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Fiscal Variables and Monetary Policy in Brazil

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Abstract

This study analyzes the reaction function of the Central Bank of Brazil in setting the Selic rate, taking into account the influence of macroeconomic and fiscal variables between 2003 and 2024. To this end, we estimate different specifications of the Taylor Rule using the Generalized Method of Moments robust to heteroskedasticity and autocorrelation (GMM-HAC). We initially estimate the model with macroeconomic variables, including the lagged interest rate, the output gap, the real effective exchange rate, the deviation of inflation expectations from the target, and the commodity price index. Subsequently, we incorporate fiscal variables—namely, public debt (% of GDP) and the primary deficit (% of GDP)—to assess their impact on the conduct of monetary policy. The analysis covers the full sample and two distinct subperiods (2003–2013 and 2014–2024) for the Brazilian economy, allowing the identification of asymmetries in the monetary authority's response over time. The results indicate strong inertia in monetary policy, as evidenced by the coefficient of the lagged interest rate. The output gap proves relevant, especially during economic and fiscal stability periods. The deviation of inflation expectations from the target influences the interest rate, reinforcing the Central Bank of Brazil's commitment to the inflation-targeting regime. Among the fiscal variables, public debt is statistically significant, particularly when its trajectory is under control. In contrast, the primary deficit shows no short-term impact, suggesting an indirect effect through the increase in debt.

Keywords: Taylor rule, Central Bank of Brazil, Monetary policy, Interest rate, GMM-HAC

1. Introduction

The Selic rate (the Brazilian economy's benchmark interest rate) plays a key role in monetary policy and shaping the country's financial conditions. Since adopting the inflation-targeting regime in mid-1999, this rate has been widely used as a primary instrument for controlling inflation, anchoring expectations, and promoting economic stability.

Moreover, the Selic rate serves as a reference for interest rates throughout the economy, directly affecting the cost of credit in a given period. Accordingly, increasing its level tends to dampen aggregate demand by reducing investment to curb the general rise in prices of goods and services. Conversely, a reduction in this rate is expected to stimulate economic activity.

Given the significant influence of interest rates on the economy, the monetary authority should not focus solely on the inflation target when determining the Selic rate. As argued by Blanchard (2017), concentrating exclusively on the inflation target does not preclude the possibility of monetary policy playing an active role in reducing output fluctuations since achieving an inflation target aligned with expectations implies maintaining unemployment at its natural rate and, consequently, output at its potential level.

The literature offers extensive analysis of the macroeconomic variables that influence monetary policy decisions. One of the foundational contributions in this area is by Taylor (1993), who proposed that the reaction function of the U.S. monetary authority in setting the interest rate adjusts according to the deviation of inflation from its target and of actual output from its potential level.

Subsequent studies tested the empirical regularity of the Taylor Rule, with notable contributions from Clarida, Galí and Gertler (2000), who examined the rule not only for the United States but also for several European countries. Their approach employed rational expectations and forward-looking measures of inflation and output gaps. Svensson (1999) emphasized the importance of incorporating the exchange rate into the Taylor Rule in open economies that are subject to external shocks. Christiano, Eichenbaum, and Evans (1996) recommended including commodity prices as control variables in the estimation of monetary policy rules in economies with strong exposure to these sectors. Finally, Dornbusch (1998) and Pires (2008) highlighted the need to monitor the potential effects of fiscal variables on the dynamics of the interest rate and to assess whether the monetary authority responds to such indicators.

This study aims to estimate a monetary policy rule for the Brazilian economy by incorporating the main variables recommended in the literature, emphasizing the effects of fiscal indicators on the Brazilian interest rate. To that end, we employ monthly data from January 2003 to July 2024 and estimate the model using the Generalized Method of Moments, robust to heteroskedasticity and autocorrelation (GMM-HAC). We conduct robustness exercises using subsamples associated with different macroeconomic conditions in Brazil to identify possible asymmetries in the conduct of monetary policy. In this respect, the present study seeks to contribute to the existing literature by demonstrating that fiscal variables can influence the conduct of monetary policy, especially during periods of heightened economic instability, thereby enhancing our understanding of the interaction between fiscal and monetary policy in Brazil.

This study comprises four sections in addition to the introduction. The following section presents a literature review of the Taylor Rule. Section three outlines the methodological strategy. Next, the empirical results are presented and discussed. The final section offers concluding remarks.

2. Literature Review

In 1993, John Taylor published his work titled "Discretion versus Policy Rules in Practice," which sought to determine the reaction function of the U.S. central bank—the Federal Reserve System (FED). This function aimed to determine the nominal interest rate based on the sum of the interest rate considering full employment (the natural interest rate), the inflation accumulated over the past twelve months, the inflation gap (the difference between actual inflation and its target), and the output gap. Although the author did not estimate these parameters, his rule can be explicitly expressed as follows:

$$i_t = a_0 + a_1 i_{t-1} + a_2 \tilde{\pi} + a_3 \tilde{y}_t + \varepsilon_t \quad (1)$$

From the equation above, Taylor assumed that the natural interest rate (i_t) is constant over time, while the other variables are the lagged interest rate (i_{t-1}), the inflation gap $(\tilde{\pi})$ and the output gap $(\tilde{y}_t)$. In this way, Taylor employed a backward-looking formulation. It is important to note that the author acknowledged the relevance of the exchange rate for small, open economies. However, he omitted this variable, arguing that a more aggressive response to the exchange rate could impair the reaction to inflation and the output gap.

