25 years of inflation targeting in Brazil: 3 failures rooted in fiscal fragility

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Abstract

Considering the theoretical principle that fiscal fragility can drive inflation beyond target levels (Araujo, Berriel, and Santos [2016]), we assessed the effectiveness of the five governors' administrations of the Brazilian Central Bank in minimizing inflation-output volatilities over the past 25 years, despite three episodes of inflation overshooting in Brazil (Figure VIII). We concluded that all administrations were effective. This finding contrasts with literature criticizing the monetary policy between 2011 and 2016 as excessively dovish. Instead, our results suggest that it is unreasonable to blame the Central Bank of Brazil for any of the missed targets.

Keywords: Monetary Policy, DSGE, Taylor rule

JEL Classification: E17, E52, E58

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1 Introduction

The observed outcomes of 25 years of inflation targeting in Brazil are summarized in Figure VIII. Three distinct episodes where actual inflation deviates from the target can be observed. A common trend in all these episodes is the expectation of high public expenditures despite a high level of public debt. In the first episode, after several attempts, a left-wing party inaugurated its first term in the federal government by winning the elections with a populist discourse promising a significant increase in public expenditures. In the second episode, the then-president was impeached for excessive fiscal spending beyond what was allowed by the fiscal responsibility law. In the third episode, public spending increased substantially due to COVID-related aid.

Although fiscal fragility is a common factor and an obvious candidate as a trigger for the crisis of confidence in the local currency, some economists interpret the second episode as being more due to a lenient central bank that failed to act appropriately, rather than excessive public spending.

In this paper, we carefully analyze this second episode and conclude that it is not reasonable to attribute the coordination failure of expectations around the inflation target to monetary policy.

1.1 DSGE for policy analysis

Sims and Zha [2006] claimed that monetary policy and its history are complex, and that the abstract theoretical models we use to organize our thoughts about them can obscure what was really happening. Yet, we must continue evaluating central bankers by formally combining theory and data to improve data interpretation and, ultimately, monetary policy prescriptions. In this paper, we provide a method based on an estimated DSGE model to assess the past performance of the Brazilian Central Bank and the reasons behind the controversial monetary policy decisions of the 2011-2016 administration.

In fact, because estimated DSGE models are theoretically founded and have consistently delivered decent empirical outcomes worldwide, with reasonable data-fit, they have become key to appraising central bank decisions. As pointed out by Christiano and Trabandt [2018], "the enterprise of dynamic stochastic general equilibrium modeling is an organic process that involves the constant interaction of data and theory... we do know that DSGE models will remain central to how macroeconomists think about aggregate phenomena and policy. There is simply no credible alternative to policy analysis...".

Moreover, the integration of official DSGE models in policy-making has enabled central banks to communicate their decisions within a coherent narrative framework, thereby fostering consistent monetary policy decisions over time.

We utilize the Central Bank of Brazil's official DSGE model (SAMBA), as detailed in Castro, Gouvea, Minella, Santos, and Sobrinho [2015], to assess Brazilian monetary policy decisions over the past 25 years. SAMBA captures the cross-correlation between output and inflation within a structural equation framework, serving as a proxy for the Brazilian monetary authority's perspective and reactions.[1]

1.2 The Taylor rule to assess monetary policy decisions

DSGE models commonly adopted by central banks, including SAMBA, assume that policymakers consistently adhere to predefined fiscal and monetary policy rules. This convenient hypothesis ensures that the model's results describe how economic aggregates fluctuate around the steady-state in the short term, while also guaranteeing the convergence of both debt and inflation to their long-term equilibrium values.

Policy rules are a realistic approach for the Brazilian economy, where the fiscal authority sets an annual target for the primary surplus of the non-financial public sector as a proportion of GDP, and the monetary authority aims to achieve a predefined inflation target. From an academic perspective, policy rules are also well accepted. First, they are considered superior

[1]Actually, research papers have been using SAMBA to address Brazilian macroeconomic facts as in Fernández, González, and Rodríguez [2018], Cavalcanti, Vereda, de B. Doctors, Lima, and Maynard [2018], Buffie, Airaudo, and Zanna [2018],Palma and Portugal [2014], Gonçalves, Portugal, and da Silva Bejarano Aragón [2016]

to discretion[2]. Second, numerous empirical studies advocate that policy rules are adequate tools for managing optimal policy decisions[3].

In this article, we evaluate the efficiency of past monetary policy decisions by examining whether these decisions, assessed using an estimated Taylor rule, minimized the volatility of inflation and output[4]. We considered alternative parameterizations of the Taylor rule for each governor's administration. If certain administrations failed in minimizing the volatility their decisions cannot be considered to have followed an efficient monetary policy.

We present results for the 25 years of Inflation Targeting in Brazil, considering both the traditional Taylor Rule, which exactly matches the rule specified in the SAMBA model, and a modified version.

The traditional Taylor rule primarily focuses on GDP growth and inflation. However, Araujo et al. [2016] suggest that monetary authorities should also consider public debt in their decision-making process. Excessive public debt levels can lead to coordination issues and inflationary pressures if investors anticipate that higher inflation is needed to finance deficits. In such scenarios, a cautious monetary policy, rather than a hawkish one, is recommended to improve welfare. In other words, while GDP and inflation provide snapshots of economic activity and price stability, they do not fully capture overall economic health. Public debt is a critical fiscal component, and its inclusion in central bank considerations offers a more comprehensive view. By accounting for public debt and fiscal fragility, central banks can better fine-tune interest rate decisions, choosing either a faster or slower convergence to the inflation target.

Therefore, we also present results using an extended Taylor rule, where the public debt-to-GDP ratio influences the interest rate. Our estimations suggest that the interest rate tends to be negatively correlated with the public debt level, without altering the central bank's response elasticity to either inflation or the output gap.

[2] Kydland and Prescott [1977]

[3] Di Bartolomeo, Di Pietro, and Giannini [2016], Steve Ambler and Rebei [2004], Kollmann [2002], Heresi [2023], Stephanie Schmitt-Grohé [2006]

[4] Efficient frontier is numerically constructed simulating all Samba's schocks and considering all possible parameters for a Taylor rule

1.3 Results and Literature

The assessment of monetary policy decisions can vary significantly across different economies and time periods. Sims and Zha [2006] combined theoretical priors with over 40 years of U.S. data, concluding that historical interest rate decisions likely followed a consistent and adequate policy rule over time. Smets and Wouters [2007] proposed a DSGE model that fits the main U.S. macroeconomic data well, incorporating a rich stochastic structure and various frictions. In their model, the central bank's response is described by a Taylor rule with fixed coefficients. Adolfson, Laséen, Lindé, and Villani [2007] applied a DSGE model to Europe, arguing that their estimated monetary policy rule provides an empirically plausible framework for analyzing Eurozone business cycles.

However, for emerging economies, it is generally challenging to find empirical evidence supporting a unique and stable monetary policy rule over time. Brazil is no exception to this trend.

Ferreira, Palma, and Hasegawa [2021] identified time-varying asymmetries in the preference parameters of the Central Bank of Brazil during the inflation targeting regime. They argued that the administration from 2011 to 2016 was notably lenient towards the inflation rate. Cortes and Paiva [2017] provided strong empirical evidence of the Brazilian central bank's shift towards a looser, more discretionary policy during the 2011-2016 administration. Both authors based their results and conclusions on monthly data, which is not the most suitable frequency for analyzing central bank policy.

Carvalho and Muinhos [2023] reached the same conclusion and noted that, since 2011, monetary policy has become significantly more dovish. During the period from 2011 to 2016, the estimated time-varying coefficient for a forward-looking Taylor rule was consistently below one. Although this work is based on quarterly data, the model's structure is extremely simplified, and several dummies were necessary to make adjustments, which may have biased the final results.

These three papers seem to have crystallized the monetary policy errors during the 2011-

2016 period. This article contributes to the discussion by offering an alternative explanation: misguided fiscal policy limited the central bank's ability to coordinate expectations. This diagnosis is crucial as it suggests that fiscal discipline, rather than a more hawkish central bank, is essential for controlling inflation.

