BOLETIM
ECONOMIA EMPÍRICA
v. 5, n. 2 (2025) | ISSN: 2675-3391

Taylor Rule in Brazil — A Comparison of Output Gaps

Adonias Evaristo[†]
[†]Autor correspondente: adoniasevaristo@hotmail.com

ARTICLE INFO

Keywords:
Interest rates
Taylor rule
Asymmetric information

ABSTRACT

This paper estimates Taylor rules using different measures of output gaps for Brazil. Monetary policy from 2003–2024 can be well described by a Taylor rule, with all output gap measures being statistically significant. There is no evidence of private information about economic activity from the monetary authority.

1. Introduction

This paper estimates Taylor rules for Brazil and compares different measures of output gaps. The main goal is to understand whether the Central Bank of Brazil (CBB) has been reacting to economic activity over the last 20 years. This is particularly important given that Law 179/2021, which granted autonomy to the Central Bank of Brazil, established the goal of smoothing the economic cycle and fostering employment as secondary goals, besides the primary role of price stability.

While the original Taylor rule (Taylor, 1993) is specified with interest rates responding to the deviations of inflation from its target and the output gap, most papers that estimate Taylor rules to understand interest-rate setting in Brazil use alternative measures of economic activity, mostly filtered measures of industrial production. These measures neglect that the Brazilian economy is predominantly based on services, and that agriculture, even though small relative to the size of GDP, is one of the most dynamic sectors, displaying increasing productivity over time.

In order to try to understand the role of economic activity in the determination of interest rates in Brazil, different measures of output gaps that are available for Brazil at the quarterly frequency are used: (i) the output gap provided by Instituição Fiscal Independente (IFI); (ii) the output gap computed by FGV; and (iii) the output gap released by the Central Bank of Brazil in their inflation reports. All these measures have become publicly available over the last years. They have the advantage of adhering to the original Taylor rule specification, and encompass all sectors of the economy.

The Central Bank of Brazil has been recently releasing its measure of output gap. This series allows researchers to investigate if the monetary authority has an information advantage, i.e., if it knows more than other players do about economic activity. The idea that central banks may have private information about the economy that is reflected in interest rate setting has been around since Romer and Romer (2000).

This paper is organized as follows. In addition to this introduction, Section 2 discusses the related literature. Section 3 introduces the model. Section 4 describes the data. Section 5 presents the results. Section 6 concludes.

2. Literature Review

There is a large literature about Taylor rules in Brazil, the majority of which uses industrial production as a measure of economic activity.

Salgado et al. (2005) estimate linear and non-linear (TAR — Threshold Autoregressive) models from 1994 to 2000. They use inflation, the output gap — measured by industrial production — and changes in international reserves as explanatory variables in their models. They find that the non-linear model fits the data better. Specifically regarding the output gap, it is statistically significant only during tranquil periods in non-linear specifications, while it is not statistically significant in the linear models.

Aragón and Portugal (2010) investigate asymmetries in the objectives of the Central Bank of Brazil and estimate nonlinear reaction functions. They use industrial output as a measure of economic activity. They find no evidence of a nonlinear response of interest rates to the output gap. Aragón and Medeiros (2015) estimate forward-looking reaction functions with time-varying parameters from 2000 to 2011. They use the industrial production gap as a measure of output gap and find a stable reaction of interest rates to this variable after 2003, and an increase in 2009 depending on the specification. Medeiros et al. (2016) investigate nonlinearities in the reaction function of the Central Bank of Brazil. In their models they use the industrial production gap as a measure of output gap. They find that the response of the Selic rate to this variable increased after 2003.

Barbosa et al. (2016) consider that the natural rate in an open economy is the sum of the international interest rate, the country risk premium and the exchange rate risk premium. They then estimate Taylor rules from 2003 to 2015 using measures of time-varying natural rates. As a measure of economic activity, they use the economic activity index of the

Central Bank of Brazil (IBC-Br). They find evidence of a lower response to inflation deviations and a larger response to the output gap after 2011.