Clarida, Galí and Gertler (1998), in turn, proposed that the monetary authority's reaction function should capture future expectations about inflation and output. In this way, the authors incorporated rational expectations with a forward-looking view, as follows:

$$i_t^* = i^* + \beta\left(E\left[\pi_{t,k} \middle| \Omega_t\right] - \pi^*\right) + \gamma E[x_{t,q} | \Omega_t] \quad (2)$$

Where the variable i_t^* is the nominal interest rate for period *t*; i^* is the natural interest rate; E[.] is the expectation operator; $\pi_{t,k}$ is the percentage change in inflation between periods t and t+k; Ω_t represents the information available to the Central Bank at period *t*; and $x_{t,q}$ is the average of the output gap between periods *t* and *t*+*q*.

Based on this specification, the authors conducted the study in six countries, which were divided into two groups. Both groups were estimated using the GMM. The group formed by Germany, Japan, and the United States, which had an independent central bank, performed better from a forward-looking perspective. On the other hand, the group formed by the United Kingdom, Italy, and France, which had a central bank more dependent on the European Monetary System, showed better performance when the backward-looking perspective was used. The authors caution that a simple monetary policy rule model does not capture the tendency of central banks to smooth changes in interest rates. To account for this smoothing, they introduced gradual adjustment in the model, where the adjusted interest rate depends on the previous rate, reducing abrupt fluctuations. Their main findings in countries with independent central banks indicated that monetary authorities respond strongly to expected inflation and the output gap and seek to smooth changes in interest rates.

Christiano, Eichenbaum and Evans (1996) analyzed the effects of monetary shocks on the U.S. economy using a Vector Autoregressive (VAR) model. Initially, they estimated the response of macroeconomic variables, such as real GDP, inflation, the commodity price index, the federal funds rate, and bank reserves. Subsequently, they included employment and unemployment variables and, finally, fiscal and sectoral financing factors. To isolate the effects of monetary policy, they considered exogenous shocks to the short-term interest rate and unborrowed reserves. In their conclusions, they found that monetary shocks affect the economy in a delayed and heterogeneous manner. A contractionary shock significantly reduces GDP after two quarters, with prolonged effects. Inflation remains stable for one year before declining, while commodity prices fall rapidly. In the labor market, unemployment rises after two quarters and persists for years. Business debt initially increases before declining, indicating financial constraints. Households do not immediately adjust their debt, while the public sector reduces its debt initially but increases it as the recession progresses.

Dornbusch (1998) analyzes the relationship between public debt and monetary policy in the European and American contexts. Without resorting to an econometric model, he uses empirical evidence to examine the effects of debt on monetary stability, focusing on the German hyperinflation of the 1920s and the gradual liquidation of U.S. debt between 1950 and 1980. The study highlights that inflation can reduce the real value of debt, especially long-term debt, while for short-term debt, the impact depends on inflation predictability, potentially requiring a higher interest rate. The author argues that high levels of debt can constrain central banks from adopting more restrictive policies due to political costs, leading to tolerance of high inflation levels and potential loss of credibility. Furthermore, unemployment and public debt put pressure on expansionary policies, even with inflationary risks. It is concluded that debt indexing may encourage alignment between monetary and fiscal policy.

Svensson (1999) discusses the inflation-targeting regime within the context of monetary policy rules. The author distinguishes between instrument rules, which specify how monetary policy instruments should respond to economic variables, such as the Taylor Rule, and target rules, which set explicit goals that guide monetary policy, such as inflation targets. Although the author does not use a traditional econometric model, he employs a linear model with a quadratic loss function to demonstrate that target rules are more efficient than instrument rules, as this regime increases the predictability of monetary policy, reduces macroeconomic volatility, and enhances transparency with other economic agents. The author concludes in favor of a forward-looking monetary policy, specifically regarding inflation expectations and the output gap. Furthermore, he points out that monetary policy should not be rigid due to the need to stabilize the output gap, reinforcing the idea of a trade-off between price stability and economic activity stability and emphasizing the need for smoothing interest rates to avoid excessive volatility in the economy.

Mohanty & Klau (2004) analyzed the behavior of monetary policy in several emerging countries, including Brazil. For this study, in addition to the explanatory variables proposed by Taylor, they included the variation in the real exchange rate. The authors found a strong correlation between the nominal interest rate and the inflation rate in Brazil. On the other hand, they observed a small negative correlation between the nominal interest rate and the exchange rate. Finally, in most countries, including Brazil, the correlation between the nominal interest rate and the output gap was positive.

Another noteworthy study was conducted by Holland (2005). The author estimated, using the Generalized Method of Moments (GMM), the reaction function of the monetary authority by applying the forward-looking version of the Taylor Rule proposed by Clarida, Galí and Gertler (1998) for Brazil during the period from July 1999 to January 2005. In his study, the author used the IPCA as the measure of real inflation, the industrial production index to estimate the output gap using a linear trend, the Hodrick-Prescott (HP) filter, and the real exchange rate. Additionally, he employed a dummy variable for the energy crisis period from May 2001 to February 2002. His results pointed to a strong and statistically significant response to inflation. The coefficient of the output gap was negative and statistically significant, contrary to the expectation that the monetary authority would act to contain inflationary pressures from excess demand. However, the author suggests that this result may be explained by supply shocks, such as energy rationing, which raised inflation while reducing economic activity. Finally, it was found that the real exchange rate was not significant. However, when the nominal exchange rate was included in the model, it became statistically significant.

Gonçalves & Fenolio (2007), by estimating the reaction function of the Central Bank, sought to verify whether electoral cycles influenced Brazilian monetary policy between 2000 and 2006. In their work, the authors used electoral dummies to capture potential political manipulations in the interest rate. The method employed was GMM, which used quarterly data to allow for comparison with other countries. Subsequently, the same method was applied with monthly data to test the robustness of the results, with no significant variations in the estimates. According to the results obtained, the authors found no evidence that elections influenced monetary policy decisions in the country, suggesting that the Central Bank acted independently during the analyzed period. They also estimated the reaction function with both monthly and quarterly data using the OLS (Ordinary Least Squares) and GMM methods, free from electoral influences, considering that the Selic rate is a function of lagged interest rates, inflation expectations relative to the target, and changes in the nominal exchange rate. They found that all economic variables were statistically significant with positive coefficients.