Re-estimated results after extending the Taylor Rule did not change the conclusions. By including the debt, the estimated elasticity indicates caution in raising interest rates as the debt level increases.

The economic interpretation is straightforward: under higher public debt, central banks tend to be more cautious about the fiscal costs associated with interest rates. This behavior aligns with a more dovish stance than the SAMBA model with a traditional Taylor Rule recommends.

The macroeconomic outcomes observed during the 2011-2016 administration, especially towards the end, were costly and undesirable. This is well-known. However, this paper offers an alternative interpretation of the perceived "central bank failure." Was there an error by the central bank, or did its decisions reflect uncertainty about the fiscal authority's ability to adhere to the fiscal rule, and thus support the fiscal costs associated with increasing rates?

Our estimates suggest that over the 25 years of inflation targeting, the central bank acted appropriately, indicating that fiscal fragility was the cause of all three episodes where inflation expectations became unanchored.

2 Model

To evaluate the periods of monetary policy in Brazil, we employed the official DSGE model, SAMBA[5]. DSGE models have been the subject of research in several Central Banks, for example, Canada[6], Chile[7] and Sweden[8]. Since 2012, the Central Bank of Brazil has been using the

[5] Castro et al. [2015].
[6] Murchison and Rennison [2006]
[7] Medina and Soto [2007]
[8] L. Cristiano and Walentin [2007]

SAMBA model to generate macroeconomic forecasts across various scenarios, to decompose variables in historical periods based on estimated structural shocks of the model and other research.

The model combines standard features of DSGE models (such as price and wage rigidities as in Calvo [1983], habit persistence in consumption as in Boldrin, Christiano, and Fisher [2001], and capital adjustment costs) with other specific features of the Brazilian economy: financially constrained households; imported inputs as intermediate goods to produce differentiate varieties; external finance for imports; regulated prices as part of consumer prices; and an explicit target for the primary surplus.

In this small open economy model, there are several types of agents: households, domestic producers, importing firms and government. There are two types of households: optimizing households and rule-of-thumb households. Both have the same endowment of time (to allocated between labor and leisure) and supply differentiated labor services.

Optimizing households make decisions on consumption, saving, and investment in a forward-looking manner. They own the capital stock and all shares of the firms, and have access to financial markets through non-contingent one-period bonds issued locally or abroad. Rule-of-thumb households, on the other hand, are financially constrained and consume their entire labor income.

The production of sectoral goods in the SAMBA model occurs in three stages. In the first stage, there is a representative domestic input producer and importers. The domestic input producer operates in a perfectly competitive market and produces domestic inputs using capital and labor. Importers purchase differentiated inputs from abroad and resell them to an assembler of imported goods. This assembler transforms the differentiated goods into a homogeneous imported input, which is then sold to sectoral intermediate good producers: private consumption goods, government consumption goods, investment goods, and exports.

In the second stage, there is a continuum of intermediate goods producers for each sector. These producers operate with constant return-to-scale technologies that utilize bundles of capital and labor, as well as the imported input, to produce sectoral differentiated goods. This stage also requires financial services, potentially sourced from abroad.

In the third stage, sectoral assemblers transform the differentiated goods into the respective sectoral homogeneous goods.

The government is represented by fiscal and monetary authorities. The fiscal authority collects lump-sum taxes, makes transfers to firms, demands government consumption goods, and issues one-period domestic bonds. Spending decisions are subject to an empirical fiscal rule that targets the primary surplus-to-GDP ratio. The monetary authority sets the interest rate based on an empirical rule (a forward-looking Taylor rule) aimed at stabilizing inflation to its target and mitigating the output gap.

The model has a total of 23 shocks: domestic risk premium, investment adjustment, household preference, import adjustment cost, administered prices, price markup, inflation target, wage markup, transitory technology, permanent technology, uncovered interest parity, country risk premium, government consumption, tax rate, primary surplus target, monetary policy, foreign price markup, foreign inflation, foreign interest rate, world demand, imports relative price, foreign investors' risk aversion and world income demand. Also, the model has 118 parameters and 61 equations.

2.1 Estimation

We aimed to compare distinct periods of monetary policy in Brazil. Despite the CBB having been guided by similar objectives over the last decades, the idea of distinct monetary policy preferences within the same country has long been explored in the literature. For the US economy, Chappell, Havrilesky, and McGregor [1993] found that partisan influence could affect monetary policy-making. Chappell, Havrilesky, and McGregor [1995] studied the individual monetary policy preferences of the Federal Open Market Committee (FOMC) members. The authors were interested in the factors that may influence those preferences, such as professional and career backgrounds. Romer [2004] provided evidence that Federal Reserve chairmen are heterogeneous in their views of how macroeconomics works, which may affect their monetary policy decisions.

In our work, the monetary policy is represented by the Taylor Rule, following the SAMBA model. Consequently, we only estimated these parameters' equation in each subsample. We defined five subsamples, each one corresponding to a CBB governor's administration (see annex for more details). Given that our sample size is small, we chose a Bayesian method that uses prior distributions and few parameters to be estimated to make the estimation feasible.

Furthermore, note that besides the period being delimited according to the CBB governor, several members participate in the Brazilian Monetary Policy Committee (Copom). For this reason, it is not possible to attribute the decisions to only one member, not even the governor. Here, we used the governor solely to delimit the period.

We based on the original paper results to calibrate our model. All parameters were set to their correspondent values in the SAMBA[9] including the shocks' standard deviation. Starting from this calibration of the whole model, we estimated the Taylor Rule [10] in each sub sample, while keeping the structural parameters of the economy fixed.

As mentioned, the monetary policy is represented by:

$$r_t = \gamma_R r_{t-1} + (1-\gamma_R)\left[\bar{\pi}_t^C + \gamma_\Pi \, \mathbb{E}_t\left(\frac{1}{4}\pi_{t,t+4}^C - \frac{1}{4}\bar{\pi}_{t,t+4}^C\right) + \gamma_Y y_t\right] + z_t^R \tag{1}$$

where r_t is the nominal interest rate, $\bar{\pi}_t^C$ is the inflation target, $\pi_{t,t+4}^C$ is the four-quarter inflation rate, $\bar{\pi}_{t,t+4}^C$ is the four-quarter inflation target, y_t is the output gap, z_t^R is an exogenous monetary policy shock, and $(\gamma_R, \gamma_\Pi, \gamma_Y)$ are parameters. Note that this formulation captures the forward looking feature of monetary policy. Additionally, the inflation target in Brazil is set in June for the calendar year that starts one year and half later. Hence, the inflation target, $\bar{\pi}_{t,t+4}^C$, is known in t. Given this formulation, the preferences of each period is summarized by the estimations of $(\gamma_R, \gamma_\Pi, \gamma_Y)$.

The SAMBA model was originally estimated using Bayesian methods. This approach has the advantage of utilizing available information in the form of prior distributions of pa-

[9] We used the posterior distribution mean to calibrate each parameter.

[10] The parameters $\gamma_R, \gamma_\Pi, \gamma_Y$ were estimated given the fully calibrated model as a constraint.

rameters. These priors are updated with observed data and generate posterior distributions of parameters. Here, we employed the same method [11].

The variables used to estimate the preferences were:

1. y_t: log of Real GDP (seasonal adjusted) per capita
2. r_t: Selic interest rate (per quarter)
3. π_t^C: Quarterly growth of IPCA
4. $\bar{\pi}_t^C$: IPCA inflation target (per quarter)

All variables are trend-free. Seasonal adjustment was applied to inflation. The treated variables are presented in Figure II. For each period, we obtained the posterior distributions for the parameters $(\gamma_R, \gamma_\Pi, \gamma_Y)$. These results are shown in figure IV.

3 Counterfactual simulation

In this section, we present some results from counterfactual exercises for the third period. The observed preference for this period coincides with the preference estimated for this subsample. Through this estimation, we also obtained the shocks and initial values of the endogenous variables. Therefore, the counterfactual exercises involved replacing the observed preference with preferences from other periods to obtain the macroeconomic variables in an alternative scenario.