More recent papers include Cortes and Paiva (2017), who use industrial production as a measure of output gap in Markov-Switching reaction functions and other models, focusing on the changes in monetary policy from 2011 onwards. Carvalho and Muinhos (2023) estimate time-varying parameter Taylor rules from Q2 2003 to Q3 2020. As a measure of output gap, they use the weighted average of the utility capacity gap and the employment rate gap.

From an international point of view, this paper is related to Smets (2002), who finds that greater uncertainty about the output gap is associated with a smaller response to the output gap in the Taylor rule. In other words, measurement error in the output gap reduces the optimal weight of the output gap in the Taylor rule, relative to a situation in which the output gap is known with certainty. For sufficiently large values of the standard deviation of the output gap, it could become optimal not to respond to it.

Earlier references in the study of reaction functions include Clarida et al. (1998, 2000), who researched the response of monetary authorities in developed countries, with the estimation of forward-looking Taylor rules and through the GMM method. Relatedly, Taylor (1999) performs a historical analysis of policy rules for the international gold standard, Bretton Woods and post-Bretton Woods eras, finding a larger response of interest rates to inflation for the period 1987–1997, associating it with greater macroeconomic stability.

3. Model

The following model is estimated:

$$i_t = \rho_1 i_{t-1} + \rho_2 i_{t-2} + (1 - \rho_1 - \rho_2)\left[i^* + \alpha(\pi^e - \pi^*) + \beta(y_t - y^*)\right] + \varepsilon_t \tag{1}$$

where i_t is the Selic rate at quarter t, i^* is the neutral interest rate, π^e is the 1-year ahead inflation expectations in quarter t, π^* is the inflation target, and $y_t - y^*$ is the output gap, defined as the difference between output at quarter t (y_t) and its potential level (y^*). The coefficients ρ_1 and ρ_2 give the degree of smoothing in interest-rate setting.

The Taylor rules were estimated using Non-Linear Ordinary Least Squares. Carvalho et al. (2021) show that, although there is endogeneity in estimating Taylor rules by OLS, the resulting bias is proportional to the fraction of the variance of the endogenous regressors explained by monetary policy shocks. Since these are small in standard DSGE models, their bias is small, resulting in a good performance of single-equation OLS estimation of Taylor rules[1].

4. Data

In order to be consistent with the output gap measures, the models are estimated at the quarterly frequency. The Selic rate comes from the SGS database of the Central Bank of Brazil (code 432) and then quarterly averages were taken. The series of inflation expectations and the inflation target were obtained as follows. Annual data of inflation expectations (originally at the daily frequency) and inflation targets were transformed into constant maturity series, and then quarterly averages were taken.

Data on inflation expectations is available since 2000. The output gap from FGV is available from 1970Q1[2], the one from IFI since 1996Q1[3], while the output gap from the Central Bank of Brazil is available since 2003Q2[4]. In order to use the same range across all specifications, the sample period used is 2003Q2–2024Q4, encompassing the inflation targeting regime. According to CODACE, there were four recessions in this period: 2003Q1–2003Q2, 2008Q4–2009Q1, 2014Q2–2016Q4 and 2020Q1–2020Q2.

The series used are displayed in Figure 1.

