Frequency of Central Bank Evaluation in an Inflation Targeting Regime: the Brazilian Experience

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Abstract

This paper analyses the optimal frequency for Central Bank evaluation in an inflation-targeting regime, applied to the Brazilian economy. Setting a frequency of accountability is an important issue in the design of an inflation-targeting regime, since it allows the matching of conflicting targets between the monetary authority and the government: while the government cares about inflation and employment, the Central Bank should be concerned only about inflation. Through stochastic simulations, it was possible to conclude that the Central Bank should be evaluated every two or three years. However, there are little losses involved in the current Brazilian regime, where the Central Bank is evaluated in the end of every calendar year. Only in case of very frequent evaluations, like at every two quarters, the social welfare loss would be significant, with high output gap and inflation variances.

Keywords: Inflation targeting, monetary policy, accountability of the Central Bank
JEL classification: E52, E58

Frequency of Central Bank Evaluation in an Inflation Targeting Regime: the Brazilian Experience

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I - Introduction

The objective of this paper is to evaluate the optimal frequency of Central Bank evaluation in an inflation-targeting regime, with application for the Brazilian case. Optimality refers to establishing a frequency of evaluation that is compatible with the minimization of a loss function, whose arguments are inflation and output gap variances. Regarding the frequency of evaluation, in the Brazilian inflation-targeting regime, the performance of the Central Bank is assessed in the end of every calendar year. The Central Bank will have a positive evaluation in case the observed inflation lies within the admitted tolerance interval[1]. Otherwise, the Governor of the Central Bank will have to write an open letter explaining the reasons of missing the target and describing the measures that will be taken in order to make inflation come back to the target. The accountability of the Central Bank is a common feature of the existing inflation targeting regimes, although there is a wide variation in assessing the performance of the Central Banks[2].

Since in the Brazilian case an eventual punishment will depend exclusively on the behavior of the inflation, it is reasonable to assume that, independently of the preferences of the Central Bank, monetary police will be conducted in a way to minimize the probability that observed inflation is out of the tolerance interval. Therefore there is a potential conflict of interests: on one side, the Central Bank, in spite of deciding the basic interest rate in all periods, should be only directly concerned with the deviation between actual inflation and the target in the period where evaluation occurs, that is, it should be mainly concerned with year-end outcomes. On the other hand, the government should be worried not only with

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♦♦ The author wishes to thank Gil Riella for his valuable computational support. Interpratation and any remaining errors are my own responsibility. This paper expresses only the opinion of the author and in not those of the Banco Central do Brasil.
[1] In Brazil, the tolerance interval is plus or minus 2.5 pp around the central target established for 2003 and 2004.

inflation outcomes during the whole year but also with the variance of output gap. It is possible, therefore, that the Central Bank conducts monetary policy in an inefficient way, from the point of view of the government.

However, the conflicting objectives between government and Central Bank should not necessarily generate inefficiency. Clarida et al. (1999) show that, when output gap variance has a strictly positive weight in the loss function, it is optimal to make a gradual convergence of inflation to the target. Battini and Haldane (1999) also argue that output variance depends on the horizon of the inflation target. Intuitively, through the transmission mechanism of police monetary via aggregate demand, variations in the interest rate lead to variations in the output gap. If the frequency of evaluation is very high, the Central Bank will be forced to generate high volatility in the nominal interest rate, increasing the volatility of output gap. If the evaluation of the Central Bank is made at longer intervals, there is a smaller probability that abrupt alterations in the interest rate are necessary and, hence, output variability should be smaller. For England, Batini and Nelson (2000) estimated an optimal horizon between 8 and 19 quarters.

In this way, by choosing the frequency of evaluation of the Central Bank, the government can generate inflation and output outcomes that maximize its own utility function. The main exercise of this paper will be to estimate the optimal frequency of Central Bank evaluation for the Brazilian case, given different weights for inflation and output gap variance in the government's loss function.

