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Did The Taylor Rule Stabilize Inflation in Brazil?

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JEL Codes: C32, C51, E52, E58

DID THE TAYLOR RULE STABILIZE INFLATION IN BRAZIL?[1]

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[1]Comments are welcome. I would like to express my gratitude for the contributions and comments of Lars Hansen, John Cochrane, and Monika Piazzesi. I acknowledge the financial support from CAPES, GVPesquisa, grant Colegiado, and from FAPESP, grant 2007/04255-2. All errors in this paper are my sole responsibility.

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1 Introduction

This paper characterizes the monetary policy in Brazil through a forward-looking Taylor-rule-type reaction function before and after the Real plan, which stabilized inflation in July 1994. The results show that the interest rate response to inflation was greater than one-to-one before stabilization and smaller than that afterwards, hence inverting the Taylor's principle. Several robustness checks, using mainly distinct proxies for output, output gap and data frequency strongly confirm the findings.

For ease of exposition and motivational purposes, I divide the recent Brazilian monetary history into three periods[1], all of them shadowed accordingly in Figure 1. The first period goes from January 1980 to June 1994 and is labeled Megainflationary Era,[2] when (log) inflation peaked almost 500% per year[3] in the first quarter of 1990. The figure also shows labels of other attempts that failed to beat inflation. The second period goes from July 1994 to December 1999 and is labeled Real Era, when inflation stabilized around 8% per year. The last period begins in January 2000 and portrays the inflation targeting regime announced in the preceding year.

Many empirical studies on central bank rules, part of them surveyed in Taylor (1999), have been undertaken since Taylor's (1993) influential paper. They concentrate on developed economies like the United States as, for example, Orphanides (2004) and Clarida, Galí and Gertler (2000), among many others. I follow the latter authors' model to characterize the Brazilian monetary policy since 1980.

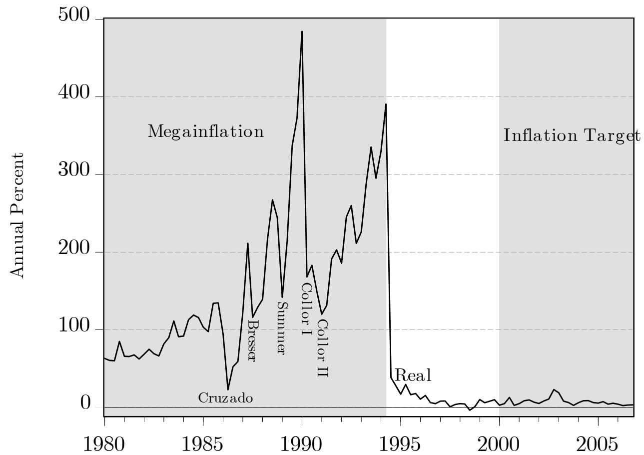
The importance of analyzing Brazil rests on the inarguable monetary instability

[1] Bueno (2006) finds roughly the same subdivision using a Markov Switching Model, in which the states are endogenously determined.

[2] All contracts were indexed to a price index, in such a way that the purchasing power decreased *relatively* slowly. That arrangement dates back to the early 1960s and held inflation very high for a long time. That is why it was not a typical hyperinflation.

[3] The figure corresponds to an effective inflation of almost 12,600% per year.

Figure 1: Brazilian Inflation (IPCA)



Quarterly data, in log. The lower labels indicate the stabilization plans. The period from 1980:1 to 1994:2 is the Megainflationary Era. From 2000:1 on, the central bank announced they would pursue a target for inflation.

before 1994 and on verifying whether the prescriptions of a Taylor rule work in such an economy as stated theoretically in Woodford (2003), among others. Although Brazil is an example of a successful stabilization plan, surprisingly no one has looked at its monetary policy from the Taylor rule standpoint before the Real Era. The sparse research available has concentrated on the Inflation Target period. For example, Favero and Giavazzi (2002) try to explain the high level of interest rate in Brazil using a Taylor rule in which they exclude output gap from the reaction function. Salgado *et alli* (2005) estimate the rule using a threshold autoregressive model (TAR) in a sample beginning in July 1994, but it is difficult to compare their results with mine because they treat interest rate as a nonstationary variable. Minella *et alli* (2002, 2003) estimate the Taylor rule after 2000 and show an active monetary policy.

The Taylor rule characterizes monetary instability[4] as an interest rate that responds to inflation in a smaller than one-to-one basis, whereas monetary stability means a response to inflation in a magnitude greater than one-to-one (see Woodford, 2003, ch. 4). This claim is known as the Taylor's principle and expresses a simple idea[5]: if inflation increases, the nominal interest rate must grow faster in order to make the real interest rate rise, so as to push consumption and investment down and thereby inhibit inflationary tendencies. We shall see, however, that the Taylor's principle applied in Brazil during the Megainflationary Era did not work out. In addition, the interest rate response to inflation in the Real Era was smaller than one-to-one, but monetary instability did not return as in all other past attempts. The results are confirmed statistically by Wald tests. A first corollary is that monetary policymakers did look ahead trying to stabilize inflation before 1994, instead of the backward-looking argument in Brazil that rests on the fact that contracts were indexed to past inflation. Another corollary is that the inflation coefficient does not need to be greater than one to characterize monetary stability, that is, an inflation coefficient greater than one may not stabilize price growth. Bueno (2008) reaches a similar conclusion for the U.S. by enabling the inflation coefficient to fluctuate over time using the Kalman filter. Blinder and Reis (2005) also find an inflation coefficient less than one during Greenspan's chairmanship. Cochrane (2007) argues that inflation determination demands elements beyond an interest rate response that

[4] In order to link the ideas of (in)determinacy and price (in)stability, Woodford (2003, p. 88) writes: *"[...] the indeterminacy is plainly undesirable if price stability is a concern [...] Indeed, since the class of bounded solutions includes solutions in which the unexpected fluctuations in inflation are arbitrarily large, at least* some *of the equilibria consistent with* interest-*rate targeting policy are worse* (assuming a loss function that penalizes squared deviations of inflation from target, say *than the equilibrium associated with* any *policy that makes equilibrium determinate*." That is, price instability is characterized by price indeterminacy, and price stability, by price determinacy.

[5] Although Cochrane (2007) argues that the reasoning is unsuitable for the forward-looking version of the Taylor rule, many authors still take it for granted.

follows the Taylor's principle.

In the third period, the interest rate responds to inflation deviation from the target announced in advance. That means a change in the reaction function, as inflation target deviation replaces inflation. In that case, all coefficients are very close to Favero and Giavazzi's (2002) and Minella's (2002).

I estimate all rules using the generalized method of moments, GMM, by Hansen (1982). Particularly in the third period, the interest rate response is greater than one-to-one when observed expectations are on the right hand side. Nevertheless, Wald tests fail to reject that the inflation coefficient is equal to one. Minella et *alli* (2003) estimate the model by ordinary least squares and find an inflation parameter larger than two, probably because of some endogeneity in their model[6]. Alternatively, I estimate another model through which I show that monetary policymakers follow a rule with current inflation on the right hand side, in such a way that its corresponding parameter continues to be smaller than one-to-one. Empirically both models are equally plausible descriptions of the monetary policy. Consequently, we can see again stable inflation associated with an accommodative monetary policy.

The paper is organized as follows. The basic econometric model is discussed in Section 2. The data used in the paper and the construction of the variables are in Section 3. The empirical strategy and the analysis of the results are in Section 4, which is divided into three subsections, according to the periods defined previously. I also present part of the robustness checks there, and relegate the remaining checks to the appendix. The last section concludes.

[6] The target in July 2002 was adjusted to match up with the growing market expectations on inflation. The interest rate increased, too. Therefore, the reaction to inflation target deviation also increased, since inflation deviation shrank.

2 The Model

I follow Clarida, Galí and Gertler (2000) to set up the model. I assume that the central bank defines a target rate given by:

$$i_t^* = (r^* + \pi^*) + g_\pi E_{t-1}\left(\pi_{t,k} - \pi_t^*\right) + g_x E_{t-1}\left(x_{t,q}\right), \tag{1}$$

where

i_t^* is the target interest rate followed by the Central Bank at time t;

r^* is the long-run equilibrium real rate;

π^* is long-run target for inflation;

$i^* \equiv (r^* + \pi^*)$ is the desired nominal rate when both inflation and output are at their target levels;

$E_t(\cdot) \equiv E[\cdot|\,\Omega_t]$ is the expectation taken with respect to the information set, Ω_t, available at t;

$\pi_{t,k}$ is the inflation rate between periods t and $t+k$;

π_t^* is the inflation target at time t;

$x_{t,q}$ is the output gap between the beginning of t and the beginning of $t+q$.

