Targets and inflation dynamics*

Sergio Alves†  Waldyr Areosa‡
Central Bank of Brazil

August 23, 2005

Abstract

Brazil has experienced crucial changes in its inflation process since the adoption of inflation targeting in mid 1999. This article addresses changes in the analytical framework employed to track the inflation dynamics, specifically the relevance of an explicit target for inflation. A New-Keynesian Phillips curve (NKPC) is derived incorporating indexation not only to past inflation but also to inflation targets, generalizing the Gali and Gertler (1999) hybrid curve.

In our modeling, firms that do not optimally set their prices in a given period adjust them only by indexing their previous prices to a weighted average of the inflation target and lagged inflation. In such a framework, the impact of inflation targets on agents’ decisions regarding the supply side can be analytically measured by the parameter associated to the inflation target. It is shown that inflation target affects the welfare-based monetary policy objective function by penalizing deviations of actual inflation from target instead of from zero. This result establishes the micro foundation basis for ad-hoc loss functions as indicated in traditional literature. Therefore, the inflation target also affects the optimal target criterion.

The Brazilian inflation targeting period (1999-2004) is examined to assess the relevance of the model. In order to consider the effects of external shocks on the Brazilian inflation rate, a mark of the period under study, we use a small open economy extension to our model that encompasses the effects of the exchange rate dynamics. We find that the inflation target parameter is quantitatively relevant and statistically significant. Recursive estimates of this parameter indicate that an inflation target effect on inflation dynamics becomes higher in periods when inflation expectations are closer to the targets. The empirical evidence also shows that even after major shocks, the target ability of anchoring inflation can be restored provided the monetary authorities demonstrate a firm commitment to meet the inflation targets, and the government provides the necessary support through consistent fiscal policy.

Keywords: Inflation targets; inflation dynamics; optimal monetary policy

---

*Preliminary (Comments welcome). We are grateful to the participants of the Research Department of Central Bank of Brazil internal seminar for helpful comments. All remaining errors are our own responsibility. The views expressed here are those of the authors and not necessarily those of the Central Bank of Brazil.

†Central Bank of Brazil, Special Studies Deputy Governor’s Office. sergio.lago@bcb.gov.br

‡Central Bank of Brazil, Special Studies Deputy Governor’s Office. waldyr.dutra@bcb.gov.br
1 Introduction

Why a monetary authority should adopt an explicit target for inflation? Since the early 1990s, a growing number of central banks in industrial and emerging countries have been considering this question, including the US\textsuperscript{1}.

The inflation targeting literature points out that much of its benefits can be attributed to its impact on inflation expectations\textsuperscript{2}. Woodford (2004) argues that the most important achievement of inflation-targeting central banks has not been the reorientation of the goals of monetary policy toward a stronger emphasis on controlling inflation, but rather the development of an approach to the conduct of policy that focuses on a clearly defined target. According to him, one important advantage of commitment to an appropriately chosen policy rule is that it facilitates public understanding of policy, which is crucial in order for monetary policy to be most effective\textsuperscript{3}.

This seems to be the case in Brazil. As pointed out by Cerisola and Gelos (2005), the adoption of an explicit and public target for inflation influenced the expectations of private agents. The authors examine the macroeconomic determinants of survey inflation expectations in Brazil since the adoption of inflation targeting in 1999. The results suggest that the inflation targeting framework has helped anchor expectations, with the dispersion of inflation expectations declining considerably. They also find that the inflation target has been instrumental in shaping expectations while the importance of past inflation in determining expectations appears to be relatively low.

The success of inflation targeting is solidly based on credibility. Private agents must believe that the central bank will act consistently within the inflation targeting framework. During the process of credibility construction in the context of large shocks, however, even a strong response by the monetary authority, will not be able to prevent expectations to deviate from the targets. In this case communication with the public so as to explain the reasons of the breach becomes crucial. Furthermore, it is important that expectations converge to the target over a certain time horizon. Minella et al (2003) presented some evidence on the behavior of the Central Bank of Brazil, private agents’ expectations, and changes in inflation dynamics. The authors conclude that the Central Bank of Brazil has been reacting strongly to expected inflation. It conducts monetary policy in a forward-looking manner, and responds to inflationary pressures. Although the actual inflation has been above the upper limit of the tolerance interval in 2001 and 2002, the inflation-targeting regime has been successful in anchoring expectations, with a substantial reduction in the degree of inflation persistence after inflation targeting was adopted. This is a direct consequence of credibility gains that the Central Bank of Brazil has obtained since the implementation of the new regime. Credibility, however, is still under construction as it takes time to achieve and great effort to preserve.