Pires (2008) analyzed the relationship between monetary and fiscal policy in Brazil, focusing on public debt and its impact on the effectiveness of monetary policy. The analysis sought to verify how the indexation of public debt to short-term interest rates affects monetary policy. In his study, the author used the structural VAR and partially cointegrated VAR econometric methods, along with bootstrap techniques, to demonstrate that the high share of Treasury Financial Bills (LTF) in public debt reduces the wealth effect, diminishing the efficiency of monetary policy in controlling aggregate demand and inflation. The author concluded that an improvement in the relationship between fiscal and monetary policy, as well as more efficient management of public debt composition, could enhance the effectiveness of the monetary authority's interventions, mitigating the need for highly restrictive monetary policies.

Soares & Barbosa (2006) investigated the BCB's reaction function from 1999 to 2005. The authors found a strong response from the monetary authority to deviations in inflation expectations from the target when using the first-difference interest rate in both the short and long run. Furthermore, they observed that exchange rate fluctuations had statistical significance in the reaction function.

Moura & Carvalho (2010) used 16 specifications for the Taylor Rule in Brazil from 1999 to 2008 and found that the BCB tends to be forward-looking when setting the Selic rate in response to inflation deviations. They also observed a strong reaction from the monetary authority to deviations in inflation and the output gap when inflation is below target or when output is below its potential.

Medeiros (2014) aimed to verify the nonlinearity of the reaction function of BCB using the Inverse Quantile Regression method. The author observed that forward-looking variables prevail over backward-looking ones in determining the interest rate and that nonlinearity is present throughout the analyzed periods. To assess the presence of structural breaks in the reaction function, the author used the bootstrap method and concluded that there was a break in the linearity of the components of the Brazilian Taylor Rule with the change in the Central Bank presidency. Furthermore, the author found an increase in the Selic rate's response to the output gap and a reduction in the response to the current inflation gap during the presidency of Meirelles-Tombini, in addition to a reaction to the exchange rate.

Jesus & Lopes (2017) estimated a forward-looking Taylor Rule for 2003-2016 using data from the Brazilian economy, aiming to test whether the two main parameters of this rule changed between 2011 and 2016. The main results of the study suggest that i) the monetary policy rule followed by the Central Bank of Brazil (BCB) is not destabilizing; ii) during the Tombini era, the parameter for the output gap increased, and the parameter for the deviation of inflation expectations from the target decreased; iii) there is strong evidence that the BCB has taken exchange rate shocks into account in its reaction function.

Gurgel, Arruda and Ferreira (2023) investigated the existence of asymmetries in Brazilian monetary policy under different levels of trade openness. In his study, the author employed a nonlinear threshold Taylor Rule and found that, in scenarios of greater trade openness, the monetary authority’s response to inflation expectations is statistically insignificant, in contrast to scenarios of lower trade openness. Regarding the output gap, the study verified that the Brazilian monetary authority responds robustly under any degree of openness, although more aggressively in a relatively more closed economy.

Along the same lines, Mansilla, Arruda & Ferreira (2024) analyzed the occurrence of asymmetry in Brazilian monetary policy under different inflation levels. To this end, they used monthly data from 2003 to 2021 and a nonlinear Taylor Rule. The results indicated that, in a low-inflation environment, the effect of deviations in inflation expectations from the target is not statistically significant, revealing the monetary authority’s preference for price stability. Furthermore, the results point to a smoothing process in the conduct of monetary policy, with economic activity and the exchange rate being statistically insignificant in the Central Bank’s reaction function during the analyzed period.

Finally, Salomão Neto and Silva (2024) analyzed the coordination between monetary and fiscal policy under political and economic uncertainty in Brazil (2003–2022) using a system of simultaneous equations estimated via GMM. The results indicate both differences and similarities in Brazil’s economic dynamics depending on the degree of policy coordination and the presence of uncertainty. Without coordination, a monetary rule focused on current inflation prevails, disregarding expectations and the output gap. In other words, without fiscal support, the Central Bank reacts solely to inflation through economic activity. However, the macroeconomic anchor system performs better under coordination, allowing monetary policy to consider current and expected inflation. In addition, coordination provides greater flexibility for monetary policy to pursue a dual mandate. Nonetheless, higher public indebtedness leads to a structurally higher nominal interest rate.

As discussed, the reviewed literature provides important insights into monetary policy rules. This study contributes to the field by showing that fiscal variables may influence the conduct of monetary policy in Brazil, particularly during periods of heightened economic instability, thereby enhancing the understanding of the interaction between fiscal and monetary policy. Additionally, by incorporating fiscal variables into a robust dynamic framework (GMM-HAC) and exploring asymmetries in monetary policy through subsample analyses, this research offers a more comprehensive view of fiscal-monetary policy interaction in the Brazilian context.

3. Methodological Aspects

3.1 Descriptive Data Analysis

This study aims to analyze the conduct of Brazilian monetary policy under the inflation-targeting regime. To this end, we adopted a traditional specification of the Taylor Rule, which includes the following explanatory variables: the lagged interest rate (as an indicator of interest rate smoothing), the deviation of inflation expectations from the target, the output gap, the real exchange rate, and the change in the commodity price index. As fiscal variables, we included the primary deficit and the debt-to-GDP ratio. The analysis relies on monthly data from January 2003 to July 2024. Table 1 summarizes the variables employed in this study.