The information set from the econometrician's standpoint corresponds to dating of expectations not being observed in real time. Therefore, following Jondeau, Bihan and Gallès (2004) I define $\Omega_{t-1} = \left\{i_{t-1}, \pi_{t-1}, x_{t-1}, \pi_{t-1}^*, \ldots\right\}$.[7]

Equation (1) nests other plausible models, provided that either inflation (lagged) or a linear combination of inflation and output gap is a sufficient statistic for predicting future inflation. For example, Taylor (1993) proposes a rule with lagged inflation and output. Rudebusch and Svensson (1999) set up a model where current inflation

[7] The information set in CGG is the same, but they set it as Ω_t.

and output gap enter the rule and report a high R^2, however in their model the information set includes current variables.

2.1 Smoothing the Interest Rate

Equation (1) fails to describe actual changes in the interest rate. Clarida, Galí and Gertler (2000), among others, claim that there is a central bank's tendency to smooth variations in the interest rate. Thus, they set the *actual* interest rate, i_t, as a weighted average between lagged and targeted interest rate:

$$i_t = g_i i_{t-1} + (1 - g_i)\, i_t^* + \upsilon_t, \tag{2}$$

where

$g_i \in [0, 1)$ indicates the degree of smoothing of the interest rate changes;

υ_t is a zero-mean, homokedastic, non autocorrelated, exogenous shock on the interest rate.

The shock υ_t allows for a bit of reality. It is impossible to avoid some degree of randomness in policy actions associated with misforecasts of the economy. Moreover, the central bank does not succeed perfectly in keeping interest rate at the desired level through open market operations, as equation (1) posits.

Woodford (1999) provides technical reasons for the presence of lagged interest rate in the rule. Furthermore, it is agreed that lagged interest rate may improve the stabilization performance of the rule.

Combining the partial adjustment equation (2) with the target model (1) and rearranging, one obtains the policy reaction function that will interest us during both the Megainflationary and Real eras, where I enforce that $\pi_t^* = \pi^*$:

$$i_t = g_i i_{t-1} + (1-g_i)\{[r^* - (g_\pi - 1)\pi^*] + g_\pi \pi_{t,k} + g_x x_{t,q}\} + \varepsilon_t, \qquad (3)$$

where $\varepsilon_t = \upsilon_t - (1-g_i)\{g_\pi[\pi_{t,k} - E_{t-1}(\pi_{t,k})] + g_x[x_{t,q} - E_{t-1}(x_{t,q})]\}$.

Apart from υ_t, the term ε_t follows, by construction, a moving average process of order $\max(k,q) - 1$, thereby it will be serially correlated except when $k = q = 1$. In the most part of this paper, I assume $k = q = 1$. Thus, let us see the properties of ε_t in that case. First, for ease of notation define

$$\begin{aligned} f_{t+1} &\equiv -(1-g_i)\{g_\pi[\pi_{t,1} - E_{t-1}(\pi_{t,1})] + g_x[x_{t,1} - E_{t-1}(x_{t,1})]\} = \\ &= -(1-g_i)\{g_\pi[\pi_{t+1} - E_{t-1}(\pi_{t+1})] + g_x[x_{t+1} - E_{t-1}(x_{t+1})]\}, \end{aligned}$$

and observe that

$$E_{t-1}(f_{t+1}) = 0 \Longrightarrow E(f_{t+1}) = 0.$$

Hence:

$$E_{t-1}(\varepsilon_t) = E_{t-1}(\upsilon_t) \Longrightarrow E(\varepsilon_t) = 0.$$

We still can have autocorrelation in ε_t, however. To see that, consider what happens between t and $t+1$:

$$\begin{aligned} E_{t-1}(\varepsilon_{t+1}\varepsilon_t) &= E_{t-1}[(\upsilon_{t+1} + f_{t+2})(\upsilon_t + f_{t+1})] = \\ &= E_{t-1}[\upsilon_{t+1}\upsilon_t + \upsilon_{t+1}f_{t+1} + f_{t+2}\upsilon_t + f_{t+2}f_{t+1}] = \\ &= \underbrace{E_{t-1}(\upsilon_{t+1}\upsilon_t)}_{=0} + E_{t-1}(\upsilon_{t+1}f_{t+1}) + \underbrace{E_{t-1}(f_{t+2}\upsilon_t)}_{=0} + \underbrace{E_{t-1}(f_{t+2}f_{t+1})}_{=0} = \\ &= E_{t-1}(\upsilon_{t+1}f_{t+1}). \end{aligned}$$

The first term is zero because υ_t is not autocorrelated by assumption. The last term is zero because f_{t+1} and f_{t+2} are expectational errors, so as they belong to mutually independent sets. The third term is zero because:

$$E_{t-1}\left(f_{t+2}\upsilon_t\right) = E_{t-1}\left[E_t\left(f_{t+2}\upsilon_t\right)\right] = E_{t-1}\left[\upsilon_t E_t\left(f_{t+2}\right)\right] = 0.$$

The first equality comes from the Law of Iterated Expectations and the result follows. Notwithstanding, we cannot disregard the possibility that $E_{t-1}\left(\upsilon_{t+1}f_{t+1}\right) \neq 0$, since both factors belong to the same information set. There is no reasonable motive to make $E_{t-1}\left(\upsilon_{t+1}f_{t+1}\right) = 0$.

The term ε_t contains a linear combination of forecast errors and exogenous shocks, thus any vector of instruments $\mathbf{z}_{t-1} \in \Omega_{t-1}$ is orthogonal to the information set when i_t is determined:

$$E_{t-1}\left(\varepsilon_t \mathbf{z}_{t-1}\right) = 0 \Longrightarrow E\left(\varepsilon_t \mathbf{z}_{t-1}\right) = 0.$$

Equation (3) will be the main model to be explored in this article. It will be estimated using the GMM with an optimal weighting matrix to account for possible serial correlation in $\{\varepsilon_t\}$.

Since there is some interest in knowing the target inflation π^*, once again I follow Clarida, Galí and Gertler (2000) and impose one more restriction. I assume the equilibrium real rate r^* to be the observed sample average and introduce such restriction directly into equations (4) and (3), in order to identify π^*.

In the Inflation Target Era, the rule changes a bit, because one can observe expectation of inflation for the next twelve months. That is the rule becomes:

$$i_t^* = \left(r^* + \pi^*\right) + g_\pi E_{t-1}\left(\pi_{t,k}^{mkt} - \pi_t^*\right) + g_x E_{t-1}\left(x_{t,q}\right),$$

where $\pi_{t,k}^{mkt}$ is the market's expected inflation between periods t and $t+k$.

So, I define the inflation deviation from the target as $d_{t,k} = \pi_{t,k}^{m} - \pi_t^*$.[8] Therefore, I shall estimate the following rule:

$$i_t = g_i i_{t-1} + (1 - g_i) \{(r^* + \pi^*) + g_\pi d_{t,k} + g_x x_{t,q}\} + \varepsilon_t, \tag{4}$$

where $\varepsilon_t = \upsilon_t - (1 - g_i) \{g_\pi [d_{t,k} - E_{t-1} (d_{t,k})] + g_x [x_{t,q} - E_{t-1} (x_{t,q})]\}$.

Notice now that I do not make any simplification regarding the inflation target π_t^*. Also, since it is unusual that $\pi_t^* = \pi_{t-1}^*$, the term $[d_{t,k} - E_{t-1} (d_{t,k})]$ reduces to $\left[\pi_{t,k}^{mkt} - E_{t-1}\left(\pi_{t,k}^{mkt}\right)\right]$, which is similar to what we have seen before.

2.2 Exchange Rates and Reserves

Since Brazil is a small open economy, Ball (1999) would include the exchange rate in the rule by arguing that a Taylor rule would perform poorly without such a variable. Taylor (2001), however, does not share the same conviction and argues exactly the opposite. He claims that the use of exchange rate in a forward-looking reaction function is needless, because there is an indirect effect of exchange rates on interest rates through inflation. In other words, even if the central bank followed a policy rule disregarding a direct exchange rate effect, inflation would transmit such an effect over time. Accordingly, Svensson (2000) shows that the exchange rate makes inflation volatility undesirably high.

Exchange rate was fixed daily by the central bank in Brazil until 1999; that is, it was an almost flexible rate. Under that regime, if there was an external disequilibrium, the reserves would be quickly depleted, as happened in the Asian and Russian

[8] Later, I show how to calculate $d_{t,k}$ in details.

crises in November 1997 and September 1998, respectively. Because these variables belong to the information set of policymakers by the time they set the interest rate, I include them as instruments in the GMM estimation[9].