Next section summarizes Brazilian inflation targeting framework. In section 3 we present the analytical framework that captures the changes in inflation dynamics highlighted in the empirical works mentioned before. The adoption of an explicit target for inflation together with a perceived commitment of the monetary authority to pursue this target were, to a large extend, responsible for the remarkable change in the inflation process during the period, mainly in regards to inflation persistence. Section 4 assesses the credibility process using the framework presented. Section 5 concludes and points out the challenges ahead.

\textsuperscript{1}According to Mishkin (2004a), the Federal Reserve should adopt inflation targeting.

\textsuperscript{2}See Mishkin and Schmidt-Hebbel (2001) for a survey of early experiences with inflation targeting. Ball and Sheridan (2003) present a more pessimistic view from experience to date.

\textsuperscript{3}In Woodford’s (2004) own words “For not only do expectations about policy matter, but, at least under current conditions, very little else matters.”
2 Inflation targeting in Brazil

Soon after changing to a floating exchange rate regime in 1999, Brazil has adopted an explicit inflation targeting framework as part of an extensive program of economic reforms. This development ended a period during which the exchange rate had been the main anchor for monetary policy\(^4\).

In June 1999, a presidential decree established the new monetary framework, whose key points are listed below:

- Adoption of an explicit target for inflation;
- Inflation targets as well as the respective tolerance intervals were to be set by the National Monetary Council on the basis of a proposal by the Minister of Finance\(^5\);
- Targets to be set no later than June 30, two years in advance;
- The Central Bank was given the responsibility to implement the policies necessary to achieve the targets;
- The Central Bank were to issue a quarterly inflation report that would provide information on the performance of the framework, the results of monetary policy actions, and the outlook for inflation; and
- In case the targets were breached, the Central Bank’s Governor would be required to issue an open letter to the Minister of Finance explaining the causes of the breach, the measures to be adopted to ensure that inflation returns to the tolerated levels, and the period of time that will be needed for these measures to take effect.

The mounting uncertainties after the floating of the real in early 1999 enticed the implementation of a more strict inflation targeting framework, one that would represent a firm commitment to prevent inflation from getting out of control. Also, the relatively loose fiscal stance at the outset of the new regime as well as the lack of formal operational autonomy of the Central Bank presented additional challenges to the conduct of monetary policy, in particular to the construction of credibility. In order to deal with these concerns, the Central Bank has adopted a flexible and accountable approach in conducting policy. For instance, even when the targets were breached and revised, the process was undertaken in a very transparent manner through open letters from the Central Bank.

As noted by Mishkin (2004b), the role of the Central Bank in this accomplishment provides a good example for other emerging markets considering adopting inflation targeting: the way the Central Bank articulated the reasons why the initial inflation target was missed, how it responded to the shock, and how it planned to return to its longer-run inflation goal.

The new regime has been tested in a number of different ways during its short lifetime, with the intensity and frequency of shocks being unprecedented. Despite challenging conditions the new monetary framework has proven to be an effective guide for expectations. Even when current inflation deviated from the established targets, monetary policy under inflation target was, most of the times, capable of keeping inflation expectations in line with the official inflation targets. In the following section we will formally analyze how the adoption of an explicit target for inflation affects inflation dynamics and monetary policy.

