrowing requirement (*NFSPPRI*), public sector net debt (*DLSP*), real exchange rate (*CAMBIOR*), real interest rate (*SELICR*), inflation (*INFLACAO*), wages (*MASSASAL*), and inflation expectations (*EXPCIPCA*). Based on Hannan-Quinn and Akaike information criteria, a model with four lags was chosen as the best one to be analyzed (table A2 in the online appendix).

Figure A1 in the online appendix reports the impulse response functions from the estimated VAR system. GDP expectations respond negatively to GDP, government spending, inflation and inflation expectations shocks, especially between the fourth and sixth quarters. As for GDP, it initially responds negatively to an interest rate shock, probably due to typical consumption reduction, as well as to inflation and inflation expectations. The same pattern can also be found in the case of a shock from government spending.

Innovations from GDP and GDP expectations cause movements in the nominal interest rate, indicating a concern of the monetary authorities with output gap. Inflation and inflation expectations shocks affect the nominal interest rate positively, indicating the central bank's concerns regarding inflationary processes. Exchange rate innovations also lead to nominal interest rate increases.

As for the government budget, measured by public sector borrowing needs, its response is negative to a shock caused by the Brazilian real interest rate and positive due to a public debt shock, at least in the beginning. On the other hand, public debt responds positively to a shock in government spending and to inflation and inflation expectations, at least towards the end of the response. Nominal interest rate shocks show that rising interest rates increase the cost of debt. Exchange rate responses are more pronounced to shocks coming from GDP expectations than to actual GDP. Shocks coming from inflation and inflation expectations also result in initial

exchange rate increases, indicating that inflationary processes lead to initial exchange rate increases. As for shocks to wages, they cause a negative response from the exchange rate and dissipate after six quarters. On the other hand, real interest rate responses seem to be less prominent than the others.

Inflation responses to shocks coming from GDP and GDP expectations have a declining trend, probably due to interest rate adjustments. The same pattern can be observed in responses coming from exchange rate and inflation expectations. In relation to wage responses to inflation and inflation expectations shocks, the trend seems to be positive. As for shocks from inflation and nominal interest rate, they result in an initial higher inflation expectation, but the effect becomes slightly negative. Innovations from wages have a negative influence on inflation expectations, but there is an upward trend from the fifth quarter on. Conversely, inflation expectations respond positively to a shock coming from the Brazilian real exchange rate, but dissipation starts after the sixth quarter. Finally, the effect of a GDP shock on inflation expectations is positive, with dissipation after the sixth quarter. A similar pattern is also found for shocks coming from GDP expectations, but the response dissipates only after the tenth quarter.

6. Conclusions

This article aimed to analyze how monetary and fiscal policies interacted in Brazil. For the period from the beginning of 2003 until the end of 2017, we were able to find some interesting results, which are relevant for the understanding of the Brazilian economy as an emerging market economy.

When we look at the demand side, we can see that the country's output depends on its past results, but also on the expected evolution of economic activity, besides real interest rate. The same pattern is detected on the supply side of the economy, once inflation is influenced by its own inertia, but also by how agents see prices in the future. Moreover, the behavior of the exchange rate proved to be important in the determination of inflation in Brazil, which poses a great challenge to policymaking in Brazil since external shocks can affect capital flows worldwide, including Brazil. Therefore, our estimations show how important it is to both output and inflation expectations in the models and also that the country's economy must have solid foundations in order to absorb external shocks and, at the same time, work with a flexible exchange rate.

But any economic decision made, in order to influence aggregate demand and supply, depends on how the central bank is able to be credible on its interest rate decisions. That is why it is important to analyze both a Taylor rule and a fiscal rule together and, again, as seen previously, inflation expectations play a significant role in monetary policy actions in Brazil, as well as economic activity. However, our fiscal policy rule shows no strong evidence of countercyclical fiscal policy in Brazil, indicating no signs of coordination with monetary policy.

This comes as no surprise, as part of this problem is because the Brazilian public budget is very rigid. A lot of public expenditures are related to the constitutional welfare state, for instance. But the other part of this lack of coordination is also very costly to the Brazilian economy. When monetary and fiscal policy officials do not take economic decisions in a coordinated way, the country and its population pay a high price. In fact, Brazil has been going through one of its greatest recessions ever, which was generated, at least partially, by a series

of fiscal policy decisions that had no connection to monetary policy actions. This cycle could have been much smoother if both economic policies were more coordinated. Therefore, the relevance of this article is to shed some light on this interaction discussion.

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