3 Data

3.1 Variables

Although the usual data frequency in the literature is quarterly, monthly data will be necessary mostly after the Real plan, because there are very few quarterly observations between 1994:3 and 1998:4 and even during the inflation target period.

Gross domestic product (GDP), industrial production index (IND) and total consumption of electric power in gigawatts/hour (GWh) are the proxies for output, which are either quarterly or monthly observed or both. If the series is not originally seasonally adjusted as quarterly GDP (in real R$ million), then I use the X-12 procedure. Those were the cases of monthly GDP (in US$ million), GWh and IND.

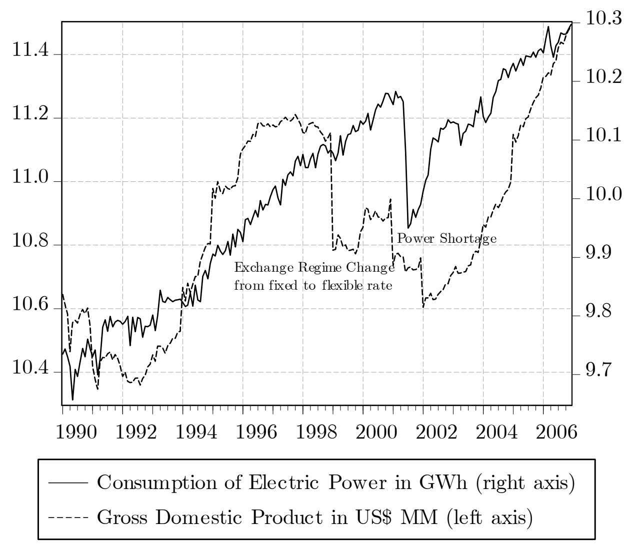
Monthly GDP and IND are only available after 1990. The Brazilian central bank calculates monthly GDP; however, such variable can be measured very poorly exactly due to the high frequency of measurement. That reason justifies employing more precise indices as GWh and IND[10] as proxies for output, besides serving as checks for robustness. Figure 2 contains two proxies for output.

The series experienced some abrupt events that made them considerably diverse between each other. First, when the exchange rate regime became floating in January 1999, there was an expressive currency depreciation, causing monthly GDP to

[9] Both in log differences.

[10] Minella *et alli* (2002, 2003) also employ IND in their work.

Figure 2: Output Proxies (log scale)



drop sharply. In 2001, the water level of reservoirs had lowered too much due to unfavorable weather conditions. In order to avoid a collapse in the electrical power supply (heavily based on hydroelectric generation), consumers were rationed to a limited amount of energy per month. These events are indicated in Figure 2. On the other hand, the industrial production index is much smoother over time, but data are shorter and start in 1991.

Table 1 shows that yearly growth correlations between these variables on a monthly basis are really low[11]. That analysis is important because the outcomes will be stronger if they remain qualitatively unchanged to variations in output proxies and data frequency.

The IPCA consumer price index is the government's official inflation rate and it is used as the basis for monetary policy and inflation targeting. The inflation series

[11]Growth correlation between GDP and GWh on a quarterly basis is 0.97.

Table 1: Growth Correlation Between Output Proxies in Brazil - Monthly Frequency

	GDP	**GWh**	**IND**
GDP	1	0.336	0.380
GWh		1	0.303
IND			1

GDP: Gross domestic product; GWh: Consumption of electric power in gigawatt/hour; IND: Industrial production index; log-difference between t and $t-12$.

was split into two parts and then each sample was seasonally adjusted by the X-12 procedure. The first part ends where the second part begins in June 1994. That procedure is undertaken in order to mitigate a potential contamination from the Megainflationary Era into the stable inflation period and vice versa.

SELIC is the interest rate controlled by the central bank through daily open market operations.

Data are collected at the end of each month. For quarterly data, monthly variations are accrued over the quarter and then annualized, similarly to what happens with other variables of equal frequency.[12] For example, let i_t be the interest rate in month t. Then, the interest rate corresponding to quarter $3t$ is:

$$i_{3t} = \ln \prod_{j=3t}^{3t+2} (1 + i_j) .$$

In the instrument set, I include lags of output gap, inflation, interest rate, inflation target deviations, exchange rate and reserves. Appendix A contains more detailed statistics of the variables used in this paper.

[12] Aggregation is an arbitrary procedure. Clarida, Galí and Gertler (2000) take the interest rate of the first month of each quarter. Minella *et alli* (2002) take the average of the months within the quarter. My procedure is equivalent to Minella's.

3.2 Output Gap

It is the combination between output gap and inflation that determines the size of the rule coefficients. Hence, different methods for obtaining the output gap may yield different coefficients. In view of this criticism and with the goal of checking the model robustness in Brazil, I employ two alternative but usual ways of extracting output gap from output: linear and quadratic detrend. Notwithstanding, I estimate the output gap at t using only data available up to period t, as a way to *mitigate*[13] the criticism raised by Orphanides and Norden (2002), who argue that most studies employ data available later[14] than date t. Therefore, I define the potential output, q_t^n, as a deterministic trend:

$$q_t^n = \alpha_t + \beta_t t + \gamma_t t^2. \tag{5}$$

The subindex on α, β and γ stresses the fact that these coefficients are estimated by ordinary least squares with a sample of t observations. Then, the output gap, x_t, will represent the residual of a rolling-over regression of the observed output, q_t, against the potential output at each time:

$$x_t = q_t - \widehat{q}_t^n, \ t = 1, 2, \ldots, T.$$

where $\widehat{q}_t^n = \widehat{\alpha}_t + \widehat{\beta}_t t + \widehat{\gamma}_t t^2$ stands for the estimated potential output at time t.

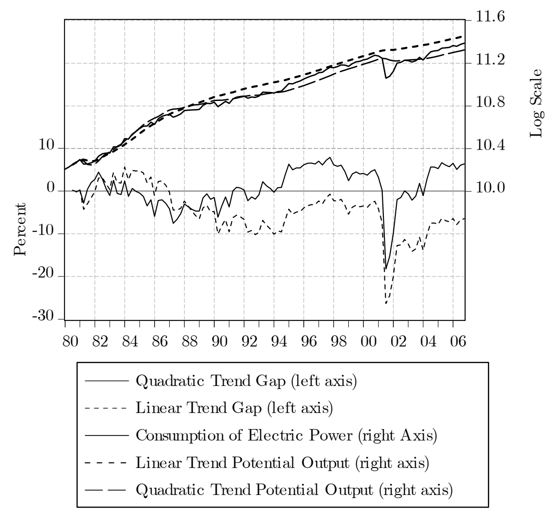
Despite the fact x_t is an estimated variable and thus the standard-deviation of its coefficient in the Taylor rule should take that into account, I shall consider it

[13] Real data are hardly available in Brazil.

[14] Extracting the output gap through Hodrick-Prescott filter is an example of using data available later than t.

as observed in accordance with many authors like CGG, Blinder and Reis (2005), Taylor (1999), among others. Figure 3 shows the output gaps resulting from the procedures just discussed.

Figure 3: Output, Potential Output and Output Gap based on Consumption of Electrical Power in GWh - Quarterly Data



The rolling-over procedure puts emphasis on the arrival of new information in order to calculate the output gap. I estimate the output gap based on a linear trend (by imposing $\gamma = 0$) and on a quadratic trend. The distinction turns out to have important consequences, since one gap may indicate a policy recommendation contrary to the other. For instance, we see in Figure 3 that between 1994 and 2001, the gap from linear detrend indicates recession while the one from quadratic detrend indicates expansion.

Figure 3 also shows that the potential output based on quadratic trend is economically more reasonable than the linear trend, because the former indicates alternate periods of recessions and expansions, while the latter at some point indicates only recession. In particular, it is true that the second oil shock, coupled with the exchange rate depreciation in the early 1980s, led Brazil to a recession. Also, it is true that the Real plan in 1994 led to an expansion. Such beliefs are clearly delineated in the quadratic trend gap, but not in the linear trend one, although both show a similar tendency over time. The picture may be different with monthly data, however (see Appendix B), mainly because of sample differences.

3.3 Inflation Target Era

The inflation target regime started a few months before 2000 and has been the focus of many Brazilian researchers since then. Thereby, this work would be incomplete if I did not analyze it, although it is unnecessary to establish the main point. The procedures lead to numbers similar to the ones obtained by other articles and, to some extent as we shall see in the next section, they are consistent with the results presented in the preceding subsamples.