We compared the actual variables of the third period with the counterfactual scenario where the preferences defined by the Taylor Rule were the same as those in the fourth and second periods. In this simulation, we used the initial conditions of the economy at the beginning of the third period. To obtain the counterfactual results, the only changes made were to the estimated parameters in the Taylor Rule $(\gamma_R, \gamma_\Pi, \gamma_Y)$.

[11] Our estimations were conducted using MatLab and Dynare software. Further details can be found in Adjemian, Bastani, Juillard, Karamé, Maih, Mihoubi, Mutschler, Perendia, Pfeifer, Ratto, and Villemot [2011].

We estimated that inflation accumulated over 22 quarters would be 5.5% lower under the fourth preference compared to that observed in the third period. For growth, we would have -16.0% in total. In annualized terms, that translates to -1.0% and -2.8%, respectively. Therefore, we would have had lower inflation and reduced growth. The same statistics comparing the actual scenario with the 2nd preference would result in -0.8% and -2.1%, respectively, in annualized terms. This supports the findings to be presented in the next section, which suggest that the third administration is too dovish given the level of output volatility.

In the figure VI, we showed the last quarters of the 3rd period. The interest rate would have been higher if the fourth period's preference had been in effect at that time. The same would apply if it had been the second preference.

The inflation target for 2011 and 2014 would have been more comfortably achieved in the counterfactual exercise, especially in 2014 when it would have been at the center of the target, whereas actual inflation reached the upper bound of the target. However, by the end of 2015, even under the counterfactual preference, inflation would have been above the upper bound of the inflation target. Administered prices, notably for fuel and electricity, were significant contributors to high inflation at that time.

4 Evaluating Central Bank Responses

In this section, we asked whether the Central Bank has a general specification for preferences that includes the usual dual mandate.

Central Banks around the world have distinct goals and priorities. For example, the Brazilian Central Bank has as its "fundamental objective assure the price stability" and "with no loss for the fundamental objective" there are other goals as "stability and efficiency of the financial system, smooth the fluctuations in the economic activity level and foment employment full" (Government [2021]). The primary objective of European Central Bank is the price stability and "only support general economic policies without prejudice to the objective of price stability" (Michael Ioannidis and Zilioli [2021]). In the case of the US, the Fed is suppose "to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates" (see of Governors [2021]).

In our analysis, the Central Bank of Brazil problem is defined as:

$$min_{(\gamma_R, \gamma_\Pi, \gamma_Y)} \mathbb{E}\left\{L_t\right\} \tag{2}$$

where $\mathbb{E}$ denotes the unconditional expectation operator and L_t is the Loss function given by:

$$L_t = (1-\gamma)(\pi_t^C - \bar{\pi}_t^C)^2 + \gamma y_t^2 \tag{3}$$

and $\gamma \in [0,1]$ is the relative weight given to the output gap . Note that $\pi_t^C - \bar{\pi}_t^C$ and y_t have zero mean, since the inflation, π_t^C, should converge to the inflation target[12], $\bar{\pi}_t^C$, and y_t denotes the output gap (the deviation of output from its steady-state value). Hence the loss function is an average mean of variances. If $\gamma = 0$ the CBB only cares about inflation variance and if $\gamma = 1$, then it is only concerned with the output gap. The loss function value is smaller when the administration is more committed to the objective. Note that this formulation includes the dual mandate.

Moreover, we emphasize that our approach evaluates the CBB using the same model and parameterization they use to support monetary policy decisions. Therefore, each administration is expected to be efficient under this approach.

In figure VIII, we plotted the variance of the output (y_t) on the x-axis and the inflation variance ($\pi_t^C - \bar{\pi}_t^C$) on the y-axis. Starting with $\gamma = 0$, it is possible to find $(\gamma_R^*, \gamma_\Pi^*, \gamma_Y^*)$ that solves the problem 2 and the inflation and output variances related to them (see the annex). Proceeding with this method for a range of γ, such as $\{0, 5\%, 10\%, 15\%, ..., 100\%\}$, we obtained the solid line representing the optimal frontier. On the southeast corner, we have the point associated with $\gamma = 0$, featuring the largest variance for output and the smallest for inflation. In the northwest corner lies the point corresponding to $\gamma = 100\%$, exhibiting the maximum volatility for inflation and minimum for output. Points below the solid line

[12]Henceforth, we refer to the deviation of inflation from the inflation target as "inflation".

are unattainable within our model. The northeast direction increases both inflation and output variance. Therefore, these internal points could potentially be improved, meaning that inflation variance could be reduced given the output variance.

Note that the optimal frontier should be regarded as a reference for evaluating other points, and we consider points near it to be optimal in practice. To achieve this rigorously, we normalized both axes by the highest value on the frontier. This means that in Figure VIII, the value 1 on the x-axis represents the maximum variance of output on the optimal frontier (which occurs when γ=0), and similarly for the y-axis. Then, to consider two points statistically equal, they have to be close enough according to some metric. Since we normalized both axes, we adopted the rule of thumb of 5% as our confidence interval measure. Therefore, in this graph, we plotted each period as a circle with 5% diameter. We also plotted the upper bound (dashed line) at a distance from the frontier equal to the circle's radius. Hence, an administration is considered efficient when its representative circle touches the upper bound of the frontier, which means that it is not possible to reduce inflation variance given the output variance.

We also plotted each administration's preference on the graph. The first period is more concerned about output stabilization relative to the others. The second period is the most concerned with inflation stabilization. The third period (2011-2016 administration) is the only one not on the frontier, indicating it statistically has room for improvement.

Since our approach used the same model as the CBB, this decoupling in the third period was not expected. While the simplest explanation could be a CBB error, there are other reasons that may explain these results. As mentioned, the SAMBA model includes a fiscal authority that always adjusts the primary surplus to stabilize sovereign debt in the long term. This rule implies that the government does not consider the possibility of strategic default, nor do agents expect it to be possible. However, actual data revealed a public account turnaround in the third period, primarily represented by negative results in the primary surplus starting in 2014. We can see from graph (Figure IX) that the previous results were around 2.0% and this abrupt change could have influenced monetary policy management and expectations.

Moreover, the nominal exchange rate steadily devalued during most of the third period, as observed in Figure X. This period was comparable only to the first and fifth periods but had a higher peak than those periods[13]. The country risk premium exhibited a similar pattern.

In figure XI, we presented the Commodity Research Bureau Index (CRB). The third period is notable for its steady decline in commodity prices. Unlike the 1st, 2nd, and 5th periods, which experienced a recovery after sharp decreases, the third period did not show such a rebound.

Hence, the inefficiency observed in the third administration may result from the Central Bank evaluating variables not explicitly included in the SAMBA model. Since the model simplifies reality, even in a medium-sized model like SAMBA, it is reasonable to consider additional information beyond technical model prescriptions, especially amid increasing uncertainty that may indicate profound changes in the economic scenario.

With this background in mind, we consider an additional variable in the Taylor rule to estimate the Central Bank's reaction to economic uncertainty. In this case, uncertainty may influence interest rate decisions not only indirectly through inflation expectations and the output gap. We utilized the economic uncertainty index (from FGV-Ibre) plotted in Figure XII. This variable is computed and independently released by FGV.

After controlling for this effect in an extended Taylor rule, we obtained Figure XIII. Then, this approach presented an alternative interpretation for the 2011-2016 administration. This period is the one that suffered the most influence from (endogenous) economic uncertainty (and possibly from other variables as mentioned) that are not captured by SAMBA. This compelled the administration to consider these factors in their monetary policy decisions. This could be seen as the CBB recognizing that the model is inherently incomplete. Hence, all periods may be considered optimal (for some preferences) when comparing periods with the same level of economic uncertainty.