The interest rate used as the dependent variable in all models is the annualized monthly Selic rate since the Central Bank of Brazil (BCB) uses this instrument to keep inflation within the target range established by the National Monetary Council (CMN). To obtain the deviation of inflation expectations from the target, the analysis relies on the series of average 12-month-ahead inflation expectations, as calculated by the BCB, and the inflation target set by the CMN. The deviation is computed as the difference between these two indicators.

For the exchange rate variable, the variation in the real effective exchange rate indexed to the IPCA, as provided by the BCB, is employed. The model also includes the variation in the commodity price index published by the BCB, which reflects the weighted monthly average (in Brazilian reais) of the prices of commodities that are most relevant to Brazil's inflation dynamics. Regarding the output gap, the Central Bank's Economic Activity Index (IBC-Br) is used as a proxy for GDP. The output gap is obtained by applying the Hodrick-Prescott filter to extract the potential GDP from the IBC-Br series. The difference between the actual and potential values of the index represents the output gap. Lastly, the fiscal variables included in the model are the primary deficit and the debt-to-GDP ratio.

Table 1. Description of the Variables

Variable	**Proxy**	**Period**	**Data Source**
Interest Rate	Annualized SELIC rate	01/2003–07/2024	BCB
Output Gap	Difference between the IBC-Br and its trend generated by the HP filter	01/2003–07/2024	BCB
Deviation of Expectations.	Difference between the mean inflation rate (IPCA) for the ensuing 12 months and the inflation target.	01/2003–07/2024	Focus survey of the BCB/CMN.
Inflation	Official Inflation Index in Brazil - (IPCA)	01/2003–07/2024	BCB
Commodity Index	Variation of the Commodity Price Index	01/2003–07/2024	BCB
Real Effective Exchange Rate	Real effective exchange rate indexed by the IPCA	01/2003–07/2024	BCB
Primary Result (%GDP)	Primary Result in relation to GDP (%)	01/2003–07/2024	BCB
Debt (%GDP)	Net General Government Debt as a Percentage of GDP (%)	01/2003–07/2024	BCB

Source: Prepared by the authors.

3.2 Econometric Strategy: Generalized Method of Moments Robust (GMM-HAC)

We aim to analyze the Central Bank of Brazil (BCB) reaction function in setting the Selic rate, considering different specifications of the Taylor Rule. In such specifications, forward-looking variables—such as expected future inflation—may cause the explanatory variables to be correlated with the error term, thus giving rise to the problem of endogeneity.

Two widely used techniques for estimating models affected by endogeneity are the Generalized Method of Moments (GMM) and the Instrumental Variables (IV) approach. However, in heteroskedasticity, IV estimation may be inconsistent, making GMM the more appropriate method (Baum, Schaffer, and Stillman, 2003; 2007). The GMM estimator is based on the idea that the parameters of a model can be estimated using moment conditions, i.e., equations that relate the model variables to the unknown parameters in such a way that the residuals of these relationships are, on average, zero. The method addresses the endogeneity problem by using instrumental variables, which are correlated with the endogenous explanatory variable but uncorrelated with the error term. Additionally, when there is heteroskedasticity and/or autocorrelation in the residuals, its robust version, GMM-HAC, adjusts the variance-covariance matrix to ensure efficient and robust estimates against these issues.

In this regard, to evaluate the effects of fiscal variables on the monetary policy rule of the BCB, a benchmark version of the Taylor rule will first be used as follows:

$$Selic_t = \beta_0 + \beta_1 Selic_{t-1} + \beta_2 Gap_t + \beta_3 REER_t + \beta_4 COMM_t + \beta_4 DevExp_t + \varepsilon_t \quad (3)$$

where, $Selic_t$ is the interest rate at time t; $Selic_{t-1}$ is the lagged interest rate at time t-1; Gap_t is the output gap at time t; $REER_t$ is the real effective exchange rate at time t; $COMM_t$ is the commodity price index at time t; $DevExp_t$ is the inflation expectations deviation from the target at time t; ε_t is the error term.

Next, expanded versions of the benchmark model will be estimated, incorporating the fiscal variables proposed in the study, namely: government debt at time t ($DDGP_t$); the primary surplus/GDP at time t ($DPrim_t$), in addition to the full model with all variables, totaling 4 (four) models. The full specification of this version is shown below:

$$\begin{aligned} Selic_t = \beta_0 + \beta_1 Selic_{t-1} + \beta_2 Gap_t + \beta_3 REER_t + \beta_4 COMM_t + \beta_4 DevExp_t \\ + \beta_4 DGDP_t + \beta_4 DPrim_t + \varepsilon_t \end{aligned} \quad (4)$$

Therefore, to address potential correlations between the explanatory variables and the error term in the specifications, the GMM method will be applied. The orthogonality conditions in the GMM estimation for the four models can be represented by the equation below, where Z_t is the vector of instrumental variables:

$$E[Z_t' \varepsilon_t] = E[Z_t'(Selic_t - X_t \beta)] = 0 \quad (5)$$

Up to six lags of inflation measured by the IPCA and deviations of inflation expectations from the target will be used as instruments, following the approach of Gurgel, Arruda & Ferreira (2023) and Mansilla, Arruda & Ferreira (2024).

To verify the suitability of the GMM method compared to the Instrumental Variables (IV) method, the Pagan and Hall (1983) test will first be applied to detect the presence of heteroskedasticity. If this test rejects the null hypothesis of homoscedasticity, the GMM method will be considered more appropriate. Additionally, the Cumby and Huizinga (1992) test will be used to analyze the presence of autocorrelation in the residuals. If autocorrelation and heteroskedasticity are present, the robust GMM method for heteroskedasticity and autocorrelation (GMM-HAC) will be the most appropriate. Another relevant test for the proposed model is Hansen's (1982) overidentification test, or the J-test, which checks if the instruments used are orthogonal to the regression disturbance and simultaneously correlated with the endogenous regressors. If the null hypothesis of the J-test is not rejected, the GMM estimators will be consistent and asymptotically normal.