By the end of 2005, the inflation target in Brazil had changed considerably over time and has been more stable since then. The monetary policy committee - Copom - defines the inflation target for the following years. Therefore, it is necessary to weigh current- and next-year target inflation to approach the target for the next twelve months. To be precise, let $\pi^*_{t,m}$ be the current-year inflation target at period t, to which corresponds a month $m = 1, 2, \ldots, 12$. Let $\pi^{*+1}_{t,m}$ be the next-year inflation target at period t. If the weighting scheme posits that inflation distributes evenly over the year, the inflation target for the next twelve months at period t, π^*_t, is given by:

$$\pi^*_t = \left(\frac{12-m}{12}\right) \ln(1+\pi^*_{t,m}) + \frac{m}{12} \ln\left(1+\pi^{*+1}_{t,m}\right).$$

Indeed π^*_t in known even in advance, since the target is announced in previous year. I kept it belonging to Ω_t for two reasons. First for consistency with the model as whole. Second, in 2002, the target changed without prior announcement.

Every day Brazilian central bank collects inflation expectation for current and next year from the market. Every Friday, they release a report with these data. I weight the median expectations using the last report of each month and find the expected inflation for the next twelve months[15]. Let $\pi_{t,m}^{post}$ be the realized inflation between month 1 and m, that is, $1+\pi_{t,m}^{post} = \prod_{j=0}^{m-1} (1+\pi_{t-j})$. Let $\pi_{t,m}^{e}$ be the market's expected inflation for the current year at period t, to which corresponds a month $m = 1, 2, \ldots, 12$, that is, the expected inflation between $t-m$ and $t-m+12$. Let $\pi_{t,m}^{e+1}$ be the market's expected inflation for the next year, collected at period t, that is, the expected inflation between $t-m+12$ and $t-m+24$. Again, if the weighting scheme posits that inflation distributes evenly over the year, the market's prior for inflation one year from now, is given by:

$$\pi_{t,12}^{mkt} = \ln\left(\frac{1+\pi_{t,m}^{e}}{1+\pi_{t,m}^{post}}\right) + \frac{m}{12}\ln\left(1+\pi_{t,m}^{e+1}\right).$$

Hence, the expected inflation deviation from the target at period t, $d_{t,k}$, is simply:

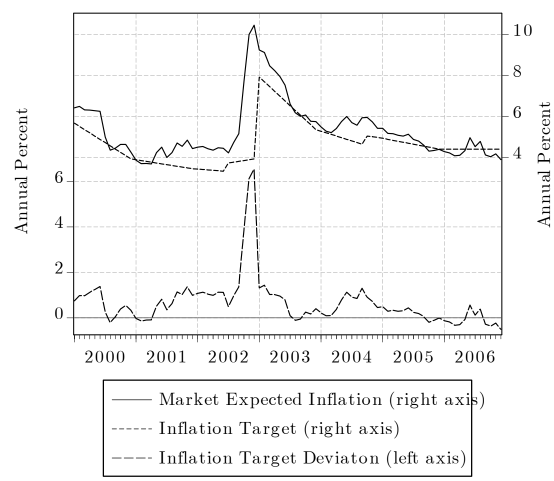
$$d_{t,k} = \pi_{t,12}^{mkt} - \pi_t^*.$$

Figure 4 depicts the dynamics of the market's expected inflation, inflation target

[15] Brazilian Central Bank started to collect market expectations for the next twelve months only in 2001. I take the weighted average of the medians for three reasons. First, to be consistent with the calculations of the target inflation. Second, Minella *et alli* (2002) and Favero and Giavazzi (2002) adopt an alternative strategy. They make a weighted average like me until 2001, and then, they merge the so constructed series with the market expectations for the next twelve months series. Since the numbers are quite close to theirs as we shall see, my procedure must be empirically innocuous. Third, to be internally consistent in order to avoid either mixing two different series or using a shorter sample in the Inflation Target Era.

and the discrepancy stemming from them. The spike in 2002 is due to the presidential race. We can notice the market's expectations increasing in advance to the inflation target. That is, the target for inflation is adjusting itself to expectations[16].

Figure 4: Expected Inflation Target Deviation - monthly data



4 Empirical Strategy and Results

I set out data into three main periods as mentioned in the Introduction. Although economic arguments should be enough to justify such split, a numerical motivation also helps see the big picture. For that purpose, Table 2 shows the standard deviation of inflation and of output in each subsample[17]. It seems quite obvious that inflation volatility decreases enormously over time, although it is still high compared with the U.S., where it is about 1.6% (see Bueno, 2008).

[16] Granger tests indicate causality in either direction both between the market's expected inflation and inflation target and between the market's expected inflation and inflation itself.

[17] The year 1999 is excluded from the sample for reasons that will become clear later. Including it, however, would not change the conclusions here.

Table 2: Aggregate Volatility Indicators - Monthly Frequency

Date	Period	Standard Deviation of: Inflation	Standard Deviation of: Output Gap
1990:01 1994:06	Megainflation	123.3	2.14
1994:07 1998:12	Real	12.5	1.99
2000:01 2006:12	Inflation Target	5.5	6.86

The output gap volatility, measured in GWh (quadratic detrend), is diminishing and comparable with that of the U.S. The most recent increase is due to the shortage of electric power, as pointed out in Figure 2.

The figures delineate three very distinct monetary periods in Brazil, which practically match up with Bueno's (2006) findings. However, he determines these subperiods endogenously through a Markov switching model with three states.

From now on, I will proceed with the empirical estimations in each period[18]. With the aim of testing the robustness of the results, there are eight possible Taylor rule estimates in each of them, depending on the variable used as output gap. The output gap, in turn, depends on the data frequency, on the output proxy, and on the potential output scheme. For quarterly data, the proxies for output are GDP and GWh. For monthly data, the proxies for output are GDP, GWh and IND. Output gaps based on GWh (monthly and quarterly) and monthly GDP are both extracted from linear detrend and from quadratic detrend, so there are six possibilities. The output gap is exclusively obtained from linear detrend in the cases of quarterly GDP and (monthly) IND, because the parameter of t^2 is statistically nonsignificant, so there are two possibilities. Besides, I make two other robustness checks with the last

[18]The models were estimated using quadratic kernel, Andrews bandwidth selection and prewhitening. Some of them, however, turned out to be unfeasible under such specification. In those cases, I have switched the option to Bartlett kernel and/or fixed Newey-West bandwidth, in that order. The maximum number of iterations is 5000, and only one did not converge. The program contains more details and is available upon request.

sample based on distinct rule specifications, in a total of 24 sets of estimates.

In the main text I compare the results using two different output gaps of each frequency. For quarterly data, I pick up the output gaps extracted using linear detrend from GDP and quadratic detrend from GWh. For monthly data, I take the output gaps extracted using a quadratic detrend from both GDP and GWh. Appendices C to E contain the outcomes with the remaining possibilities, but the conclusions remain unchanged.

4.1 Megainflationary Era

For convenience, I repeat the model estimated in this section by using GMM:

$$i_t = g_i i_{t-1} + (1 - g_i) \left[(r^* - (g_\pi - 1) \pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q} \right] + \varepsilon_t,$$

where $\varepsilon_t = \upsilon_t - (1 - g_i) \{ g_\pi [\pi_{t,k} - E_t (\pi_{t,k})] + g_x [x_{t,q} - E_t (x_{t,q})] \}$.

I restrict the real interest rate r^* to be the average difference between *ex post* nominal interest rate and inflation. The rates are identical regardless the data frequency, except in here, since monthly and quarterly date encompass distinct samples. The quarterly real interest rate is 20.9% per year and the monthly real interest rate is 13.8% per year.[19]

In order to obtain the "desired" nominal rate when both inflation and output are at their target levels, so to speak since inflation was uncontrolled, one should simply sum up r^* and the π^* reported in the tables.

Table 3 shows the Taylor rule estimations using different calculations for output gap. Following the approach of CGG, $(k, q) = (1, 1)$. Although there was no explicit

[19] The approach refers to the intercept, so whatever the assumption one takes estimate the real interest rate, it should not affect the other coefficients, which are the focus of the analysis.

inflation target during the Megainflationary Era, the models seem to agree on a very high π^*, around 120%. Considering the inflation volatility at that time, such a picture comes at no surprise. The "target inflation" is very high, but the average inflation in that period was about 175%. Occasionally, depending on the output gap proxy, residual tests may show some autocorrelation in monthly data (not in quarterly), but they never support nonstationarity.