Furthermore, when we used the extended Taylor rule, the optimal behavior is character-

[13] An exchange rate devaluation was observed at the beginning of the period, but it quickly decelerated. As mentioned, the fiscal situation was much better at that time.

ized by higher weight on mitigating output volatility than in the regular Taylor rule. Figure XIV shows the sharpest GDP decline in each administration and the change in parameter estimate γ_Y between the regular Taylor rule and the extended Taylor Rule. For instance, the largest GDP decline on 12-month basis occurred during the third period, where γ_Y increased from 0.17 under the regular Taylor Rule to 0.33 under the extended Taylor Rule. Our interpretation is that the Central Bank aims to avoid recession by giving greater weight to the output gap during periods of uncertainty, i.e., being more cautious.

Note that our second interpretation does not rule out the inefficiency of the 2011-2016 administration. If the BCB governor had been removed from the position, there would have been technical pressure regarding interest rate responses (based on models). Hence, the increase in macroeconomic uncertainty during that period (considering the fiscal and political issues at the time) may explain a more dovish reaction. Therefore, our exercise does not absolve the administration; however, it opens the possibility for a second interpretation.

Table I: Add caption

Par	Só Taylor	SAMBA orig	Wholeperiod	3 Parametros					4 Parametros				
				BC_1	BC_2	BC_3	BC_4	BC_5	BC_1	BC_2	BC_3	BC_4	BC_5
γ_R	0.86	0.79	0.80	0.60	0.74	0.84	0.60	0.63	0.60	0.74	0.84	0.60	0.63
γ_Π	3.17	2.43	4.45	2.79	3.65	2.69	2.69	2.36	2.79	3.65	2.69	2.69	2.36
γ_Y	0.26	0.16	0.11	0.43	0.18	0.14	0.19	0.19	0.43	0.18	0.14	0.19	0.19
γ_B	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	-0.01	-0.02	-0.01	-0.02	-0.01

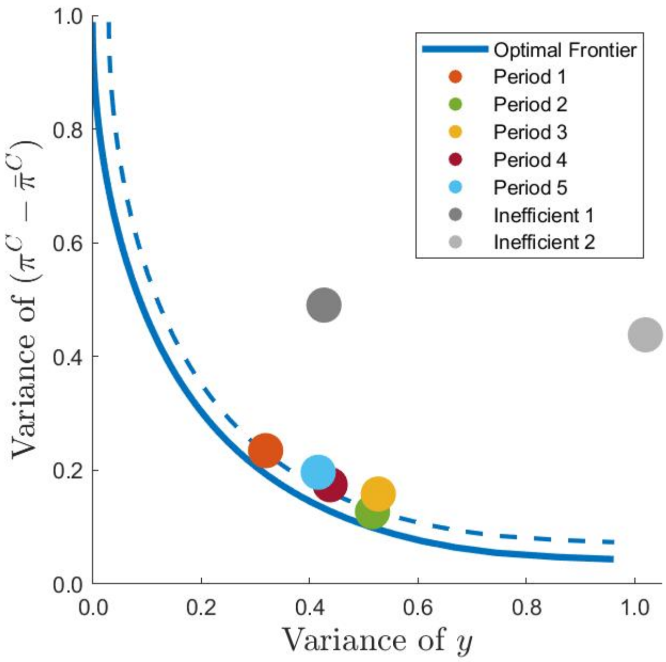

Figure I: SAMBA por periodo - 4 parametros

5 Remarks

We evaluated central bank decisions across five different administrations during Brazil's inflation targeting regime. We specifically challenge the diagnosis of the third period (2011-2016), which some authors describe as inefficient and neglectful of inflation.

Our estimations based on SAMBA suggest that central bank decisions were efficient across all five administrations, including the third period (2011-2016).

We believe it is important to incorporate fiscal fragility into the central bank's decision-making process. We extended the Taylor Rule to include the local public debt level. Our re-estimations indicate that interest rates tend to be lower when debt is high. These re-estimations suggest, again, that central bank decisions were efficient for at least some preferences in all five administrations.

Our paper indicates that it is a diagnostic error to blame the 2011-2016 administration for high inflation. The caution exercised by the central bank during that period was justified by fiscal fragility and adhered to the Taylor principle. Fiscal fragility contributed to higher inflation by weakening the ability to coordinate expectations. Correctly diagnosing past errors is essential for improving the economic policy framework over time.

References

Stéphane Adjemian, Houtan Bastani, Michel Juillard, Fréderic Karamé, Junior Maih, Ferhat Mihoubi, Willi Mutschler, George Perendia, Johannes Pfeifer, Marco Ratto, and Sébastien Villemot. Dynare: Reference manual version 4. Dynare Working Papers 1, CEPREMAP, 2011.

Malin Adolfson, Stefan Laséen, Jesper Lindé, and Mattias Villani. Bayesian estimation of an open economy dsge model with incomplete pass-through. *Journal of International Economics*, 72(2), 2007.

A. Araujo, T. Berriel, and R. Santos. Inflation targeting with imperfect information. *International Economic Review*, 57(1):257–270, 2016.

Michele Boldrin, Lawrence J. Christiano, and Jonas D. M. Fisher. Habit persistence, asset return and business cycle. *American Economic Review*, 91(1):149–166, 2001. doi: 10.1257/aer.91.1.149.

Edward F. Buffie, M. Airaudo, and Felipe Zanna. Inflation targeting and exchange rate management in less developed countries. *Journal of International Money and Finance*, 81:159–184, 2018.

G. Calvo. Staggered prices in a utility maximizing framework. *Journal of Monetary Economics*, 12:383–398, 1983.

Filipe Gropelli Carvalho and Marcelo Kfoury Muinhos. The central bank of brazil's time-varying taylor rule. *Revista Brasileira de Economia*, 77, 2023.

M. Castro, S. Gouvea, A. Minella, R. Santos, and N. Sobrinho. Samba: Stochastic analytical model with a bayesian approach. *Brazilian Review of Econometrics*, 35(2):103–170, 2015.

Marco A.F.H. Cavalcanti, Luciano Vereda, Rebeca de B. Doctors, Felipe C. Lima, and Lucas Maynard. The macroeconomic effects of monetary policy shocks under fiscal rules constrained by public debt sustainability. *Economic Modelling*, 71:184–201, 2018.

H.W. Chappell, T.M. Havrilesky, and R.R. McGregor. Partisan monetary policies: presidential influence through the power of appointment. *The Quarterly Journal of Economics*, 108(1): 185–218, 1993.

H.W. Chappell, T.M. Havrilesky, and R.R. McGregor. Policymakers, institutions, and central bank decisions. *Journal of Economics and Business*, 47(2):113–136, 1995.

Martin S. Eichenbaum Christiano, Lawrence J. and Mathias Trabandt. On dsge models. *Journal of Economic Perspectives*, 32(3):113–140, 2018.

Gustavo S. Cortes and Claudio A.C. Paiva. Deconstructing credibility: The breaking of monetary policy rules in brazil. *Journal of International Money and Finance*, 74:31–52, 2017.

Giovanni Di Bartolomeo, Marco Di Pietro, and Bianca. Giannini. Optimal monetary policy in a new keynesian model with heterogeneous expectations. *Journal of Economic Dynamics and Control*, pages 383–398, 2016.

Andrés Fernández, Andrés González, and Diego Rodríguez. Sharing a ride on the commodities roller coaster: Common factors in business cycles of emerging economies. *Journal of International Economics*, 111:99–121, 2018.

Diego Ferreira, Andreza Aparecida Palma, and Marcos Minoru Hasegawa. Time-varying monetary policy reaction function under asymmetric preferences: revisiting the brazilian inflation targeting experience. *Journal of Economic Studies*, 48(4):893–911, 2021.

Caio César Soares Gonçalves, Marcelo Savino Portugal, and Edilean Kleber da Silva Bejarano Aragón. Assessing brazilian macroeconomic dynamics using a markov-switching dsge model. *EconomiA*, 17(1):23–42, 2016.