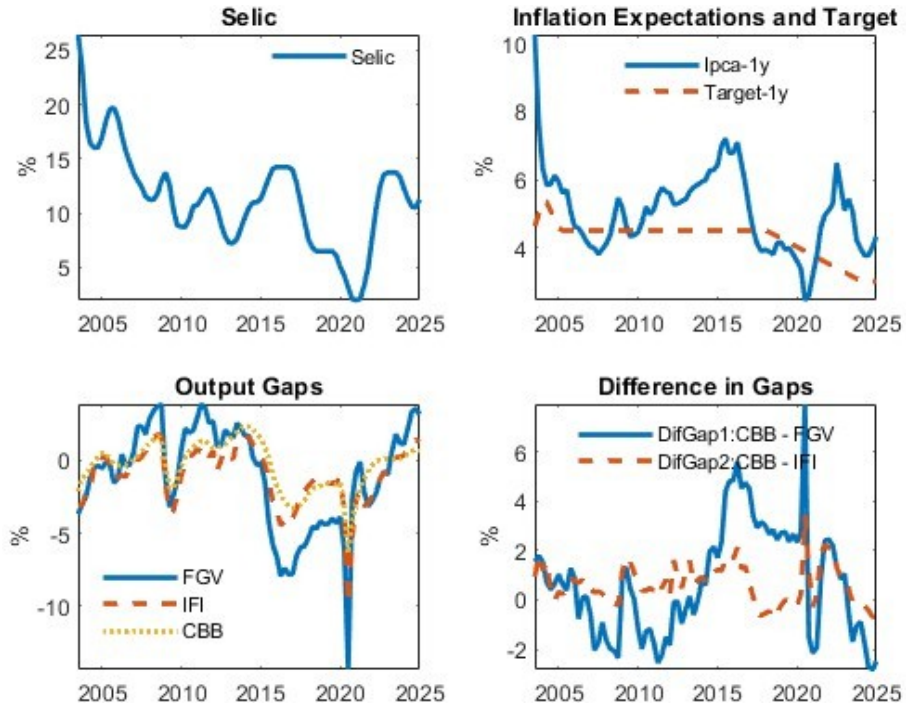
[1] They also show that using Generalized Methods of Moments (GMM) to estimate Taylor rules, using lagged endogenous variables as instruments, is complicated when the monetary shocks are persistent, because in this case the instruments and monetary shocks will be correlated, resulting in weak instruments. The bottom line is that the bias in using OLS is small, and that, while both methods lead to similar results, estimates by OLS imply model dynamics with higher precision than by single-equation GMM estimates (p. 15).

[2] The data was downloaded from: https://blogdoibre.fgv.br/posts/o-hiato-do-produto-continuou-positivo-no-4o-trimestre-de-2024

[3] The series was downloaded from: https://www12.senado.leg.br/ifi/dados/arquivos/estimativas-do-hiato-do-produto-ifi/view

[4] The series was downloaded from the Inflation Report of December 2024: https://www.bcb.gov.br/publicacoes/anexos-rpm?ano=2024

Figure 1. Data



Source: own elaboration.

In order to assess whether there is private information about the output gap, two additional variables were computed: $\text{difgap}_1 = \text{outputgap}_{cbb} - \text{outputgap}_{fgv}$ and $\text{difgap}_2 = \text{outputgap}_{cbb} - \text{outputgap}_{ifi}$. These variables were then included in the Taylor rule, replacing the output gap. The intuition is that if there is an information advantage about the output gap, these variables would be statistically significant in the Taylor rule. If the economy is more heated than what is given by the output gap of FGV and IFI, then $\text{difgap}_1 > 0$ and $\text{difgap}_2 > 0$. Likewise, if $\text{difgap}_1 < 0$ and $\text{difgap}_2 < 0$, there would be more slack in the economy according to the central bank measure. These variables are displayed in the last panel of Figure 1.

5. Results

Table 1 presents the estimations of the Taylor rule in Equation 1 for different measures of the output gap. The sample period runs from 2003Q2 to 2024Q4. The results show that monetary policy over this period can be well represented by a Taylor rule, with explanatory power of 98%. All measures of the output gap are statistically significant at the 1% level. The largest coefficient is given by the specification that uses the Central Bank of Brazil output gap as explanatory variable in column (3), with $\hat{\beta} = 1.43$. Curiously, in this specification the difference of inflation expectations from its target is not statistically significant, meaning that the Central Bank only reacts to economic activity.

For the specifications that use the FGV gap and the IFI gap, respectively (1) and (2), the coefficient on the inflation gap is close to 2, meaning that the Taylor principle was satisfied over this period. The smoothing degree, given by $\rho_1 + \rho_2 = 1.44 - 0.55 = 0.90$, is similar in all specifications. Finally, the equilibrium nominal rate is estimated to be close to 10% in all specifications.