Table 3: Taylor Rule in the Megainflationary Era $(k, q) = (1, 1)$

Frequency	Quarterly		Monthly	
Output: $q_t =$ Output gap: $x_t =$	GDP $q_t-(\alpha_t+\beta_t t)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GDP $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$
Coef./Period	**81:3-94:2**	**81:4-94:2**	**90:09-94:06**	**90:09-94:06**
π^*	106.926* (12.786)	116.339* (22.328)	3.030 (74.206)	155.435* (31.260)
g_π	1.414* (0.094)	1.500* (0.139)	1.375* (0.119)	1.681* (0.192)
g_x	−0.520 (0.422)	−3.961*** (2.345)	−1.822* (0.387)	−3.118** (1.281)
g_i	0.473* (0.048)	0.565* (0.068)	0.818* (0.048)	0.871* (0.033)
# obs.	52	51	46	46
$H_0 : g_\pi = 1$?	Reject*, $g_\pi > 1$	Reject*, $g_\pi > 1$	Reject*, $g_\pi > 1$	Reject*, $g_\pi > 1$
Prob J-test.	0.745	0.711	0.872	0.592

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard deviations are in brackets.
Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i) [(r^* - (g_\pi - 1) \pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}] + \varepsilon_t$.
GDP: Gross domestic oroduct; GWh: Consumption of electric power in GWh. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, and output gap.

The coefficients g_x are all negative and tend to be nonsignificant in quarterly data. Also they are large in absolute value, due to the remarkable difference between the interest rate level compared to output gap level. The size of the coefficients differs across output gap proxies, but not quite across output proxies. A negative coefficient is counterintuitive at first. But if we look at Figure 3 and see the great deal of recession during the 1980s, coupled with high inflation, perhaps it makes sense and explains the negative sign of g_x. Policymakers were increasing the interest rate, even in recession, to combat inflation.

The smooth parameter g_i is similar across all models, normalizing for data frequency, since $0.8^3 \simeq 0.5$. The pattern is alike even if we consider distinct subsamples, since monthly data start 10 years after quarterly data.

The inflation parameter g_π is the main point of analysis. It is greater than one in magnitude and around 1.5 across output proxies. The claim is statistically confirmed by Wald tests. In terms of economic policy, a coefficient above one means that monetary policymakers were looking ahead trying to stabilize inflation before 1994, apparently contradicting conventional wisdom in Brazil that policymakers only looked backwards[20]. Moreover, the finding implies that an inflation coefficient greater than one does not necessarily characterize monetary stability.

4.2 Real Era

The same model estimated in the last section is used here. The average annual real interest rate $r^*$was 19.5%.

Table 4 reports the Taylor rule estimates using dissimilar calculations of output gap in the Real Era. The general conclusions, mainly on the inflation parameter g_π, are similar in either frequency, although the number of observations is too different between each other. Consequently, while the similarity of the conclusions is quite unexpected, it also makes them more reliable. Moreover, since monthly outputs have

[20] Many people in Brazil believe that monetary policymakers responded only to past inflation, since most contracts were indexed to it. Therefore, I have run the model setting $(k, q) = (0, 0)$, a closer specification of Rudebusch and Svensson (1999). The results, unreported in this paper, show the same picture. The parameter g_π is greater than 1, but the magnitude is a little smaller than that of the forward-looking model.

a low correlation between each other, the conflicting patterns between models that one could foresee turned out to be false.

Table 4: Taylor Rule in the Real Era $(k, q) = (1, 1)$

Frequency	Quarterly		Monthly	
Output: $q_t =$ Output gap: $x_t =$	GDP $q_t-(\alpha_t+\beta_t t)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GDP $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$
Coef./Period	**94:3-98:4**	**94:3-98:4**	**94:07-98:12**	**94:07-98:12**
π^*	27.315** (0.089)	52.888* (5.560)	19.924* (2.089)	11.412* (3.436)
g_π	0.933* (0.017)	0.720* (0.008)	0.623* (0.114)	0.725* (0.104)
g_x	−0.155* (0.031)	−0.566* (0.049)	0.020** (0.009)	0.124* (0.041)
g_i	0.028* (0.001)	0.013* (0.003)	0.084* (0.004)	0.090* (0.004)
# obs.	18	18	54	54
$H_0 : g_\pi = 1$?	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$
Prob J-test.	0.477	0.905	0.771	0.817

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard deviations are in brackets.
Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\,\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t$.
GDP: Gross domestic product; GWh: Consumption of electric power in GWh. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, and output gap.

Few observations lead to a strong bias towards not rejecting the null, if we take into account the high standard deviations in Table 2. For that reason, any rejection, consistent of course with other checks, should be stressed. The inflation target parameter π^* is considerably different across output proxies. Arguably, that reflects some sort of adjustment in the monetary policy under controlled inflation, possibly with effects on the low g_i too. In fact, the smooth parameter g_i is low in all models. The pattern is similar even considering the difference between the number of observations.

The coefficients g_x are negative with quarterly data and positive with monthly data, and all of them decreased in size compared to the preceding sample, accompanying the interest rate level trend. Again, output gap with the quarterly sample indicates recession, rather than expansion as with the monthly sample (see Figure 6 in Appendix B). For that reason, the sign of g_x with quarterly data is negative, as though the policymaker were reinforcing the control over inflation.

The inflation parameter g_π is less than one in magnitude across output proxies. Wald tests heavily confirm the claim statistically. They are quite similar around 0.7, except for the model with quarterly GDP, although still inferior to one.

If one believes inflation was controlled, even partly, then according to the Taylor rule predictions, the parameter g_π should increase compared to the previous sample. However, what happens is quite the contrary, indeed. Hence, an inflation parameter less than one does not necessarily characterize an unstable inflation.

In previous versions of this article, I included reserves growth and exchange rate variations as explanatory variables, following Ball (1999) and Salgado *et alli* (2005). The new parameters turned out to be negligible in size and significance. Summing them up with g_π yields a number still inferior to one. I also proceeded with another unreported robustness check by setting $(k, q) = (0, 0)$. The picture is exactly the same as analyzed in this section.

4.3 Inflation Target Era

This section serves to compare the outcomes of this paper with other studies that use Brazilian data, and to confront them with what we have seen in previous sections. For that purpose, I discuss two possible rule specifications that describe the monetary policy in Brazil equally well.

To begin with, the exchange rate became floating in 1999, and the Brazilian central bank announced they would pursue a target for inflation for the next twelve months. That year constituted a transition period and expected inflation data were still unavailable publicly. Thereby, to avoid contaminating data either during the Real Era or during the Inflation Target Era, I keep them out of the sample.

In view of this explicit change in the monetary policy, I estimated the Taylor rule by taking the expectations forward one year[21], but the inflation coefficient g_π became too low, sometimes nonsignificant[22]. The coefficient g_i is aproximately 0.6. For that reason, I have skipped the tables, relegating them to Appendix E.1, and preferred to discuss other possible specifications that describe what happened more accurately.

The first alternative is to approach the rule by using current inflation, that is, setting $(k, q) = (0, 0)$. Under this hypothesis, Table 5 provides the estimated parameters.

First, the real interest rate during this period falls to 9.6%. Second, the inflation target parameter π^* becomes considerably similar across output proxies and is consistent with the average inflation target announced by Copom along the years. As expected, we see a sharp reduction in the parameter π^*, mainly compared with Table 4 in the previous section.

The output gap coefficients g_x are, in general, nonsignificant and low in size. By contrast, the lagged interest rate parameters g_i are high and significant, with a coefficient that is more similar to what is described in the literature.

In general, the inflation parameter g_π is around 0.5, similarly to what we saw in

[21] I also did estimate the model setting $(k, q) = (1, 1)$. It presented a performance as good as setting one year forward. The results are not reported, but there is a discussion about them in Appendix E.1.

[22] The other coefficients were reasonable and, in general, close to the other specifications that I discuss within this section.

Table 5: Taylor Rule in the Inflation Target Era: $(k, q) = (0, 0)$

Frequency	Quarterly		Monthly	
Output: $q_t =$ Output gap: $x_t =$	GDP $q_t-(\alpha_t+\beta_t t)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GDP $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$
Coef./Period	**00:2-06:4**	**00:2-06:4**	**00:02-06:12**	**00:02-06:12**
π^*	7.582* (0.325)	7.628* (0.939)	6.574* (0.587)	6.190* (0.500)
g_π	5.431*** (2.696)	0.171 (0.184)	0.445* (0.093)	0.444* (0.097)
g_x	0.202 (0.331)	−0.220* (0.055)	−0.001 (0.001)	−0.002 (0.003)
g_i	0.952* (0.025)	0.823* (0.047)	0.544* (0.093)	0.559* (0.097)
# obs.	27	27	83	83
$H_0 : g_\pi = 1$?	Do not reject	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$
Prob J-test.	0.946	0.937	0.074	0.045

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard-deviations are in brackets. Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\,\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t$.
GDP: Gross domestic product; GWh: Consumption of electric power in GWh. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, output gap, and 1 lag inflation target deviation.

the last section. The greater-than-one inflation coefficient using quarterly GDP is highly volatile and comes from a model with too few observations, therefore it should be read with care. In fact, all other models I have estimated present a coefficient $g_\pi < 1$, as confirmed by Table 14 in Appendix E.2. As a consequence, there is still monetary stability associated with an inflation coefficient inferior to one. Moreover, the other models in the Appendix are not rejected according to the J-test.