Brazilian Government. Complementary law. http://www.planalto.gov.br/ccivil_03/leis/lcp/Lcp179.htm#:~:text=LEI%20COMPLEMENTAR%

20N%C2%BA%20179%2C%20DE%2024%20DE%20FEVEREIRO%20DE%202021&text=Define%20os%20objetivos%20do%20Banco,31%20de%20dezembro%20de%201964, 2021.

Daniela Villacreces Heresi, Rodrigo; Villacis. From macroeconomic stability to welfare: Optimizing fiscal rules in commodity-dependent economies. *IDB Working Paper Series*, 1511, 2023.

Robert Kollmann. Monetary policy rules in the open economy: Effects on welfare and business cycles. *Journal of Monetary Economics*, 49, 2002.

Finn E. Kydland and Edward C. Prescott. Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy*, 85(3):473–492, 1977.

M. Trabandt L. Cristiano and K. Walentin. Introducing financial frictions and unemployment into a small open economy model. Technical Report 214, Sveriges Riksbank, 2007.

J. Medina and C. Soto. The chilean business cycles through the lens of a stochastic general equilibrium model. *Central Bank of Chile Working Paper*, 2007.

Sarah Jane Hlásková Murphy Michael Ioannidis and Chiara Zilioli. The mandate of the ecb: Legal considerations in the ecb's monetary policy strategy review. *Occasional Paper Series*, 2021. doi: 10.2866/190802.

S. Murchison and A. Rennison. Totem: The bank of canada's new quarterly projection model. Technical Report 97, Bank of Canada, 2006.

Board of Governors. The fed explained: What the central bank does. *Federal Reserve System Publication*, 10, 2021. doi: 10.17016/0199-9729.11.

Andreza Aparecida Palma and Marcelo Savino Portugal. Preferences of the central bank of brazil under the inflation targeting regime: Estimation using a dsge model for a small open economy. *Journal of Policy Modeling*, 36(5):824–839, 2014.

D. H. Romer, C. D. ad Romer. Choosing the federal reserve chair: lessons from history. *Journal of Economic Perspectives*, 18(1):129–162, 2004.

Christopher A. Sims and Tao Zha. Were there regime switches in u.s. monetary policy? *American Economic Review*, 96(1):54–81, 2006.

Frank Smets and Rafael Wouters. Shocks and frictions in us business cycles: A bayesian dsge approach. *American Economic Review*, 97(3):586–606, 2007.

Martín Uribe Stephanie Schmitt-Grohé. Optimal simple and implementable monetary and fiscal rules: Expanded version. *NBER WORKING PAPER SERIES*, 12402, 2006.

Ali Dib Steve Ambler and Nooman Rebei. Optimal taylor rules in an estimated model of a small open economy. *Central Bank of Canada Working Paper*, 2004.

Appendix A Estimation

The periods for each administration by governor are as follows: Arminio Fraga (1999Q1-2002Q4), Henrique Meirelles (2003Q1-2010Q4), Alexandre Tombini (2011Q1-2016Q2), Ilan Goldfajn (2016Q3-2019Q1), Roberto Campos Neto (2019Q2-present at the time of this work). As administrations can change in the middle of a quarter, we attributed each quarter to the administration that spent the majority of its tenure at the Central Bank during that period. The observed variables are detrended using the sample mean, except for GDP, for which the Hodrick-Prescott (HP) filter trend was used as the estimate of potential GDP. Also, seasonal adjustment is applied to IPCA. Our quarterly data span from 2001Q4 to 2021Q4.

A.1 Observed variables

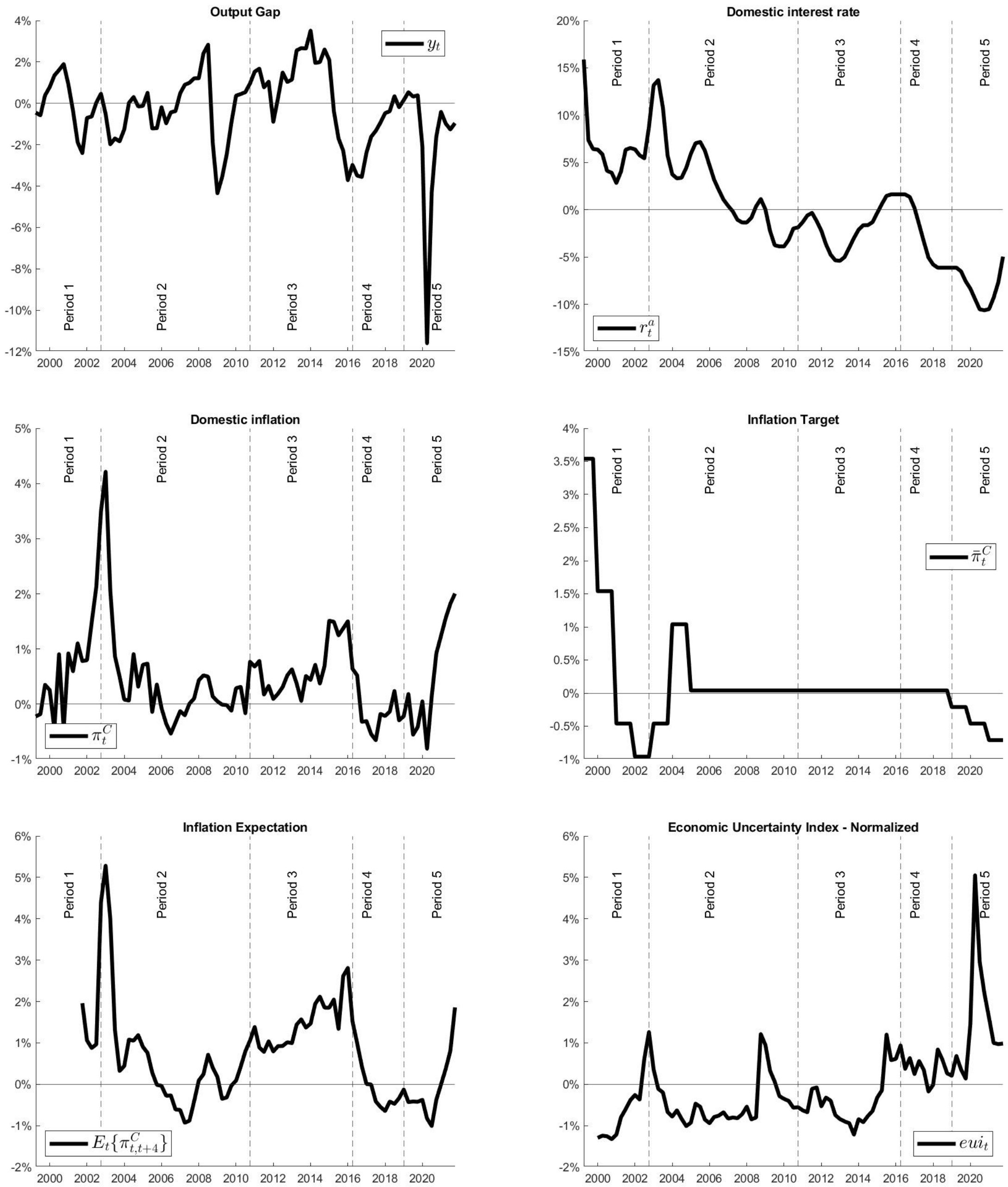

Figure II: Observed variables

Appendix B Priors

Parameter	Prior PDF	Mean	Std	Description
ρ_{eui}	beta	0.5	0.2	Autoregressive parameter of Economic Uncertainty
σ_{eui}	invgamma2	0.05	0.05	Std of Economic Uncertainty Shock
ρ_R	beta	0.5	0.2	Inertia in Taylor Rule
γ_Π	normal	2	0.5	Inflation Weight in Taylor Rule
γ_Y	beta	0.5	0.2	GDP Weight in Taylor Rule
γ_U	beta	0.5	0.2	Uncertainty Weight in Extended-Taylor Rule

The priors' distribution are based on Castro et al. [2015].