Table 1. Estimation of the Taylor Rule

Variables	(1) FGV	(2) IFI	(3) CBB
i^*	9.57***	10.2***	9.97***
	(0.95)	(1.01)	(0.94)
ρ_1	1.44***	1.44***	1.45***
	(0.14)	(0.14)	(0.14)
ρ_2	-0.55***	-0.55***	-0.55***
	(0.14)	(0.14)	(0.14)
α	2.00*	1.90*	1.44
	(1.04)	(1.03)	(1.01)
β	0.50***	1.09***	1.43***
	(0.14)	(0.29)	(0.35)
Observations	87	87	87
R-squared	0.980	0.980	0.981

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Column 1 in Table 2 shows that difgap_1, given by the coefficient $\hat{\beta} = -0.52$, is statistically significant but with the wrong sign. In the specification in column 2, the variable difgap_2 is not statistically significant.

Table 2. Taylor Rules with the output gap difference

Variables	(1)	(2)
i^*	9.21***	9.33***
	(0.98)	(1.11)
ρ_1	1.44***	1.43***
	(0.14)	(0.14)
ρ_2	-0.55***	-0.54***
	(0.14)	(0.14)
α	2.26**	2.43**
	(1.07)	(1.06)
β (difgap)	-0.52**	-0.98
	(0.21)	(0.89)
Observations	87	87
R-squared	0.979	0.978

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To further understand if the different measures of output gap reflect an information advantage about the economy and if this reflects on interest-rate setting, Table 3 presents the results of the following regression:

$$\text{selic}_t = \text{constant} + \text{difgap}_i + \varepsilon_t, \qquad i = 1, 2 \tag{2}$$

The results show that the difference in output gaps is not statistically significant in both specifications. In the spirit of Romer and Romer (2000), taking together the results of Tables 2 and 3, there is no evidence of an information advantage about the output gap for the Central Bank of Brazil. Otherwise it would be expected that interest rates would rise and lower when difgap > 0 and difgap < 0, respectively.

Table 3. Regressions with Selic and the difference in output gaps

Variables	(1) Selic	(2) Selic
difgap_1	0.018	
	(0.21)	
difgap_2		0.58
		(0.73)
Constant	11.3***	11.0***
	(0.48)	(0.56)
Observations	87	87
R-squared	0.000	0.011

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Finally, Table 4 presents the results of the estimation of the Taylor rule in Equation 1 for different governors. It considers only the output gap from the Central Bank of Brazil. For the Meirelles chairmanship, the response to inflation is estimated at $\hat{\alpha} = 2.60$ and the response to the output gap at $\hat{\beta} = 3.92$. The former is statistically significant at the 10% level, while the latter is significant at the 5% level. For the Tombini chairmanship the response to the inflation gap is estimated at $\hat{\alpha} = 2.05$, which accords with the anecdotal evidence of a more dovish administration. The response to the output gap has the wrong sign and it is not statistically significant. For Goldfajn, there are only 11 quarters, so the evidence is not so strong. For the Roberto Campos Neto (RCN) chairmanship, the response to inflation is estimated at $\hat{\alpha} = 2.94$, statistically significant at the 5% level, the largest among the four administrations analyzed. The response to the output gap is estimated at $\hat{\beta} = 0.72$, but is not statistically significant.

The equilibrium nominal interest rate is estimated at $i^* = 11\%$ for the Meirelles administration. Under Tombini it is estimated at $i^* = 8\%$, while for the RCN administration it is estimated at $i^* = 7.26\%$. There is therefore evidence of a lower equilibrium interest rate over time.