Some researchers may argue that the inflation coefficient is less than one because the central bank responds to deviations of inflation from the inflation target instead of to current or expected inflation alone. Moreover, since expected inflation is observable, and inflation target is announced in advance, those variables should be explicit in the Taylor rule. Thereby, instead of using equation (3), I estimate equation (4), which is repeated for convenience as follows:

$$i_t = g_i i_{t-1} + (1 - g_i)\{(r^* + \pi^*) + g_\pi d_{t,k} + g_x x_{t,q}\} + \varepsilon_t,$$

where $\varepsilon_t = v_t - (1 - g_i)\{g_\pi E_{t-1}(d_{t,k}) + g_x [x_{t,q} - E_{t-1}(x_{t,q})]\}$.

As already discussed, the expectations refer to inflation in the next twelve months. Therefore, it is fair to set expectations forward one year, that is, $(k, q) = (12, 1)$ for monthly data and $(k, q) = (4, 1)$ for quarterly data, according to the adjustments described in Section 3.

Table 6: Taylor Rule in the Inflation Target Era: Observed expected inflation target deviation forward one year - $(k, q) = (4, 1)$ (quarterly) and $(k, q) = (12, 1)$ (monthly)

Frequency	Quarterly		Monthly	
Output: $q_t =$ Output gap: $x_t =$	GDP $q_t-(\alpha_t+\beta_t t)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GDP $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$	GWh $q_t-(\alpha_t+\beta_t t+\gamma_t t^2)$
Coef./Period	**00:2-06:4**	**00:2-06:4**	**00:02-06:12**	**00:02-06:12**
π^*	6.103* (0.207)	2.216* (2.568)	5.603* (0.456)	5.438* (0.402)
g_π	0.818* (0.164)	2.973*** (1.577)	1.694* (0.540)	1.783* (0.594)
g_x	-0.488* (0.050)	-0.006 (0.018)	-0.438×10^{-3} (0.001)	-0.002 (0.004)
g_i	0.487* (0.053)	0.806* (0.093)	0.561* (0.091)	0.553* (0.096)
# obs.	27	27	83	83
$H_0 : g_\pi = 1$?	Do not reject	Do not reject	Do not reject	Do not reject
Prob J-test.	0.906	0.751	0.124	0.135

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard-deviations are in brackets. Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\{(r^* + \pi^*) + g_\pi d_{t,k} + g_x x_{t,q}\} + \varepsilon_t$.
GDP: Gross domestic product; GWh: Consumption of electric power in GWh. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, output gap, and 1 lag inflation target deviation.

The numbers in Table 6 are similar to those obtained by Minella *et alli* (2002, 2003) and Favero and Giavazzi (2002), especially the inflation parameter g_π and

π^{*23}. The coefficients g_x are all negative, whereas they are statistically significant only with quarterly data. The sign is consistent with Minella *et alli* (2002), but the magnitude is different. However, the big picture remains.

Not only does the smooth parameter g_i have the expected sign across output proxies, having returned to the size observed in the literature and in the Megainflationary Era, but also g_x and π^* are close to the figures in the previous table.

We see that the inflation parameter for quarterly GDP is now less than one. But the estimate is not much reliable because of the small number of observations. By contrast, the others are greater than one, but Wald tests indicate that we cannot reject that they are equal to one. Such conclusion is somewhat unexpected, because with stable inflation, we should find $g_\pi > 1$ as did Clarida, Galí and Gertler (2000) regarding the U.S.

Thus far, the models discussed in this section are equally plausible descriptions of the recent monetary policy in Brazil. In fact, if one adapted the R^2 as a measure of goodness-of-fit, then one would conclude they are practically identical, with a very tiny advantage of using the rule with inflation deviations. For example, in the rule with contemporaneous inflation, quadratic detrend of GWh, and monthly data, the R^2 is 0.544; the rule based on inflation target deviations, with the same detrend method and frequency, presents[24] an $R^2 = 0.549$. Consequently, we see again stable inflation associated with a loose monetary policy.

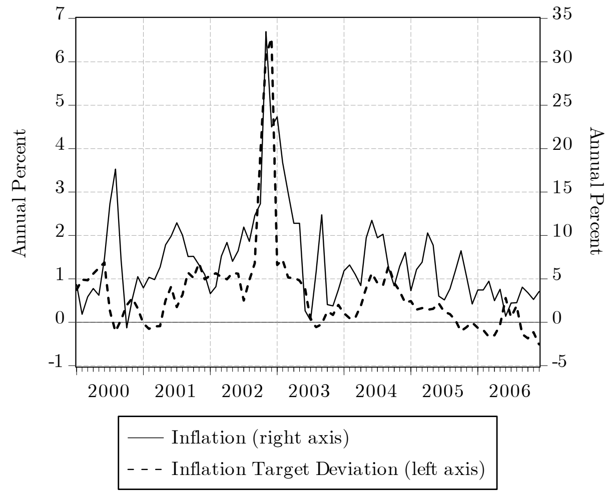
If both rules describe the monetary policy equally well, why is this so? It is beyond the scope of this paper to go further and answer that question, but perhaps a clue may help. Figure 5 suggests that current inflation and expected inflation target deviations are the two sides of the same coin, since they share similar tendencies at

[23] You must add the r^* to π^* to find their constant.

[24] The models based upon one period or one year forward present an R^2 on average equal to 0.4.

different absolute levels.

Figure 5: Overlap between Inflation and Inflation Target Deviation - monthly data



In fact, the correlation between the series is $0.6\dot{5}$. Furthermore, Granger tests indicate causality in either direction. That deviations should cause current inflation is somewhat intuitive by expectational Phillips curve arguments. However, the causality in the other direction is unexpected. Whatever the answer is, we remain in a rule where we have observed $g_\pi < 1$ under stable monetary regimes.

5 Conclusions

This paper has characterized the monetary policy in Brazil using the Taylor rule through a forward-looking Taylor-rule-type reaction function before and after the Real plan. Table 7 provides a picture of the outcomes in terms of Wald tests, using all output gap schemes and alternative rules.[25]

[25] See in Appendix E.1 the results for the Inflation Target Era using a model forward looking one year.

Table 7: Wald Test for $g_\pi = 1$

Output Model	*Potential Output*	*Megainflation* Forward	*Real* Forward	*Inflation Target* Current	Deviation
Quarterly Data					
GDP	Linear Trend	$> 1^{*}$	$< 1^{*}$	NR	NR
GWh	Linear Trend	$> 1^{***}$	$< 1^{*}$	$< 1^{*}$	$< 1^{*}$
	Quadratic Trend	$> 1^{*}$	$< 1^{*}$	$< 1^{*}$	NR
Monthly Data					
GDP	Linear Trend	NR	$< 1^{*}$	$< 1^{*}$	NR
	Quadratic Trend	$> 1^{*}$	$< 1^{*}$	$< 1^{*}$	NR
GWh	Linear Trend	$> 1^{*}$	U	$< 1^{*}$	NR
	Quadratic Trend	$> 1^{*}$	$< 1^{*}$	$< 1^{*}$	NR
IND	Linear Trend	NR	NR	$< 1^{*}$	NR

(*),(**),(***) significant at 1%, 5%, and 10%, respectively.

GDP: Gross domestic product; GWh: Total consumption of electric power in GWh, IND: Industrial production index, NR: not rejected, U: unfeasible. Forward refers to the model in which $(k, q) = (1, 1)$. Current refers to the model in which $(k, q) = (0, 0)$, however the conclusion is the same if we set either $(k, q) = (1, 1)$ or take expectations forward one year. Deviation refers to the model in which the explanatory variable is the observed expected inflation target deviation.

The table makes it clear that the inflation coefficient g_π was greater than one before stabilization and smaller than that afterwards, despite the existence of price indeterminacy in Brazil before the Real plan. During the Inflation Target Era, the coefficients are not statistically different from one even using a model where inflation deviation from the target is the explanatory variable. It is quite unexpected that the qualitative conclusions and the magnitudes of the numbers could be considerably homogeneous across different proxies for output, output gap and data frequency. This is particularly true when we remind ourselves how different the output gaps can be depending on the potential output specification, and how low the correlations between outputs with monthly data are.