This paper will have two sections, besides the Introduction and the Conclusion. Section 2 presents the Battini and Haldane (1999) model for inflation, exchange rate and output gap determination and describes the stochastic simulation used to find the optimal interest rate rule. In a few words, it was assumed that the Central Bank sets the interest rate according to a Taylor type rule. For each evaluation frequency, the parameters of the interest rate equation are chosen in order to minimize the expected inflation variance. Section 3 presents the results. It could be found that the optimal parameters of the Taylor rule are not very sensitive to the frequency of evaluation, except in the case where the Central Bank is evaluated at every two quarters. At this frequency, the reaction of the Central Bank to inflation deviations should be stronger than under longer frequencies. The optimal frequency for

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[2] Bernanke *et al.* (1999) summarizes different regimes of inflation targeting.

evaluation varies between 8 and 12 quarters, although the loss of utility is small if the evaluation is made on an annual basis, as it is currently done in Brazil. Finally, the Conclusion summarizes the main results and presents suggestions for future research.

II - The structural model and the stochastic simulation

The Battini & Haldane (1999) model will be used for determination of the output gap, inflation and exchange rate. According to this model, price rigidities enable monetary police to have real effects in the short run. Such rigidities arise as a consequence of overlapping wage adjustments. The reduced form of the model is given by:

(1) $y_t = \alpha_1 y_{t-1} + \alpha_2 E_t y_{t+1} + \alpha_3 (i_{t-1} - E_{t-1}\pi_t) + \alpha_4 z_{t-1} + \varepsilon_t^h$

(2) $\pi_t = \chi_0 E_t(\pi_{t+1}) + (1-\chi_0)\pi_{t-1} + \chi_1(y_t + y_{t+1}) + \mu[(1-\chi_0)\Delta x_t + \chi_0 E_t(\Delta x_{t+1})] + \varepsilon_t^\pi$

(3) $e_t = E_t e_{t+1} - (i_t - i_t^f) + \varepsilon_t^e$

The first equation corresponds to the IS curve and states that the output gap - y - depends on its own value lagged one period; on the expectation of output gap in the following period; on the ex-ante real rate of interest of the previous period, i_{t-1} - $E_t\pi_t$; on the rate real exchange rate, z; and on an error term. It is expected α_3 to be negative and the other parameters to be positive. Observe that there is no constant in this IS curve, what is consistent with the equilibrium real interest rate being equal to zero[3]. This is equivalent to say that the model and the simulations will refer to deviations with respect to the mean values of the variables.

The second equation is the Phillips curve, that says that the current inflation - π_t depends on expected and previous inflation; on the output gap; on the variation of the tradable goods prices denominated in local currency - Δx - which corresponds to the sum of the logarithms of the variation of nominal exchange rate and of foreign inflation; and on an error term. Observe that, unlike what happens with the IS curve,

[3] Equilibrium real interest rate - r* - is obtained by making output gap equals to zero. Making y=0 in (2) and rearranging one gets: $r^* = \alpha_4 z^* / \alpha_3$, where z* is the equilibrium real exchange rate. If z* is zero, r* will also be zero. If there were a constant term in (1), it would be added to the numerator of the above formula.

the restriction of no intercept in the Phillips curve is not only a matter of redefining measurement units. This restriction is a theoretical necessity to ensure long run verticality of the Phillips curve.

The third equation presents the nominal exchange rate determination by the uncovered interest rate parity condition. That is, expected exchange rate depreciation - $E_t e_{t+1}$ - e_t - should depend on the difference between domestic and foreign nominal interests - i and i^f -, respectively; and on an error term. This equation does not explicitly include a measurement of country risk. Although the country risk is an important factor to explain the behavior of exchange rate movements for emergent economies, this simplification does not alter the core of this paper: firstly, because since the model deals only with deviations in relation to the mean, variations in Brazil risk may be incorporated into the forecast error; secondly, it is not the objective of this paper to model the country risk.

Equations 1-3 above incorporate the main channels of the transmission mechanism of monetary police. Firstly, the presence of the lagged term for inflation in the Phillips curve allows for changes in the nominal interest rate to alter the real interest rate. From the IS curve (1), an increase in the real interest rate causes a reduction in the output gap (reminding that α_3 is negative) and, according to the Phillips curve (2), leads to a reduction in the inflation rate. This is the aggregate demand channel. The other mechanism in this model is the exchange rate one. From the exchange rate equation (3), an increase in the domestic interest rate causes an appreciation of the exchange rate and pressures inflation downwardly through reduction of tradable goods prices.