Finally, it is important to note that a stationarity test is necessary regardless of whether the IV or GMM method is used because the model will use time series data. For this purpose, the Augmented Dickey-Fuller (ADF) Test will be employed, which has the null hypothesis of a unit root, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, where the null hypothesis tests whether the series is stationary around a deterministic trend.

In summary, the stationarity of the series will first be analyzed using the ADF and KPSS tests. Then, the Pagan and Hall (1983) test will be applied in the IV estimation to detect heteroskedasticity. If heteroskedasticity is detected, instrumental variables (IV) will be discarded, and the focus will shift to the Generalized Method of Moments (GMM) to correct the issue. Finally, autocorrelation will be checked using the Cumby and Huizinga (1992) test. If both autocorrelation and heteroskedasticity are confirmed, the robust Generalized Method of Moments for both problems (GMM-HAC) will be applied. Finally, the J-test by Hansen will be performed, with the null hypothesis that the instruments are valid, to ensure the model is estimated correctly.

4. Results Analysis and Discussion

This section is dedicated to presenting the statistical and econometric analyses aimed at investigating the reaction function of the Central Bank of Brazil (BCB) in setting the interest rate according to the variation of the macroeconomic and fiscal variables considered in the study. As mentioned earlier, we initially conducted stationarity tests to verify the presence of a unit root in the different series. Subsequently, the results of the models were discussed for the full sample and for two distinct subsamples. The idea of using different subsamples was to observe any asymmetries in the conduct of economic policy in light of indications of distinct macroeconomic contexts in the Brazilian economy, as observed in Barbosa Filho (2017) and Mansilla, Arruda & Ferreira (2024). Therefore, for each of the samples (subsamples), the following specifications will be considered:

a) Benchmark: it will not consider the fiscal variables;

b) Debt/GDP: inclusion of the public debt (%GDP) variable in the benchmark model;

c) Primary Deficit: inclusion of the primary result (%GDP) variable in the benchmark model;

d) Full Model: inclusion of all regressors.

As instruments, we used up to six lags of the IPCA inflation and the deviations of inflation expectations from the target (Gurgel, Arruda, and Ferreira, 2023; Mansilla, Arruda, and Ferreira, 2024). To verify the validity of these instruments, we performed the Hansen J-test, where the null hypothesis states that the instruments are valid (uncorrelated with the residuals). Additionally, we conducted the Pagan-Hall test to detect the presence of heteroscedasticity in the model and the Cumby-Huizinga test to check for autocorrelation in the residuals.

4.1 Unit Root Test

The presence of a unit root in the series used in the model was analyzed using the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The ADF test has the null hypothesis of non-stationarity, while the KPSS test assumes the null hypothesis that the series is stationary. Table 2 presents the values of the test statistics and their critical values at certain significance levels.

Table 2. Results of the Unit Root Tests

VARIABLES	ADF	KPSS
Interest Rate	-3.44 [-2.88]$_{5\%}$	0.15 [0.21]$_{1\%}$
Output Gap	-10.28 [-2.88]$_{5\%}$	0.02 [0.14]$_{5\%}$
Real Effective Exchange Rate	-12.01 [-2.88]$_{5\%}$	0.06 [0.14]$_{5\%}$
Commodity Price Index	-12.82 [-2.88]$_{5\%}$	0.03 [0.14]$_{5\%}$
Deviation of Expectations	-5.33 [-2.88]$_{5\%}$	0.09 [0.14]$_{5\%}$
IPCA	-2.88 [-2.88]$_{5\%}$	0.09 [0.14]$_{5\%}$
Debt(%GDP) *	-11.80 [-2.88]$_{5\%}$	0.11 [0.14]$_{5\%}$
Primary Result	-10.74 [-2.88]$_{5\%}$	0.072 [0.14]$_{5\%}$

Source: Prepared by the author. * Unit root test was applied to the variation rate of debt (%GDP), as it presented a unit root at the level.

In general terms, both tests indicated the stationarity of most of the variables. Only the "Debt/GDP" variable showed signs of non-stationarity at the level, requiring transformation into a monthly variation rate to avoid spurious regression problems. Next, the GMM-HAC estimation of the monetary policy rules was carried out as previously outlined.

4.2 Analysis of the Full Sample

Table 3 presents the results of the models estimated for the entire period under analysis. The table highlights the values of the estimated coefficients and the associated p-values in brackets. Initially, it is observed that the Pagan-Hall and Cumby-Huizinga tests indicate the presence of heteroskedasticity and autocorrelation in the instrumental variables (IV) estimation, reinforcing the suitability of GMM-HAC in the employed specifications. Furthermore, the Hansen J-test showed that the instruments used in the GMM-HAC estimations were valid.

Initial analysis shows that the coefficients did not significantly change when fiscal variables were included in the different specifications. Therefore, as shown in Figure 1 below, we present the statistically significant variables and their coefficients from the full model.

The estimated coefficient of the lagged interest rate remains high in all specifications and is statistically significant at the 5% level. This indicates a significant degree of smoothing in monetary policy, suggesting caution by the authority when adjusting the Selic rate, as abrupt changes could adversely affect the market and, consequently, lead to a loss of credibility for the Central Bank.

The role of the Central Bank in stabilizing the economy can be observed in the output gap variable. Its positive coefficient reinforces that when the economy is operating above its potential, there is inflationary pressure, and in response, the Selic rate increases to contain this pressure. Moreover, the relationship between this variable and the interest rate is not sensitive to fiscal variables, as its coefficient remained stable across all specifications.