From these findings, first, one can say that an interest rate response to inflation greater than one-to-one may not characterize monetary determinacy. Second, an interest rate response to inflation smaller than one-to-one may not characterize monetary indeterminacy. The first and second conclusions invert the Taylor's principle and challenge conventional wisdom as regards the rule.

Third, since $g_\pi > 1$ during the Megainflationary Era, monetary policymakers were *active* trying to keep inflation down, but failed or, at most, were able to hold prices up in order to avoid a hyperinflation. Moreover, the inflation coefficient significance in a forward-looking reaction function reveals that policymakers were in fact looking at least one period ahead to set up the interest rate. That is, monetary authorities were not passive against inflation and did not look back as many people still believe.

It seems clear that it is necessary to look for a model which could explain the behavior encountered in this paper. With regard to the question raised in the title, the Taylor rule did not stabilize inflation in Brazil and has not held it stable.

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Appendix A: Data Description and Basic Statistics

Quarterly data are in Table 8. They were downloaded from the Brazilian central bank or IPEADATA websites[26]. All data are log-linearized. Consumption of energy in GWh and inflation (IPCA) are seasonally adjusted by the X-12 procedure.

Table 8: Annualized Data Description: Quarterly Basis from 1980:1 to 2006:4 (in log)

Series	GDP^s	GWh^s	SELIC	$IPCA^s$	TD	Δe	ΔR
Units	R$ MM	GWh	%	%	%	%	%
Mean	13.0	10.9	428.0	358.0	0.75	47.4	8.0
SD	0.186	0.333	247.8	210.8	1.3	62.2	3.2
# Obs.	108	108	108	108	28	108	108

GDP: Gross domestic product; GWh: Consumption of electric power in gigawatt/hour, GWh; SELIC: Effective federal funds rate; IPCA: Consumer price index; TD Inflation target deviation; e exchange rate; R reserves (liquidity concept); (s) = seasonally adjusted; variables in log

Monthly data are in Table 9. They were downloaded from the Brazilian central bank or IPEADATA websites. All data are log-linearized. Consumption of energy in GWh, Gross domestic product (GDP), Industrial production index (IND) and inflation (IPCA) are seasonally adjusted by the X-12 procedure.

Table 9: Annualized Data Description: Monthly Basis from 1990:01 to 2006:12 (in log)

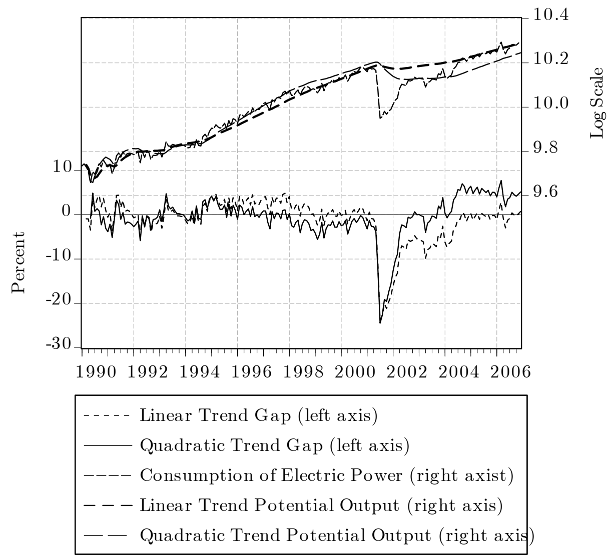
Series	GDP^s	GWh^s	IND^s	SELIC	$IPCA^s$	TD	Δe	ΔR
Units	US$ MM	GWh	2002 = 100	%	%	%	%	%
Mean	10.9	10.0	4.5	92.4	79.5	0.67	77.4	12.8
SD	0.294	0.170	0.127	136.0	134.0	1.1	148.6	94.5
# Obs.	204	204	192	204	204	84	204	204

GDP: Gross domestic product; GWh: Consumption of electric power in gigawatt/hour, GWh; IND Industrial production index; SELIC: Effective federal funds rate; IPCA: Consumer price index; TD Inflation target deviation annualized; e exchange rate; R reserves (liquidity concept); (s) = seasonally adjusted; variables in log

[26] The Websites are: http://www.ipeadata.gov.br/ipeaweb.dll/ipeadata?Lang=English&Tick=1207068162578; and https://www3.bcb.gov.br/sgspub/localizarseries/localizarSeries.do?method=prepararTelaLocalizarSeries

Appendix B: Differences in Monthly Output Gap Using GWh

Figure 6: Output, Potential Output and Output Gap based on Consumption of Electrical Power in GWh - Monthly Data



Here, both linear and quadratic gaps are quite reasonable. They indicate alternate periods of expansion and recession. Notwithstanding, the linear potential output has remained above quadratic potential output after the power shortage in 2001.

Appendix C: Robustness Check for the Megainflationary Era section with other Ouptput Gaps

The reaction function estimated here is:

$$i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t,$$

where $\varepsilon_t = v_t - (1 - g_i)\left\{g_\pi\left[\pi_{t,k} - E_t(\pi_{t,k})\right] + g_x\left[x_{t,q} - E_t(x_{t,q})\right]\right\}.$

Table 10 reinforces the results discussed in the main body of the paper, except for the fact that g_π for the GDP is nonsignificant, although very high in size. Monthly data seem to show a higher π^*, but the other conclusions remain.

Table 10: Taylor Rule in the Megainflationary Era $(k, q) = (1, 1)$

Frequency	Quarterly	Monthly		
Output: $q_t =$ Output gap: $x_t =$	GWh $q_t - (\alpha_t + \beta_t t)$	GDP $q_t - (\alpha_t + \beta_t t)$	GWh $q_t - (\alpha_t + \beta_t t)$	IND $q_t - (\alpha_t + \beta_t t)$
Coef./Period	**81:3-94:2**	**90:07-94:06**	**90:07-94:06**	**91:07-94:06**
π^*	104.021^* (9.262)	188.494^* (19.381)	201.857^* (30.877)	202.743^{**} (77.597)
g_π	2.189^* (0.624)	5.555 (4.177)	1.430^* (0.222)	1.610^* (0.537)
g_x	0.209 (1.297)	-3.133 (2.477)	-1.127^* (0.321)	-0.443 (0.506)
g_i	0.774^* (0.085)	0.946^* (0.067)	0.773^* (0.059)	0.748^* (0.082)
# obs.	52	48	48	36
$H_0 : g_\pi = 1$?	Reject***, $g_\pi > 1$	Do not reject	Reject***, $g_\pi > 1$	Do not reject
Prob J-test.	0.573	0.818	0.883	0.833

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard-deviations are in brackets.
Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t$
. GDP: Gross domestic product; GWh: Consumption of electric power in GWh; IND: Industrial production index. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, and output gap.

Appendix D: Robustness Check for the Real Era section with other Ouptput Gaps

The reaction function estimated here is:

$$i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\,\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t,$$

where $\varepsilon_t = v_t - (1 - g_i)\left\{g_\pi\left[\pi_{t,k} - E_t\left(\pi_{t,k}\right)\right] + g_x\left[x_{t,q} - E_t\left(x_{t,q}\right)\right]\right\}$.

Table 11 reinforces the results discussed in the main body of the paper, except for the fact that g_π for the IND is greater than one, although not statistically different from 1. Results for quarterly GWh seem weird, probably because of the low number of observations.

Table 11: Taylor Rule in the Real Era $(k, q) = (1, 1)$

Frequency	Quarterly	Monthly		
Output: $q_t =$ Output gap: $x_t =$	GWh $q_t-(\alpha_t+\beta_t t)$	GDP $q_t-(\alpha_t+\beta_t t)$	GWh $q_t-(\alpha_t+\beta_t t)$	IND $q_t-(\alpha_t+\beta_t t)$
Coef./Period	**94:3-98:4**	**94:07-98:12**	**94:07-98:12**	**94:07-98:12**
π^*	-18.079^* (2.574)	4.378 (5.110)		16.300^* (3.754)
g_π	0.541^* (0.019)	0.700^* (0.102)		1.260^* (0.159)
g_x	-0.922^* (0.024)	0.016^{**} (0.008)		-0.069^* (0.022)
g_i	-0.009^* (0.001)	0.085^* (0.003)		0.077^* (0.004)
# obs.	18	54		54
$H_0 : g_\pi = 1$?	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$		Do not reject
Prob J-test.	0.861	0.730		0.906

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard deviations are in brackets. Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\,\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t$. GDP: Gross Domestic Product; GWh: Consumption of electric power in GWh; IND: Industrial Production Index. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, and output gap.