Appendix C Economic Uncertainty index

The economic uncertainty index calculated by FGV-IBRE is composed of two parts. The first part is the media uncertainty index, which is based on words related to uncertainty in the main Brazilian newspapers. This accounts for 80% of the total index weight. The second part is the dispersion expectations index, based on forecast dispersion (from Central Bank polls with financial institutions) for exchange rates, interest rates, and inflation, contributing 20% to the index.

Our observed variable is a normalized version of the original index, hence having a zero mean and a standard deviation equal to 1. In our model, it is modeled as an autoregressive process of order 1, AR(1): $eiu_t = \rho_{eui} eui_{t-1} + \varepsilon_t^{eui}$, where ε_t^{eui} is an exogenous shock. This variable is not in the original SAMBA paper, therefore we estimated its parameters over the entire sample (see the results in the next section).

Appendix D Estimation

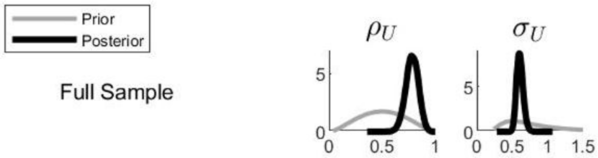

Figure III: Estimation of the Parameters of the Economic Uncertainty Equation

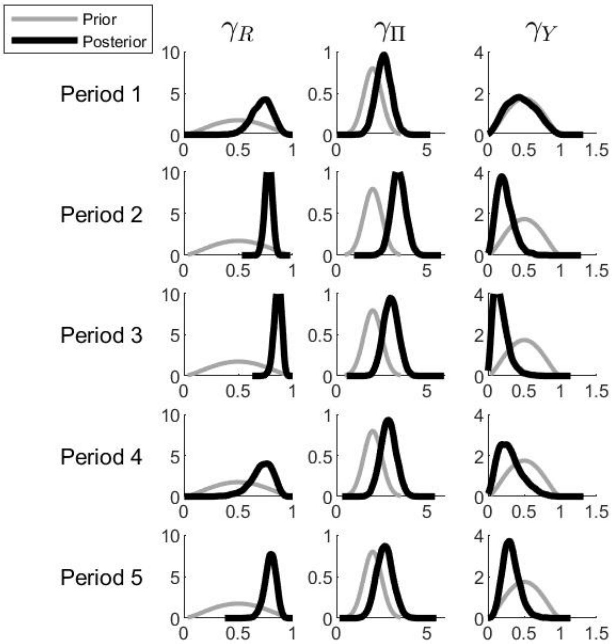

Figure IV: Estimation in sub-samples Taylor Rule

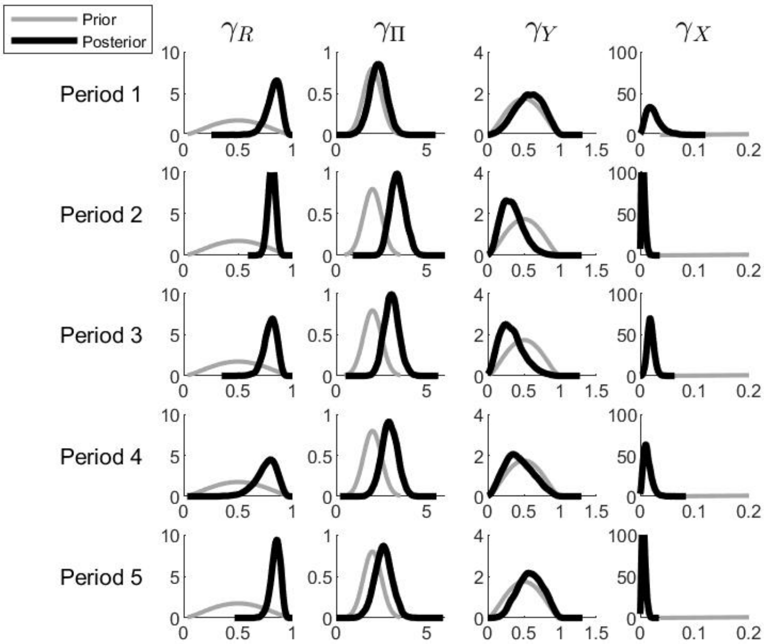

Figure V: Estimation in sub-samples Extended Taylor Rule

Appendix E Counterfactual Numerical Exercise

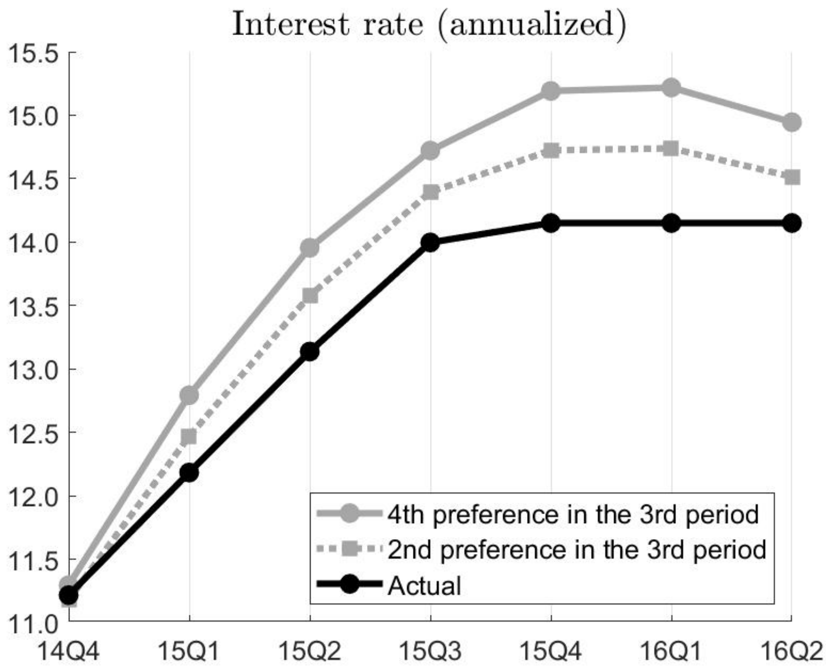

Figure VI: Counterfactual: Third period

Appendix F Evaluating Central Bank Responses

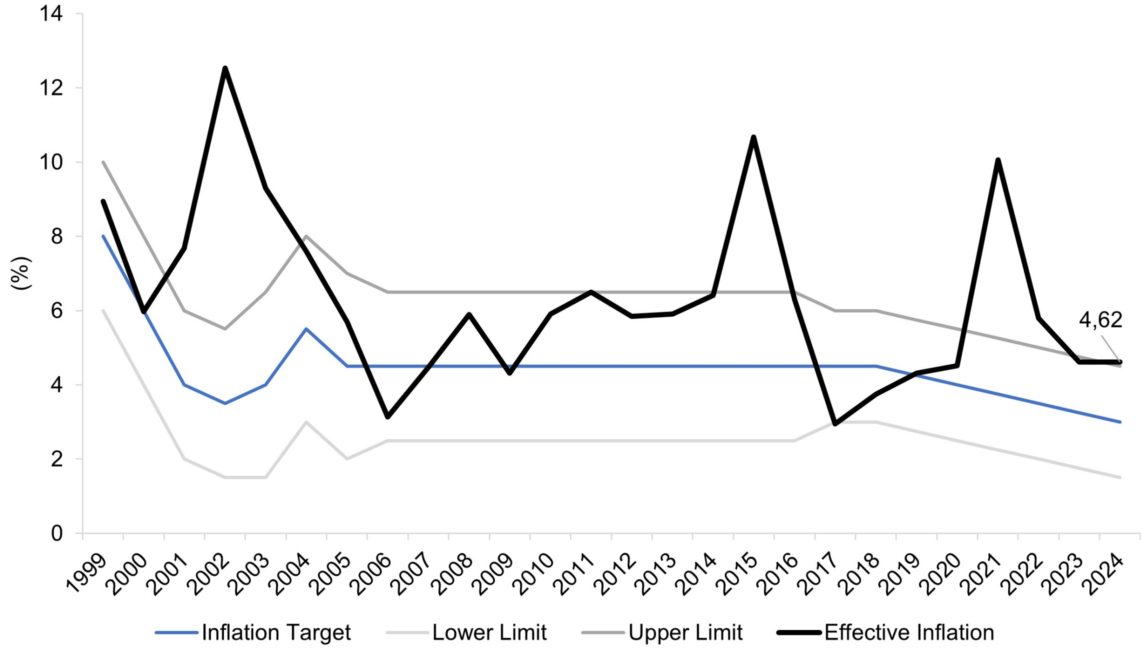

Figure VII: 25 Years of Inflation Targeting in Brazil

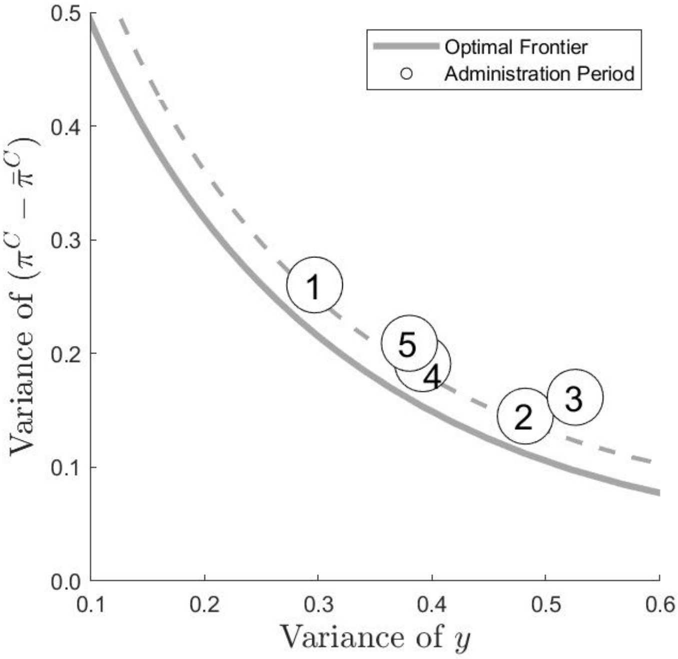

Figure VIII: Variance Frontier and CB Evaluation