The results also show that the real effective exchange rate is statistically significant in all models but with small magnitude effects. One possible reason for this result is the adoption of a floating exchange rate regime, where the Central Bank does not intervene directly to stabilize the currency. Moreover, the monetary authority has other tools to influence the exchange rate, such as foreign exchange swap contracts. The commodity price index was also statistically equal to zero in all models used, considering a 5% significance level.

The deviation of inflation expectations from the target was statistically significant in all specifications. Moreover, its coefficients confirm that the monetary authority adjusts the Selic rate to align inflation expectations with the established target. This result is consistent with the inflation-targeting strategy, in which the Central Bank uses the interest rate as its main instrument to anchor economic agents' expectations.

The fiscal variable debt-to-GDP was statistically significant, and its positive coefficients indicate that the Central Bank follows a more restrictive monetary policy, reacting preemptively to contain macroeconomic deterioration. Furthermore, a higher debt-to-GDP ratio may increase the perceived risk of the economy, prompting the market to demand higher interest rates to keep government bonds attractive.

Finally, the primary deficit was not statistically significant. This suggests that, in the short term, the Central Bank does not directly respond to this variable when setting the Selic rate. However, this does not necessarily mean the variable is disregarded since its impact may manifest over time through its effect on the debt-to-GDP ratio.

Table 3. Results of the Model for the Full Sample

VARIABLES	Benchmark	Debt (%GDP)	Primary result (%GDP)	Full Model
Interest Rate $_{t-1}$	0.93* [0.00]	0.93* [0.00]	0.930* [0.00]	0.92* [0.00]
Output Gap	0.11* [0.00]	0.12* [0.00]	0.115* [0.00]	0.121* [0.00]
Real Effective Exchange Rate	0.003* [0.01]	0.003* [0.00]	0.002* [0.00]	0.003* [0.00]
Commodity Price Index	-0.03 [0.053]	-0.02 [0.12]	-0.032 [0.06]	-0.02 [0.12]
Deviation of Expectations	0.26* [0.00]	0.29* [0.00]	0.26* [0.00]	0.28* [0.00]
Debt(%GDP)	-	0.25* [0.005]	-	0.32* [0.00]
Primary Result (%GDP)	-		0.001 [0.92]	-0.21 [0.12]
Hansen Test	7.89 [0.72]	8.06 [0.70]	8.16 [0.69]	8.33 [0.68]
Pagan-Hall Test	37.11 [0.00]	39.80 [0.00]	37.33 [0.00]	40.66 [0.00]
Cumby-Huizinga Test	38.06 [0.00]	34.16 [0.00]	38.37 [0.00]	33.85 [0.00]

Source: Prepared by the authors. The Pagan-Hall and Cumby-Huizinga tests were applied to estimate instrumental variables. * Coefficients statistically significant at the 5% level.

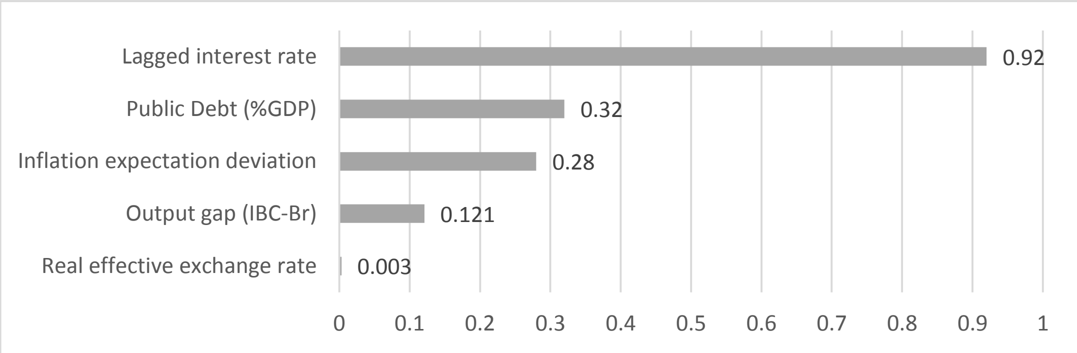

Figure 1. Complete sampling Coefficients (Full Model)

Source: Prepared by the authors.

4.3 Analysis of the Subperiods

The analysis of monetary policy behavior across two distinct periods in the sample is particularly relevant due to the structural changes in the Brazilian economy, which is in line with Barbosa Filho (2017) and Mansilla, Arruda & Ferreira (2024). Figure 2 illustrates the evolution of the debt (%GDP) throughout the sample period.

Figure 2. Percentage Evolution of the Debt/GDP

Source: Prepared by the authors.

During the first period (2003–2013), Brazil recorded several primary surpluses, which contributed to a decline in the debt-to-GDP ratio. Moreover, inflation remained within the target range for most of the time. The external environment also supported economic growth during this period, particularly due to the commodity boom, which led to increased inflows of foreign capital.

In contrast, the second period (2014–2024) was marked by a deep economic crisis, fiscal imbalance, and the COVID-19 pandemic. The year 2014 marked the beginning of rising inflation and the worsening of the fiscal crisis, which culminated in the 2015–2016 recession and the subsequent impeachment of the sitting president. After a period of fiscal adjustment and falling inflation, the rise in public spending due to the pandemic resulted in an increase in both the debt/GDP ratio and inflation.

For these reasons, splitting the sample into two subperiods allows us to assess whether the monetary authority's reaction function changed in response to the greater instability observed after 2014. To verify the robustness of the results, we employed the same instruments but used different numbers of lags across specifications. For the first period, two lags were used in the benchmark and Debt/GDP specifications, while four and three lags were used in the primary deficit and full models, respectively. For the second period, two lags were used in the benchmark model, and six lags were applied in the remaining specifications.