For the simulations that they will be presented, it will be used the parameters calibrated by Bonomo and Brito (2001), reproduced in the table below:

Parameters	
α_1	0,93
α_2	0,06
α_3	-0,44
α_4	0,08
χ_0	0,85
χ_1	0,09
μ	0,1

Observe that, according to the calibration done by Bonomo and Brito (2001), inflation has a large forward-looking component, with a coefficient of 0.85, while the output gap is more backward-looking, with coefficient of 0.93. Since output gap is very sluggish, the period necessary for the transmission mechanism to be effective should be longer. Because of this characteristic, in the short run, the whole impact of monetary police on inflation should be through the exchange rate channel.

The variance covariance matrix estimated by Bonomo and Brito (2001) is given by:

$$\Sigma = \begin{bmatrix} 0{,}0001 & -0.0001 & -0.0006 \\ & 0.0003 & 0.0004 \\ & & 0.0055 \end{bmatrix} \qquad (4)$$

Where the columns and lines refer to the residual of the output gap, of the inflation and of the exchange rate, respectively. In spite of there being contemporaneous correlation among the error terms, it is assumed that they are not auto-correlated.

These equations enable an endogenous determination of inflation, output gap and exchange rate. Therefore, it is still missing an equation for the interest rate. It is assumed that the Central Bank decides the interest rate under discretion. To simplify the analysis, it is assumed monetary policy follows a Taylor rule, whose parameters are optimally chosen:

$$i_t = \gamma_1 i_{t-1} + (1-\gamma_1)[\gamma_2 \pi_{t-1} + \gamma_3 y_{t-1}] \qquad (5)$$

That is, it is assumed the Central Bank makes decision on interest rate based on one-lagged inflation, interest rate and output gap[4].

The vector $\boldsymbol{\gamma} = \{\gamma_1, \gamma_2, \gamma_3\}$ is chosen by the Central Bank in order to maximize its utility function. As explained in the Introduction, the objective of the Central Bank is to minimize the probability of actual inflation laying out of the pre-established tolerance interval in the evaluation period, say, t+s. Thus, the objective of the Central Bank can be written as:

[4] There are other specifications for the Taylor rule (see Taylor, 2000) that keeps the simplicity of the formula above. That is, the Central Bank may set interest rate according to a linear combination of other macroeconomic variables, like exchange rate or expected inflation, instead of realized inflation.

$$\max_{\gamma_1,\gamma_2,\gamma_3} \Pr ob(\pi^*_{t+s} - \delta \leq \pi_{t+s} \leq \pi^*_{t+s} + \delta) \qquad (6)$$

where δ is interval of tolerance around the central target. For a symmetrical distribution of errors, as assumed in this simulation[5], the probability above is maximized when the Central Bank chooses the interest rate that satisfies:

$$E_t\pi_{t+s} = \pi^*_{t+s}$$

Therefore, the Central Bank will choose an interest rate that minimizes the difference between expected inflation and the target. Due to the well-known problems of minimizing differences, the Central Bank should actually minimize the square of errors, that is:

$$\min_{\gamma_1,\gamma_2,\gamma_3} [E_t\pi_{t+s} - \pi^*_{t+s}]^2$$

Finally, since all variables are being expressed as deviations from the mean, it is reasonable to work with a target constant at zero. Besides, as the objective function is quadratic and the restrictions (equations 1 to 3 and 5) are linear, one can apply the certainty equivalence principle[6] and rewrite the loss function of the Central Bank as:

$$\min_{\gamma_1,\gamma_2,\gamma_3} \left[E_t(\pi_{t+s})^2\right] \qquad (7)$$

The final problem is the determination of the "s" above, that is, to which horizon the Central Bank should look at. A simplifying assumption was made stating that, in the evaluation time, the Board of the Central Bank looses its mandate if

[5] It is assumed that the error terms are normally distributed and there is no uncertainty regarding the parameters of the model. Therefore, the inflation forecast error will be a linear function of the error term in the Phillips curve - ε^π – and the error terms in the IS and exchange rate equations - ε^y and ε^e, respectively. Since it is a linear function of normally distributed errors, the forecast error will also be normally distributed.