For a given weight of output variance in the loss function,γ, it is possible to find the optimal preference $(\gamma_R, \gamma_\Pi, \gamma_Y)$ that minimizes 3, since it is a quadratic problem subject to a linear law of motion implied by the first-order conditions of the model. In a stochastic context, the first-order approximation solution of the model takes the form $x_t^h = Ax_{t-1}^h + Be_t$, where $x_t^h = x_t - x^s$ and x^s is the steady-state value of x_t, e_t are the exogenous shocks and A and B are matrices. The variance of x_t^h, V, is given by $V = AVA' + B\Sigma^e B'$, where Σ^e is the covariance matrix of e_t. Then, we can minimize the variance of variables in x_t^h over a wide range of the preference parameters $(\gamma_R, \gamma_\Pi, \gamma_Y)$. The solution is found numerically (see Adjemian et al. [2011] for more details).

Repeating this process for a range of γ ($\{0, 5\%, 10\%, ..., 100\%\}$), we identified the optimal frontier (solid line). The southeast point corresponds to $\gamma = 0\%$ where the planner only considers inflation variance. On the other hand, the northwest point corresponds to $\gamma = 100\%$, indicating exclusive emphasis on output gap variance. We normalized the x-axis to the maximum value of y_t variance on the frontier (when $\gamma = 0$) and similarly for the y-axis.

Each administration of the Central Bank is also represented in the graph. To achieve this, we computed the mean of the posterior distribution for each parameter in the Taylor Rule, such as $(\gamma_R^1, \gamma_\Pi^1, \gamma_Y^1)$ for the first period. Then, using these parameters in $V = AVA' + B\Sigma^e B'$, we can determine the matrix V and the variances of inflation and output. Therefore, this preference can be represented by a circle where the coordinates on the graph are the variances. The diameter of the circle corresponds to 5% to account for statistical uncertainty in point estimation. Once the optimal frontier is indeed subject to the same uncertainty, we plotted its upper bound (dashed line) in a distance equal to the radius of a circle. An administration whose circle intersects the upper bound is considered optimal.