Table 4. Taylor Rule for different governors

Variables	(1) Meirelles	(2) Tombini	(3) Goldfajn	(4) RCN
i^*	11.1***	8.01***	2.95	7.26***
	(1.30)	(2.01)	(2.52)	(1.41)
ρ_1	1.26***	1.60***	0.99***	1.33***
	(0.17)	(0.13)	(0.16)	(0.14)
ρ_2	-0.40**	-0.81***	-0.40*	-0.50***
	(0.17)	(0.13)	(0.19)	(0.13)
α	2.60*	2.05*	2.45*	2.94**
	(1.36)	(1.16)	(1.21)	(1.02)
β	3.92**	-0.36	-2.64*	0.72
	(1.74)	(0.40)	(1.31)	(0.49)
Observations	31	22	11	23
Adj. R^2	0.967	0.978	0.994	0.993

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6. Conclusion

This paper has two dimensions. The first dimension is historical, along the lines of Judd and Rudebusch (1998), Taylor (1999) and Blinder and Reis (2005).

Monetary policy in Brazil over the last 20 years can be well described by a Taylor rule. The results show evidence that interest rates have been responding to the output gap, with different measures being statistically significant in Table 1. The largest response has been found for the output gap of the Central Bank of Brazil. This result contributes to the literature, because most papers about the Taylor rule used alternative measures of economic activity, rather than the output gap.

In addition to this, Law 179/2021, which granted autonomy to the Central Bank of Brazil, established the goal to smooth economic activity and foster full employment as a secondary role. The results of this paper show that this has been observed in practice considering the period 2003Q2–2024Q4.

The second dimension is theoretical. It tested the existence of private information about the state of the economy, and if this reflects on monetary policy decisions. Romer and Romer (2000) found evidence of information advantage for the FED about inflation and output. This paper found no evidence of asymmetrical information for the Central Bank regarding economic activity. Therefore, the monetary authority and other players operate under the same information set.

References

Aragón, E. K. d. S. B. and Medeiros, G. (2015). Monetary policy in brazil: evidence of a reaction function with time-varying parameters and endogenous regressors. *Empirical Economics*, 48(2):557–575.

Aragón, E. K. d. S. B. and Portugal, M. S. (2010). Nonlinearities in central bank of brazil's reaction function: the case of asymmetric preferences. *Estudos Econômicos (São Paulo)*, 40(2):373–399.

Barbosa, F. d. H., Camêlo, F. D., and João, I. C. (2016). A taxa de juros natural e a regra de taylor no brasil: 2003-2015. *Revista Brasileira de Economia*, 70(4):399–417.

Blinder, A. S. and Reis, R. (2005). Understanding the greenspan standard. *Proceedings — Economic Policy Symposium — Jackson Hole*, pages 11–96.

Carvalho, C., Nechio, F., and Tristão, T. (2021). Taylor rule estimation by OLS. *Journal of Monetary Economics*, 124:140–154.

Carvalho, F. G. and Muinhos, M. K. (2023). The central bank of brazil's time-varying taylor rule. *Revista Brasileira de Economia*, 77:e042022.

Clarida, R., Galí, J., and Gertler, M. (1998). Monetary policy rules in practice: some international evidence. *European Economic Review*, 42(6):1033–1067.

Clarida, R., Galí, J., and Gertler, M. (2000). Monetary policy rules and macroeconomic stability: evidence and some theory. *The Quarterly Journal of Economics*, 115(1):147–180.

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

Judd, J. P. and Rudebusch, G. D. (1998). Taylor's rule and the fed, 1970–1997. *Economic Review*, pages 3–16.

Medeiros, G. B. d., Portugal, M. S., and Aragón, E. K. d. S. B. (2016). Robust monetary policy, structural breaks, and nonlinearities in the reaction function of the central bank of brazil. *EconomiA*, 17(1):96–113.

Romer, C. D. and Romer, D. H. (2000). Federal reserve information and the behavior of interest rates. *American Economic Review*, 90(3):429–457.

Salgado, M. J. S., Garcia, M. G. P., and Medeiros, M. C. (2005). Monetary policy during brazil's real plan: estimating the central bank's reaction function. *Revista Brasileira de Economia*, 59(1):61–79.

Smets, F. (2002). Output gap uncertainty: does it matter for the taylor rule? *Empirical Economics*, 27(1):113–129.

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39:195–214.

Taylor, J. B. (1999). A historical analysis of monetary policy rules. In *Monetary Policy Rules*, pages 319–348. NBER / University of Chicago Press.