Similar to the full-sample analysis, the estimated coefficients—when statistically significant—did not change upon the inclusion of fiscal variables. Table 4 presents the estimated coefficients with their associated p-values in brackets, the Hansen J-test, and tests for heteroskedasticity and autocorrelation in the residuals. Table 4 below displays the statistically significant variables and their corresponding coefficients in the full model.

Table 4. Model Results in the Subsamples

VARIABLES	Benchmark		Debt (%GDP)		Primary Result (%GDP)		Full Model	
	1st subs.	2st subs.	1st subs.	2st subs.	1st subs.	2st subs.	1st subs.	2st subs.
Interest Rate$_{t-1}$	0.92* [0.00]	0.88* [0.00]	0.93* [0.00]	0.89* [0.00]	0.93* [0.00]	0.90* [0.00]	0.95* [0.00]	0.90* [0.00]
Output Gap	0.16* [0.00]	0.10* [0.00]	0.16* [0.00]	0.09* [0.00]	0.16* [0.00]	0.09* [0.00]	0.18* [0.00]	0.09* [0.00]
Real Effective Exchange Rate	0.001 [0.38]	0.003* [0.03]	0.004* [0.02]	0.002* [0.00]	0.001 [0.51]	0.002 [0.07]	0.004* [0.01]	0.003* [0.03]
Commodity Price Index	0.004 [0.90]	-0.04* [0.00]	-0.01 [0.55]	-0.03* [0.01]	-0.01 [0.78]	-0.03* [0.00]	-0.01 [0.93]	-0.03* [0.01]
Deviation of Expectations	0.22* [0.03]	0.45* [0.00]	0.09 [0.29]	0.42* [0.00]	0.21 [0.05]	0.40* [0.00]	0.131 [0.17]	0.43* [0.00]
Debt (%GDP)	-	-	0.61 [0.00]	0.22 [0.00]	-	-	0.747 [0.00]	0.23 [0.01]
Primary Result (%GDP)	-	-	-	-	0.05 [0.28]	0.014 [0.23]	0.004 [0.93]	-0.01 [0.90]
Hansen Test	1.15 [0.76]	4.62 [0.20]	3.06 [0.87]	7.71 [0.73]	1.19 [0.75]	7.97 [0.71]	1.53 [0.90]	7.95 [0.71]
Pagan-Hall Test	22.53 [0.00]	15.60 [0.04]	31.25 [0.00]	23.85 [0.12]	22.08 [0.00]	24.03 [0.11]	28.57 [0.00]	23.80 [0.16]
Cumby-Huizinga Test	18.54 [0.00]	27.56 [0.00]	14.50 [0.00]	25.27 [0.00]	18.72 [0.00]	28.54 [0.00]	15.68 [0.00]	25.24 [0.00]

Source: Prepared by the authors. The Pagan-Hall and Cumby-Huizinga tests were applied to estimate instrumental variables. * Statistically significant coefficients at the 5% level.

As shown in Table 4, the Pagan-Hall test did not reject the null hypothesis of homoskedasticity when fiscal variables were included in the specifications for the second period. However, the Cumby-Huizinga test indicates residual autocorrelation in the same period and specifications. Therefore, the use of GMM-HAC remains appropriate.

In both periods, the coefficient of the lagged interest rate was high and statistically significant, indicating strong inertia in the conduct of monetary policy. However, this coefficient was reduced between the two periods. The need for quicker adjustments in response to economic and fiscal instability during the second period may explain the larger changes in the interest rate.

The output gap was statistically significant in both periods, but its coefficient declined over time, indicating a reduced sensitivity of monetary policy to economic activity. In the first period, the monetary authority responded more strongly to fluctuations in the level of economic activity, as above-potential growth could lead to inflationary pressures. In the second period, however, the lower sensitivity of this variable suggests that inflation control became a higher priority than the business cycle.

This change in the magnitude of the monetary authority's responses can be seen in the variable capturing the deviation of inflation expectations from the target, which was statistically significant in most models and exhibited higher coefficients in the second period. This suggests that, during the second period, the monetary authority made more intensive use of the Selic rate to anchor inflation expectations, as the period was marked by high uncertainty and economic instability.

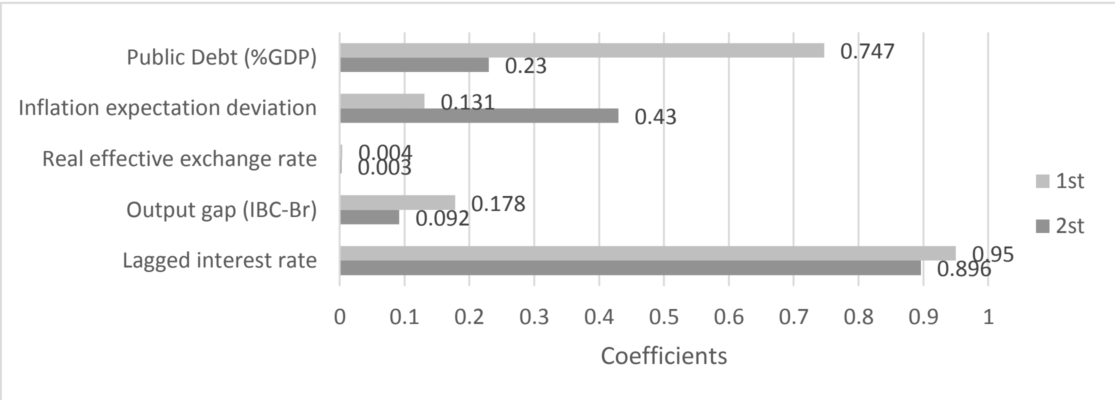

Figure 3. Subsample Coefficients (Full Model)

Source: Prepared by the authors.