[6] Estrella and Mishckim (1999) show the equivalence principle for a model similar to the one used here. However, it is necessary to assume that there is no uncertainty regarding the parameters of the model. When the certainty equivalence principle can be applied, the Central Bank is indifferent between minimizing the expected square of the deviations or the square of the expected deviations.

realized inflation falls out of the tolerance interval. Therefore, the Board should choose “s” in such a way to coincide with the first time when they are appraised. For example, if the evaluation is made every 2 periods, s=2, and so forth. That is, if the Central Bank is evaluated every two quarters, monetary policy will be conducted in order to minimize the deviation between expected inflation and the target in the following two quarters.

The dynamics of the model is the following: at the end of each period, the Central Bank chooses the interest rate and, after taking this decision, the shocks are revealed for the whole society. After each shock, economic agents reassess their expectations regarding the future trajectory of interest rate, inflation, output gap and exchange rate. Since it is a linear model of rational expectations, the solution of the system was obtained through the Blanchard-Kahn (1980) decomposition and the non pre-determined variables was inflation, output gap and exchange rate.

It is assumed that the economy is in the steady state at t=0. As the interest rate set at t=1 depends only on variables observed in the previous period, $i_{t=1} = 0$, regardless of the shocks occurred in this period. Hence, it does not make sense to evaluate the Central Bank every period and the minimum frequency of evaluation should be of two periods. After all, at t=2, the interest rate will react to the shocks observed in t=1 and will have a contemporaneous effect on inflation, mainly thorugh the exchange rate channel.

The first step to find the Taylor rule that minimizes (7) was to generate 150 series of 13 periods each, defining the shocks for inflation, output gap and exchange rate. Those shocks were generated according to the variance-covariance matrix (4). Thus, for each Taylor rule and for each sequence of shocks, the Central Bank chooses a sequence of 13 interest rates. As this exercise was repeated 150 times for each Taylor rule, it was possible to calculate the variance of inflation for each period. The optimal Taylor rule should correspond to the values of the vector $\boldsymbol{\gamma} = \{\gamma_1, \gamma_2, \gamma_3\}$ that minimizes (7). It was not possible, however, to do this optimization directly using the software Matlab, because the results did not converge. Therefore, it was necessary to span the whole space of possible values of $\boldsymbol{\gamma}$, in intervals of 0,20 and, later on, for smaller grids, reaching intervals of 0,05. By doing this exercise, it was obtained the variance of inflation for all possible combinations of γ_1 (the coefficient of the nominal interests) ranging from 0 to 1; γ_2 (the inflation coefficient) ranging from 1 to 5[7] and γ_3 (the output gap coefficient) ranging from 0 to 3.

Once one obtained the optimal variances of inflation and output gap, according to the Central Bank loss function, the Government's loss function can be calculated by the formula below:

$$L^g = \sum_{j=t}^{T} \rho^s [\lambda E_t (\pi_j - \pi_j^*)^2 + (1-\lambda) E_t y_j^2] \qquad (8)$$

where: π is the inflation rate; π^* is the inflation target; y is the output gap, defined as the difference (in logarithms) between the actual and potential output; $\lambda \in [0,1]$ is the weight attributed to inflation variability compared to output gap variability; ρ is the intertemporal discount factor[8]. Thus, for each value of λ, the optimal frequency of evaluation of the Central Bank should be the one that minimizes (8).

III - Results

The Table below exhibits the coefficients of the Taylor rule that optimize each frequency of evaluation:

Table 1: Coefficients of the Taylor rule by Frequency of Evaluation

Coefficients	Period of Evaluation			
	2	4 and 6	8	12
γ_1 (interest rate)	0.00	0.00	0.00	0.00
γ_2 (inflation)	4.40	1.65	1.60	1.55
γ_3 (output gap)	0.00	1.05	1.05	0.95

As it can be seen, except for evaluation done at every two periods, the coefficients for the other frequencies are very similar and, in the case of γ_2, the

[7] Coefficient γ_2 should be greater than 1 in order to ensure system stability. Intuitively, if $\gamma_2 \leq 1$, the Central Bank plays an accommodative monetary policy, letting real interest rate fall when inflation is rising. This behavior lead to higher aggregate demand, what pressures inflation upwardly.