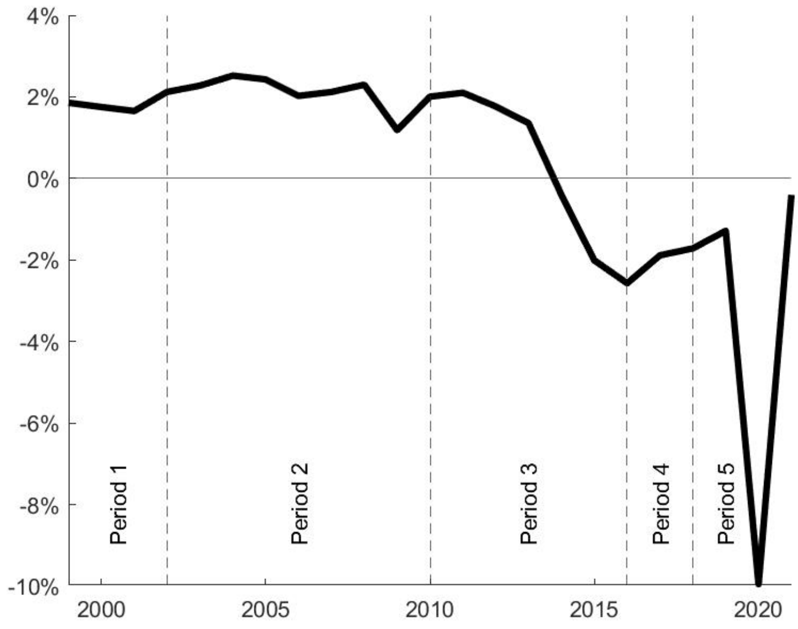

Figure IX: Primary Surplus

Central Government primary surplus

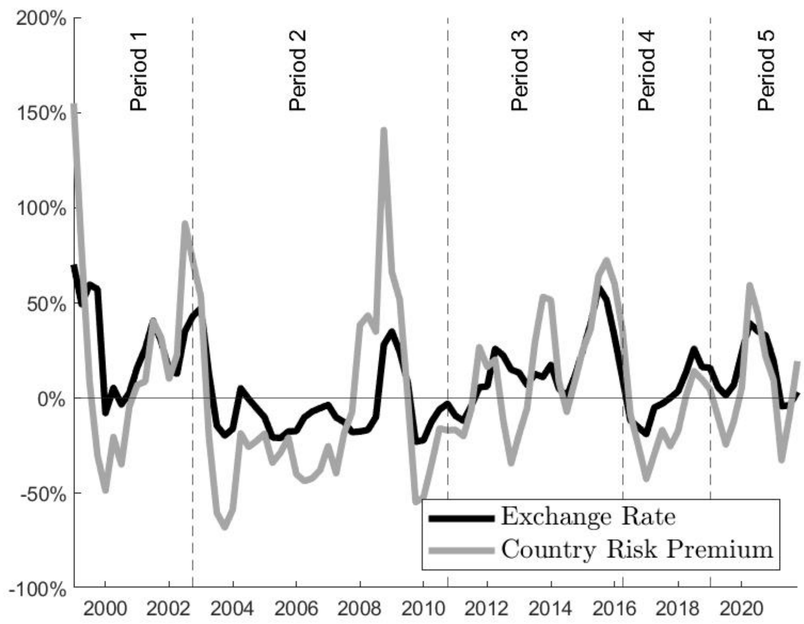

Figure X: Year-over-Year growth: Exchange Rate and Country Risk

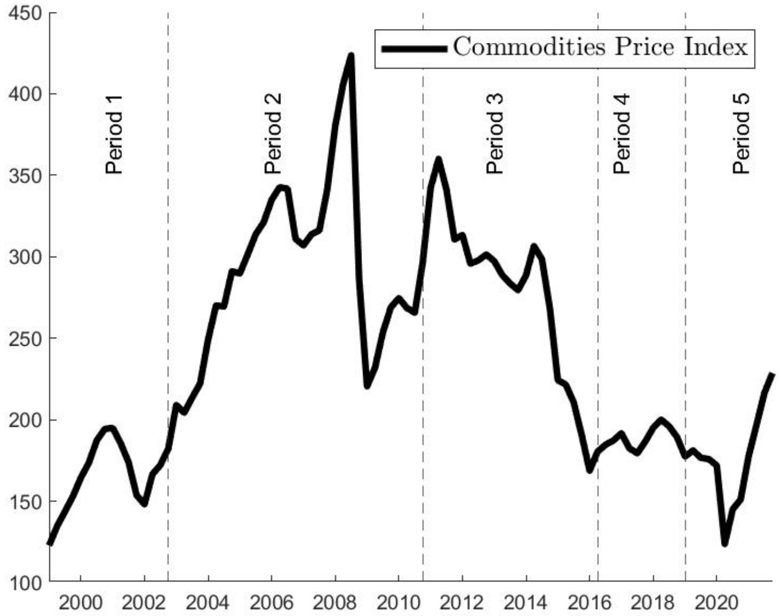

Figure XI: Commodities' price declining during third administration

Commodities Research Bureau (CRB).

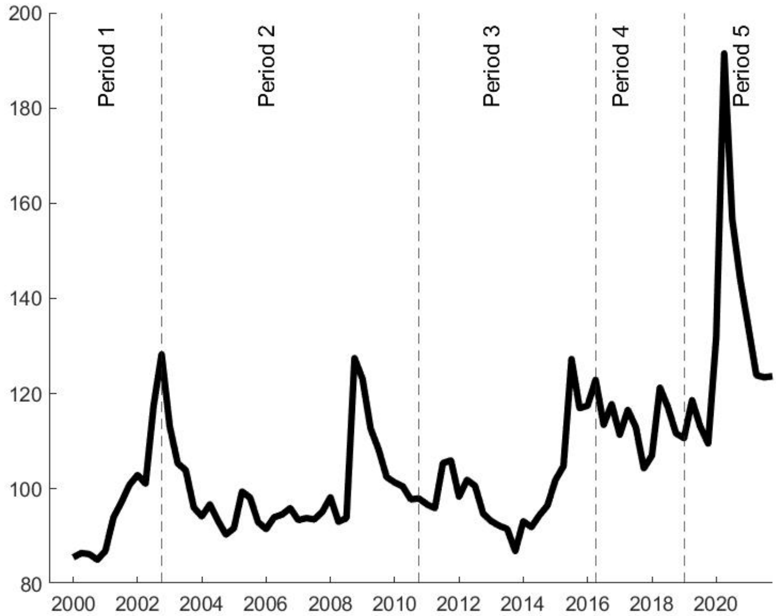

Figure XII: Economic Uncertainty Index - FGV-IBRE

To mitigate the effect of the economic uncertainty on the economy, we estimated an extended Taylor rule (γ_R,γ_Π,γ_Y,γ_U) for each sub sample:

$$r_t = \gamma_R r_{t-1} + (1-\gamma_R)\left[\bar{\pi}_t^C + \gamma_\Pi \,\mathbb{E}_t\left(\frac{1}{4}\pi_{t,t+4}^C - \frac{1}{4}\bar{\pi}_{t,t+4}^C\right) + \gamma_Y y_t + \gamma_U eui_t\right] + z_t^R \quad (4)$$

where eiu_t is the normalized economic uncertainty index.

Since our goal here is to make all periods comparable, we analyse the subsamples as if there is no influence of uncertainty. Therefore, to eliminate this effect, after estimate the equation 4 for each administration, we set $\gamma_U = 0$, keeping the other parameters fixed. Then, we plotted all subsample preferences on the same graph with the optimal frontier:

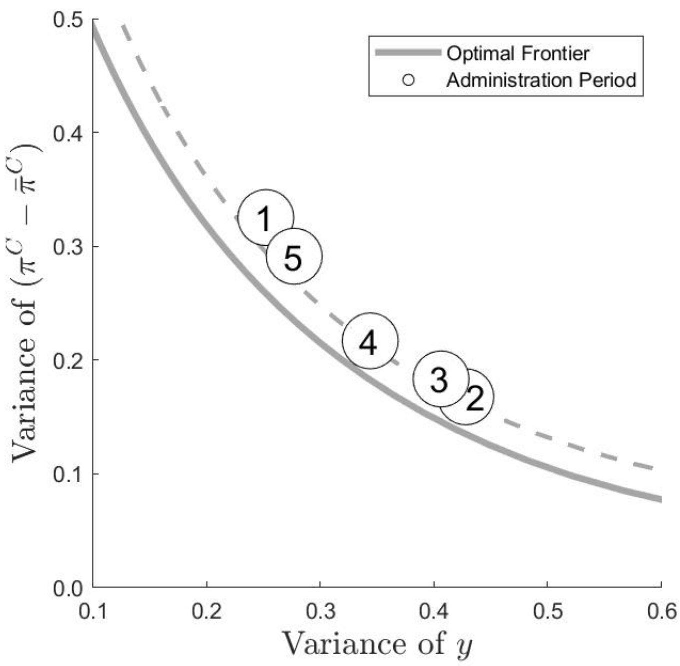

Figure XIII: Variance Frontier and CB Evaluation controlled by uncertainty

Using this new interpretation, we found that all periods can be considered efficient using the extended Taylor Rule.

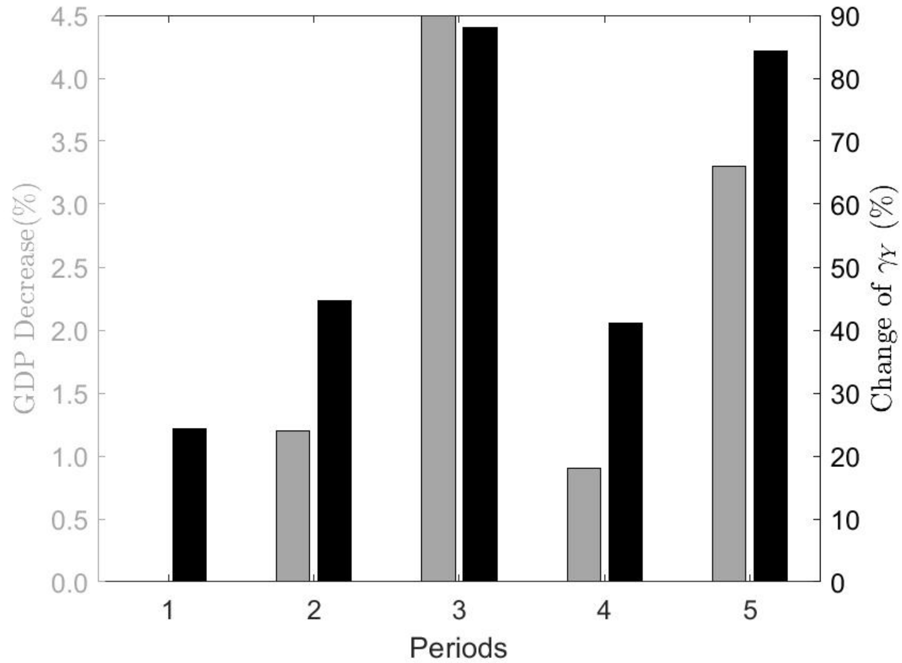

Figure XIV: Estimations' effects in the Extended Taylor Rule for each sub-sample

The left y-axis represents the most severe GDP decline in each subsample on a 12-month basis. Since a GDP drop at the end of one given period influences the 12-months growth of the next period, only data beyond the 3rd quarter of each period is considered. The right y-axis represents the percentage change of γ_Y in the extended Taylor Rule relative to the Taylor Rule. Note that GDP did not decrease in the first period according to this metric.