Appendix E: Robustness Check for the Inflation Target Era section

Appendix E.1: Forward Looking Model

The reaction function estimated here is:

$$i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t,$$

where $\varepsilon_t = v_t - (1 - g_i)\{g_\pi [\pi_{t,k} - E_t(\pi_{t,k})] + g_x [x_{t,q} - E_t(x_{t,q})]\}$.

The main difference is that now $(k, q) = (12, 1)$ for monthly data and $(k, q) = (4, 1)$ for quarterly data. Tables 12 and 13 reinforce the results discussed in the main body of the paper. The inflation coefficient g_π negative in general, and sometimes nonsignificant. The other coefficients are reasonable.

Table 12: Taylor Rule in the Inflation Target Era: Observed expected inflation target deviation forward one year - $(k, q) = (4, 1)$ (quarterly) and $(k, q) = (12, 1)$ (monthly)

Frequency	Quarterly		Monthly	
Output: $q_t =$ Output gap: $x_t =$	GDP $q_t - (\alpha_t + \beta_t t)$	GWh $q_t - (\alpha_t + \beta_t t + \gamma_t t^2)$	GDP $q_t - (\alpha_t + \beta_t t + \gamma_t t^2)$	GWh $q_t - (\alpha_t + \beta_t t + \gamma_t t^2)$
Coef./Period	**00:2-05:4**	**00:2-05:4**	**00:02-05:12**	**00:02-05:12**
π^*	7.062^* (0.045)	7.018^* (2.440)	7.337^* (0.370)	7.204^* (0.245)
g_π	-0287^* (0.011)	-0.533^* (0.078)	-0.730 (0.584)	-0.020 (0.033)
g_x	-0.477^* (0.009)	-0.049^* (0.005)	-0.004 (0.004)	-0.001 (0.001)
g_i	-0.618 (0.057)	0.427^* (0.044)	0.603^* (0.054)	0.115 (0.173)
# obs.	23	23	71	71
$H_0 : g_\pi = 1$?	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$
Prob J-test.	0.991	0.993	0.838	0.908

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard deviations are in brackets. Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t$. GDP: Gross domestic product; GWh: Consumption of electric power in GWh. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, output gap, and 1 lag inflation target deviation. The bandwidth was fixed in 11 for monthly data and 3 for quarterly data, using the Bartlett kernel.

In other estimations, not reported in this paper but available from the author upon request, I estimate the model setting $(k,q) = (1,1)$ as in the other subsamples. There are some differences. The parameter g_π is low, significant and positive for quarterly data. By contrast, it is always negative and nonsignificant for monthly data. The parameter g_i is similar to literature.

Table 13: Taylor Rule in the Inflation Target Era: Observed expected inflation target deviation forward one year - $(k,q) = (4,1)$ (quarterly) and $(k,q) = (12,1)$ (monthly)

Frequency	Quarterly	Monthly		
Output: $q_t =$	GWh	GDP	GWh	IND
Output gap: $x_t =$	$q_t - (\alpha_t + \beta_t t)$	$q_t - (\alpha_t + \beta_t t)$	$q_t - (\alpha_t + \beta_t t)$	$q_t - (\alpha_t + \beta_t t)$
Coef./Period	**00:2-05:4**	**00:02-05:12**	**00:02-05:12**	**00:02-05:12**
π^*	4.365^*	6.097^*	6.721^*	7.238^*
	(0.183)	(0.158)	(0.186)	(0.108)
g_π	-0.387^*	-2.758^*	-0.244^*	-0.751^*
	(0.078)	(0.650)	(0.086)	(0.157)
g_x	-0.071^*	-0.018^*	-0.014^*	-0.059^*
	(0.013)	(0.003)	(0.004)	(0.010)
g_i	0.561^*	0.757^*	0.435^*	0.417^*
	(0.032)	(0.064)	(0.047)	(0.085)
# obs.	23	71	71	71
$H_0 : g_\pi = 1?$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$
Prob J-test.	0.981	0.845	0.850	0.844

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard deviations are in brackets. Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i)\left[(r^* - (g_\pi - 1)\,\pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q}\right] + \varepsilon_t$
. GDP: Gross domestic product; GWh: Consumption of electric power in GWh. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, output gap, and 1 lag inflation target deviation. The bandwidth was fixed in 11 for monthly data and 3 for quarterly data, using the Bartlett kernel.

Appendix E.2: Current Looking Model

Table 14 completes the exercise with other output gaps with current inflation. It uses the same model as the last section, so it is not repeated here.

Table 14: Taylor Rule in Inflation Target Era $(k, q) = (0, 0)$

Frequency	Quarterly	Monthly		
Output: $q_t =$ Output gap: $x_t =$	GWh $q_t-(\alpha_t+\beta_t t)$	GDP $q_t-(\alpha_t+\beta_t t)$	GWh $q_t-(\alpha_t+\beta_t t)$	IND $q_t-(\alpha_t+\beta_t t)$
Coef./Period	**00:2-06:4**	**00:02-06:12**	**00:02-06:12**	**00:02-06:12**
π^*	3.173 (3.054)	6.168* (0.519)	5.877* (0.377)	6.714* (0.396)
g_π	0.609* (0.161)	0.405* (0.097)	0.384* (0.095)	0.381* (0.079)
g_x	−0.023** (0.010)	−0.001 (0.001)	−0.006 (0.004)	−0.030** (0.014)
g_i	0.757* (0.067)	0.503* (0.107)	0.481* (0.126)	0.486* (0.113)
# obs.	27	83	83	83
$H_0 : g_\pi = 1$?	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$	Reject*, $g_\pi < 1$
Prob J-test.	0.991	0.145	0.608	0.937

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard deviations are in brackets.
Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i) \left[(r^* - (g_\pi - 1)\, \pi^*) + g_\pi \pi_{t,k} + g_x x_{t,q} \right] + \varepsilon_t$.
GDP: Gross Domestic Product; GWh: Consumption of electric power in GWh; IND: Industrial production index. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, output gap, and 1 lag inflation target deviation.

Appendix E.3: Observed Expected Inflation Target Deviation Forward One Year

The reaction function is

$$i_t = g_i i_{t-1} + (1 - g_i) \{(r^* + \pi^*) + g_\pi [E_t (\pi_{t,k}) - \pi_t^*] + g_x x_{t,q}\} + \varepsilon_t,$$

where $\varepsilon_t = \upsilon_t - (1 - g_i) g_x [x_{t,q} - E_t (x_{t,q})]$.

Table 15: Taylor Rule in the Inflation Target Era: Observed expected inflation target deviation forward one year - $(k, q) = (4, 1)$ (quarterly) and $(k, q) = (12, 1)$ (monthly)

Frequency	Quarterly	Monthly		
Output: $q_t =$ Output gap: $x_t =$	GWh $q_t - (\alpha_t + \beta_t t)$	GDP $q_t - (\alpha_t + \beta_t t)$	GWh $q_t - (\alpha_t + \beta_t t)$	IND $q_t - (\alpha_t + \beta_t t)$
Coef./Period	**00:2-06:4**	**00:02-06:12**	**00:02-06:12**	**00:02-06:12**
π^*	3.584 (2.455)	5.405* (0.347)	5.212* (0.377)	6.160* (0.671)
g_π	−1.171 (0.690)	1.547* (0.558)	1.588* (0.568)	1.990** (0.818)
g_x	−0.119** (0.050)	−0.002 (0.001)	−0.007 (0.006)	−0.061* (0.020)
g_i	0.769* (0.086)	0.557* (0.089)	0.544* (0.095)	0.672* (0.068)
# obs.	27	83	83	83
$H_0 : g_\pi = 1$?	Reject*, $g_\pi < 1$	Do not reject	Do not reject	Do not reject
Prob J-test.	0.993	0.131	0.146	0.002

(*),(**),(***) significant at 1%, 5%, and 10%, respectively. Standard-deviations are in brackets. Estimated by GMM: $i_t = g_i i_{t-1} + (1 - g_i) \{(r^* + \pi^*) + g_\pi [E_t (\pi_{t,k}) - \pi_t^*] + g_x x_{t,q}\} + \varepsilon_t$.
GDP: Gross Domestic Product; GWh: Consumption of electric power in GWh; IND: Industrial Production Index. Instruments include: lags 1 to 4 of interest rate, inflation, exchange rate variation, reserves variation, output gap, and 1 lag inflation target deviation.