[8] This is the most common loss function found in the literature, although there are other specifications. In general, there are terms penalizing deviations of inflation from the target and output gap deviations,

response of nominal interest rate to inflation, the value was very close of 1.5, the one found by Taylor (1993). In all cases, interest rate is optimally set without taking into consideration its previous value ($\gamma_1 = 0$). Finally, as expected, the reaction of interest rate to deviations of inflation to the target is stronger when evaluation is made at every two quarters. In this case, due to the fact that the output gap is very auto-regressive, there is not enough time for monetary police to affect inflation through the aggregate demand channel. Therefore, the only way for interest rate to offset the shocks will be through the exchange rate channel.

Chart 1: Output Gap Variance by Evaluation Frequency

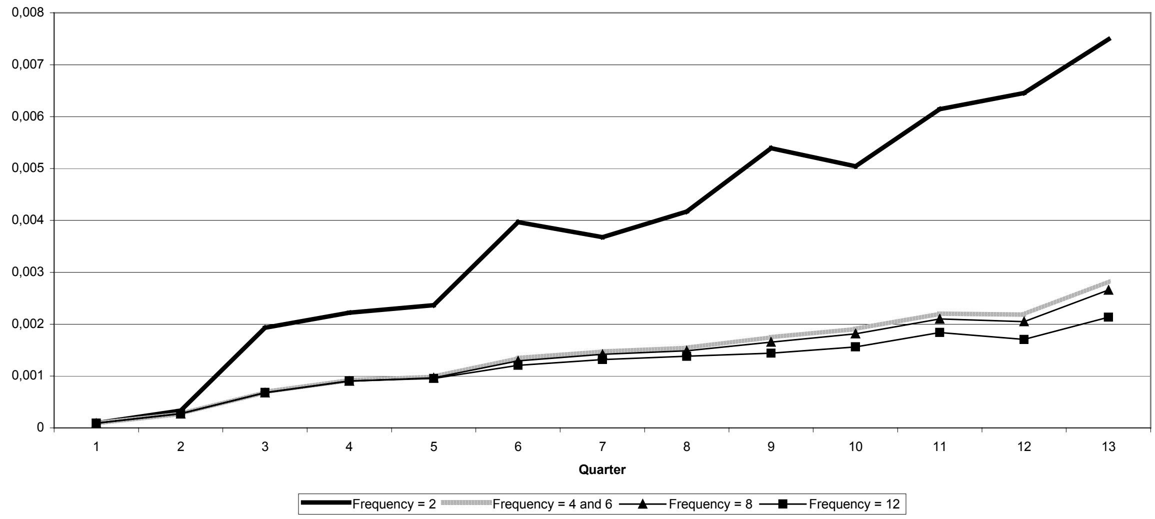

Chart 1 ratifies the hypothesis presented in the introduction that it is possible to have a certain control of output gap variance, even if the Central Bank has the sole objective to minimize the deviation of inflation to the target. Each loccus shows the variance of output gap for a specific evaluation frequency. This variance is the result of a monetary policy, which follows the Taylor rule that optimizes the utility of the Central Bank. Since the Taylor rules that optimize the frequencies from 4 to 12 periods are very similar, it is straightforward that the variances associated with these rules are also similar. The variances are more different when one considers the two-period frequency, though. From the 5th quarter on, it is more evident that the output gap variance falls monotonically with the increase in the interval of evaluation. The similarity of the output gap variance in the first two quarters among the different

although these terms are not necessarily quadratic. It is also found loss functions involving penalties

Taylor rules can be attributed to the existing lags in the transmission mechanism of monetary policy through the aggregate demand channel. In the first periods, the behavior of output gap is mostly determined by the realizations of the error term of the IS curve and are only marginally affected by monetary police.