---


\(^5\)Brazilian inflation targets, tolerance bands, and outcomes are showed in Figure 1 in the Appendix.
3 Changes in the inflation process: analytical framework

The standard approach to characterize the inflation process is some kind of Phillips curve relation, specifically the so-called "New-Keynesian" Phillips curve (NKPC), which can be derived from first principles based on assumption about nominal rigidities\(^6\) and possesses the well know specification

\[ \pi_t = \kappa x_t + \beta E_t \pi_{t+1} \]  

(1)

where \(x_t\) is a measure of the output gap, \(\pi_t\) is the inflation rate and \(E_t\) is the expectation operator based on date \(t\) information set\(^7\). The parameter \(\kappa\) measures the combined impact of nominal and real rigidities while \(\beta \in (0, 1)\) is the discount coefficient of the representative household. This specification has two sound characteristics: (i) it is derived from first principles and thus can deals with the Lucas (1976) critic, and (ii) it emphasizes the importance of the future state of the economy on current inflation. Iterating (1) forward one obtains

\[ \pi_t = \kappa \sum_{j=0}^{\infty} \beta^j E_t x_{t+j} \]  

(2)

The message of equation (2) is straightforward: if the monetary authority stabilizes all future stream of output gaps it also stabilizes inflation. Not only the current conditions of the economy are relevant but also the economic outlook.

Although appealing, the NKPC has problems when faced with the facts, specifically because the absence of any inertial component. As we can see from equation (2), the NKPC is completely forward-looking, while it does not seem to be the case of inflation in any country. In order to make the NKPC compatible with the data, some sort of backward looking behavior should be introduced. Assume that the fraction of firms that do not optimally readjust their prices in a certain period use a cost free rule-of-thumb based on lagged inflation. As a result, Phillips curve assume the so-called hybrid specification as follows

\[ \pi_t - \gamma \pi_{t-1} = \kappa x_t + \beta E_t [\pi_{t+1} - \gamma \pi_t] \]  

(3)

where \(0 \leq \gamma \leq 1\) measures the degree of indexation to the most recently available inflation measure.\(^8\) Iterating this equation forward one obtains

\[ \pi_t = \gamma \pi_{t-1} + \kappa \sum_{j=0}^{\infty} \beta^j E_t x_{t+j} \]  

(4)

Now, even if the central bank stabilizes the output gap from now on, the same would not occur with current inflation since it is influenced by its own recent history.

A typical exercise undertaken to measure the relative importance of the past versus future components of inflation is to estimate equation (3) and compare the weights associated with the backward versus forward looking components. Although relevant, it does not provide evidence of the impact of the adoption of an official target for inflation, after all, there are other events occurring in the economy that should induce the private sector to act in a more forward looking fashion. In the next section, we will present a straightforward extension of the hybrid model that can be used to assess the relevance of adopting an official inflation target.

---

\(^6\)The model of nominal rigidities proposed by Calvo (1983) was used in this case.

\(^7\)For a step-by-step derivation in a general-equilibrium model see Woodford (2003).

\(^8\)A detailed derivation of the hybrid curve is presented in Woodford (2003). A slightly different derivation, together with its empirical relevance in the US, is presented in Galí and Gertler (1999).
3.1 Targets and inflation dynamics

Why should agents only consider lagged inflation in their rule-of-thumb decisions? In an inflation targeting economy it is natural to assume that pricing decisions should also incorporate the inflation target\(^9\). In such a context, consider the following generic case that generalizes the hybrid curve (3)

\[ \pi_t - \pi_t^* = \kappa x_t + \beta E_t \left[ \pi_{t+1} - \pi_{t+1}^* \right] \]  

where now \( \pi_t^* \) equals

\[ \pi_t^* = \lambda \pi_t^0 + (1 - \lambda) \pi_{t-1} \]  

where \( 0 \leq \lambda \leq 1 \) is the weight associated to the inflation target \( \pi_t^0 \) for the current period, which, in the case of Brazil, is defined at least one year in advance by an institution other than the Central Bank of Brazil, the National Monetary Council, and so it is not affected by the monetary policy\(^{10}\). Although tempting, the association of \( \lambda \) with credibility should be made with care since that are other aspects that cannot be captured by the model. First of all, any measure of credibility should be policy-dependent\(^{11}\). Even considering that the proposed time-dependent model as a first stylized representation of a richer state-dependent approach, it is clear that the timing between monetary policy changes and its effects on the economy may cause \( \lambda \) reductions even though both the target and the monetary authority may be full credible. Another limitation is the absence of fiscal considerations, which can be taken into account in any measure of credibility. A more subtle issue is how to distinguish policy-making credibility from target credibility since they are mutually dependent.