The real effective exchange rate remained statistically robust in most models but continued to exhibit low-magnitude effects regardless of the macroeconomic context. The commodity price index was not statistically significant during the first period. However, in the second period, it became significant and had negative coefficients, indicating that increases in commodity prices reduced the need for interest rate hikes. This effect may be related to the positive impact of commodity booms on the trade balance and fiscal revenues, thereby easing inflationary pressure during a time of economic crisis.

The debt-to-GDP ratio was statistically significant across both periods. The coefficients were relatively smaller in the second period, suggesting a decrease in the sensitivity of monetary policy to public debt dynamics. This may reflect the predominance of other factors—particularly the anchoring of inflation expectations—in the decision-making process regarding the interest rate.

The primary deficit was not statistically significant in either period, suggesting that the Central Bank does not respond directly to this variable in the short term. However, this does not imply that the primary deficit is irrelevant in determining the interest rate, as its effects tend to be indirect and gradual, especially through their impact on public debt.

4.4 Discussion of the Results in Light of the Literature

The high coefficients associated with the lagged interest rate are consistent with the findings of Gonçalves & Fenolio (2007) for Brazil, who also highlight the gradual adjustment in the conduct of monetary policy. This reinforces the notion that the monetary authority adjusts the interest rate gradually to avoid abrupt changes and preserve macroeconomic stability. Similarly, Clarida, Gal í and Gertler (1998) observed a smoothing behavior in interest rate adjustments, particularly in countries with more independent Central Banks.

The positive and significant coefficients of the output gap align with the literature of Taylor (1993), Clarida, Galí, and Gertler (2000), and Mohanty & Klau (2004), indicating that monetary authorities respond to business cycle fluctuations by raising interest rates when the economy operates above its potential to contain inflationary pressures. However, Holland (2005) found a negative coefficient for this variable, suggesting that such a result may be explained by supply shocks, which tend to raise inflation while reducing economic activity. Svensson (1999) reinforces the notion of a trade-off between price stability and output stabilization.

The real effective exchange rate displayed low-magnitude coefficients, though statistically significant in most specifications. This result is consistent with findings by Medeiros (2014) for one of the periods analyzed by the author. Likewise, Mohanty & Klau (2004) reported a small negative correlation between the interest rate and the real exchange rate. In contrast, Holland (2005) found that the real exchange rate was not significant in his estimations, although the nominal exchange rate did show statistical significance. Soares & Barbosa (2006) also found significant effects associated with exchange rate fluctuations.

The commodity price index yielded mostly insignificant coefficients across the models and, when statistically significant, had a negligible effect. In contrast, Christiano, Eichenbaum, and Evans (1996) found this variable to be highly relevant in the U.S. economy. Their findings indicate that the commodity price index responds rapidly and persistently to contractionary monetary shocks, which may prompt the monetary authority to respond preemptively to commodity price changes in anticipation of inflationary pressures.

Regarding the deviation of inflation expectations from the target, the variable was statistically significant in nearly all models. This finding aligns with studies by Clarida, Gal í and Gertler (1998) and Svensson (1999), among others, which emphasize the importance of a forward-looking approach by the monetary authority to anchor inflation expectations.

As for the fiscal variables, the primary deficit was not statistically significant in any of the specifications. Nevertheless, Dornbusch (1998) argues that persistent fiscal deficits may pressure the monetary authority to adopt a monetary stance that accommodates debt financing. On the other hand, the public debt-to-GDP ratio was statistically significant in all models. Pires (2008) observes that monetary policy does react to public debt dynamics and argues that more efficient debt management could enhance the effectiveness of monetary interventions, reducing the need for excessively restrictive monetary policy.

5. Concluding Remarks

This study analyzed the reaction function of the Central Bank of Brazil in setting the Selic rate over the period 2003–2024, based on different specifications of the Taylor Rule estimated using GMM-HAC. The results allowed for the identification of changes in the conduct of monetary policy over time, reflecting structural shifts in the Brazilian economy and the distinct macroeconomic environments faced by the monetary authority, particularly after 2014.

The findings indicate that the interest rate exhibits high persistence in both periods, though its coefficient declined in the post-2014 period, suggesting a more assertive response by the Central Bank in the context of increased macroeconomic instability. Moreover, the output gap proved more relevant during the relatively stable period of 2003 to 2013. In contrast, during times of greater uncertainty—such as the post-2014 period—there is evidence that monetary policy placed greater emphasis on anchoring inflation expectations rather than responding to the business cycle.

The low coefficient associated with the real effective exchange rate suggests that this variable is not a key determinant in the Central Bank’s reaction function. In some cases, it was not statistically significant. In turn, the commodity price index was statistically significant only during the more unstable period, indicating that shocks to this variable may be more relevant in fiscally and economically challenging environments. Among the fiscal indicators, the public debt-to-GDP ratio was statistically significant, with declining coefficients in the second period. This suggests that the monetary authority began to assign greater importance to other factors, particularly the anchoring of inflation expectations. On the other hand, the primary deficit was not statistically significant in any specification, reinforcing the notion that monetary policy is more concerned with long-term debt sustainability than short-term fiscal outcomes.

In conclusion, the results contribute to a better understanding of the dynamics of monetary policy in Brazil. Splitting the sample into two distinct periods proved useful in assessing the behavior of the central bank during times of economic growth and fiscal crisis. Future research could explore the effects of institutional changes at the central bank, incorporate dummy variables for atypical events such as the COVID-19 pandemic, and consider nonlinear specifications of the Taylor Rule.

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