Chart 2 exhibits the variance of inflation by each Taylor rule. The behavior was similar to the one observed for the output gap. Along time, the variances associated with the two-period evaluation frequency get further apart from the variances associated with other frequencies. It should be observed that an excessive reaction of interest rate to the deviations of inflation to the target does not necessarily reduce the variance of inflation. After all, in the Taylor rule associated with the two-period frequency, the coefficient of inflation is almost 3 times bigger (4.4 versus about 1.55) than the coefficients for inflation associated with other frequencies. Nevertheless, the variance of inflation after three quarters is higher under the two-period frequency. As there is no interest rate smoothing (coefficient $\gamma_0 = 0$ in the Taylor rule), the smaller inflation variance under longer periods of evaluation may be explained by the fact that the Central Bank also responds to deviations of the output gap. That is, when reacting to the output gap, the Central Bank can also reduce inflation variance.

Chart 2: Inflation Variance by Frequency of Evaluation

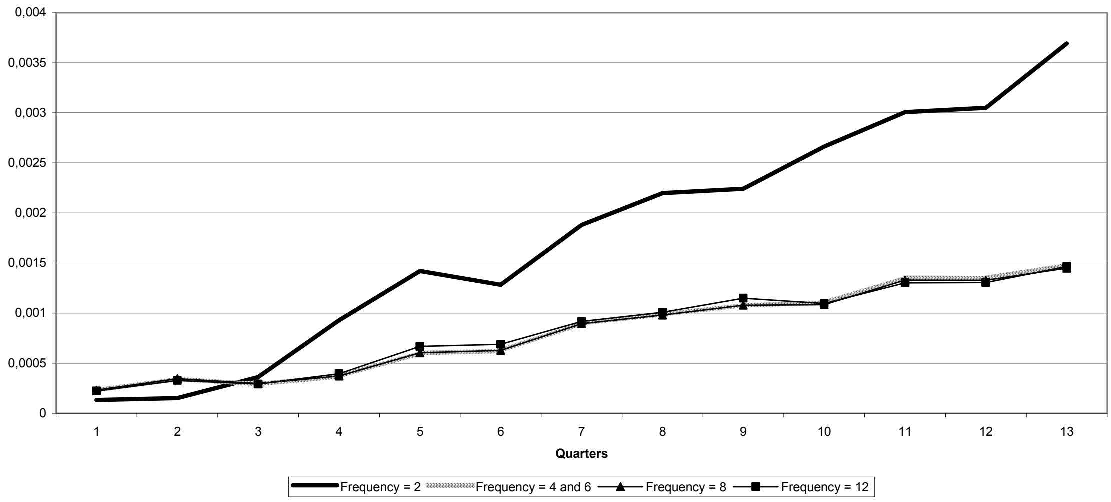

Table 2 below exhibits the loss of the government by different weights (λ) attached to inflation and output gap variances. The losses were calculated using the variances found above. It was assumed a semi-myopic society, that considers only the

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for interest rate and exchange rate variation.

first 13 periods to evaluate the loss. This limitation to 13 periods was due, mainly, to computational costs. However, from the trends presented in charts 1 and 2, it seems likely that the ordering of inflation and output gap variances should not be affected when longer horizons are introduced in the loss function. The results shown refer to a discount rate (ρ) of 0.99, but they are robust to different values of ρ[9]. As it can be seen, varying λ from 0 to 0.8, that is, in a range that encompasses a zero weight to inflation variance to a weight that is relatively large, the optimal frequency of evaluation is 3 years. If λ is between 0.8 and 1, which corresponds to a society that is extremely averse to inflation, it is optimal to evaluate the Central Bank at intervals of two years.

[9] The ordering of preferences did not change for ρ higher than 0.85.

Table 2: Value of the Government's Loss Function by λ and by Frequency of Evaluation

λ (weight for inflation)	Frequency of Evaluation			
	2	4 and 6	8	12
0.0	0.038	0.014	0.014	0.012
0.1	0.036	0.014	0.013	0.012
0.2	0.034	0.013	0.013	0.012
0.3	0.032	0.012	0.012	0.011
0.4	0.030	0.012	0.012	0.011
0.5	0.028	0.011	0.011	0.010
0.6	0.026	0.011	0.010	0.010
0.7	0.024	0.010	0.010	0.010
0.8	0.022	0.010	0.009	0.009
0.9	0.020	0.009	0.009	0.009
1.0	0.018	0.008	0.008	0.009

The result above indicates that the frequency of evaluation of the inflation-targeting regime in Brazil is sub-optimal. However, as table 3, shows, the loss associated with this sub-optimality is very small in relative terms. This table shows the incurred loss (in %) when it is used an evaluation frequency different from the one that minimizes the government's loss function, for each λ. For evaluations done at each 4 quarters, like in the Brazilian regime, the loss ranges from 15% when $\lambda = 0$ to less than 1% when $\lambda = 1$. It is possible that other aspects not captured in the model, like the credibility of the Central Bank, favor shorter frequencies of evaluation. But it is clear from the results that evaluations done at very high frequency should lead to welfare losses.

Table 3: Relative Loss by λ and by Frequency of Evaluation (in %)

λ (weight of inflation)	Frequency of Evaluation			
	2	4 and 6	8	12
0.0	211.6	14.8	10.0	0.0
0.1	203.9	13.6	9.1	0.0
0.2	195.7	12.3	8.2	0.0
0.3	187.0	11.0	7.2	0.0
0.4	177.7	9.5	6.1	0.0
0.5	167.7	8.0	5.0	0.0
0.6	157.0	6.4	3.8	0.0
0.7	145.5	4.6	2.4	0.0
0.8	133.1	2.7	1.0	0.0
0.9	120.8	1.1	0.0	0.5
1.0	109.7	0.6	0.0	2.2

Conclusions

This paper estimated optimal Taylor-type rules for different frequencies of Central Bank evaluation, using the model of Battini and Haldane (1999) and the parameters calibrated by Bonomo and Brito (2001). It was observed that, for evaluations between 4 and 12 quarters, the optimal Taylor rules were very similar. The coefficient referring to the reaction of interest rate to deviations of inflation from the target is around 1.5 and the coefficient referring to the reaction of interest rate to output gap deviation is close to 1. When evaluation is made at every two quarters, the optimal Taylor rule implies a reaction of interest rate to deviations of inflation about three times more intense than in the other cases. The main explanation for such discrepancy should be related to the lags associated with the aggregate demand channel of monetary policy transmission mechanism: with very frequent evaluations, the interest rate can only offset the effects of the shocks through the exchange rate channel and, therefore, the monetary policy should be more reactive to inflation deviations from the target.

Setting an appropriate frequency of evaluation was shown to be an instrument capable of attenuating the different objectives of the government and of the Central Bank. More specifically, while the government is concerned with the variances of inflation and output gap, the Central Bank has the only objective of guaranteeing that actual inflation lies inside a pre-established tolerance interval. By assessing the Central Bank performance at longer periods, it is possible to reduce the output gap variance and, consequently, to induce monetary policy to generate macroeconomic outcomes that are more compatible with what the government considers optimal. The stochastic simulations showed that the government can minimize its function loss by making evaluations at every 12 quarters, when the weight attached to inflation variance in its loss function ranges from 0 to 0.8. If the government is extremely averse to inflation ($\lambda > 0,8$), the optimal frequency of evaluation is around 2 years. However, the current Brazilian system, where the performance of the Central Bank is assessed in the end of the calendar year, does not impose significant welfare loss: the loss varies from 15%, when $\lambda = 0$, to less than 1% for $\lambda = 1$.

A natural extension of this work would be to test the robustness of the results. This can be made by repeating the procedure for other specifications of the IS and Phillips curves or by using other types of interest rate rules, like the ones where the interest rate is set according to expected inflation. Another possible extension would be to introduce the credibility of the Central Bank into the analysis. This may cause a shortening in the optimal period for Central Bank evaluation. The intuition is that, with very distant evaluations in time, the Central Bank can guide monetary police in order to attend other objectives (for example, short-run popularity) in the periods where there is no evaluation, increasing the probability of not achieving the target for inflation.

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