The consequences of this extension on the inflation dynamics can be assessed by iterating (5) forward to obtain a result analogous to (4)

\[ \pi_t = \pi_t^* + \kappa \sum_{j=0}^{\infty} \beta^j E_t x_{t+j} \]  

Although similar in form, equations (3) and (5) are different in spirit in a crucial aspect. Now, if the central bank stabilizes all the future sequence of output gaps, inflation converges to its target in the long-run provide that \( \lambda > 0 \). Otherwise the model resembles the hybrid curve with \( \gamma = 1^{12} \).

3.2 Targets and optimal monetary policy

The adoption of an explicit target for inflation also affects optimal monetary policy. It can be shown that in order to maximize the welfare of the representative household the monetary authority should minimize

\[ W_0 = -\Omega \sum_{t=0}^{\infty} \beta^t \left\{ (\pi_t - \pi_t^*)^2 + \phi x_t^2 \right\} \]  

\(^9\)As an example of a similar idea, Yun (1996) assumes that prices are automatically increased at some rate \( \hat{\pi} \) between occasions on which they are reconsidered. In that case, however, \( \hat{\pi} \) is not directly associated with the inflation target but instead it is the actual long-run average rate of inflation of the economy.

\(^{10}\)Note that equation (5) nest the hybrid curve as a particular case in which inflation target is zero in all periods.

\(^{11}\)Although not considered as a direct credibility measure, \( \lambda \) evolution should also be state-dependent, so our time-invariant \( \lambda \) shall be analyzed with caution in the light of the Lucas critic.

\(^{12}\)Empiric evidence towards \( \gamma = 1 \) is presented by Giannoni and Woodford (2003) in a complete model of the monetary transmission mechanism without inflation targets.
where $\Omega$ is a constant and the weight $\phi$ is based on the deep parameters of the economy, specifically, $\phi = \frac{\phi}{\pi}$, where $\kappa$ is the coefficient associated with output in the NKPC and $\theta$ represents the elasticity of substitution between goods in the economy\textsuperscript{13}.

The minimization of (8) subject to the constraint represented by the NKPC (5) generate the following criterion

$$\pi_t - \pi_t^* + \frac{\phi}{\kappa} (x_t - x_{t-1}) = 0$$

(9)

This so-called \textit{optimal target criterion}\textsuperscript{14} indicates that deviations of the inflation rate from $\pi_t^*$ should be accepted as long as they are negatively proportional to output gap variations, $x_t - x_{t-1}$, over the same period.

This criterion nests the standard and the hybrid problem as particular cases. For instance, under the hybrid curve paradigm with $\gamma = 1$ (9) becomes

$$\pi_t - \pi_{t-1} + \frac{\phi}{\kappa} (x_t - x_{t-1}) = 0$$

(10)

indicating that the acceptable inflation projection for the current period should depend not only on the projected change in the output gap, but also on the recent past rate of inflation: a higher existing inflation rate justifies a higher projected near-term inflation rate, in the case of any given output-gap projection. The above equation can be presented in an intuitive form

$$\pi_t + \frac{\phi}{\kappa} x_t = \Pi_{-1}$$

(11)

indicating that in each period the right hand side of this last equation should equal the target $\Pi_{-1} = \pi_{-1} + \frac{\phi}{\pi} x_{-1}$. This result, presented in Giannoni and Woodford (2003), now has a natural interpretation: without a target anchoring firm’s pricesetting behavior, the best policy available is to keep $\Pi_t$ unchanged.

The opposite scenario, $\lambda = 1$, has the following criterion

$$\pi_t + \frac{\phi}{\kappa} (x_t - x_{t-1}) = \pi_t^o$$

(12)

Now we have a direct relation between optimal policy and the explicit inflation target: the monetary policy should be managed in order to keep the left-hand-side of (12) equal to the official target.

In the next section we use the Brazilian inflation targeting period (1999-2004) to assess the relevance of the model. Close attention will be devoted to the evolution of the target parameter $\lambda$.

\textsuperscript{13}An extensive explanation about the methodology used to derive this loss function from microfoundations can be obtained in Woodford (2003). Basically, it is a second order Taylor approximation of the utility function of the representative household around an efficient steady state. The form of the inflation component is crucially influenced by the sticky prices assumption used, in this case, the Calvo (1983) model.

\textsuperscript{14}Following Giannoni and Woodford (2003), we obtain an optimal target criterion under a timeless perspective, in which central bank is supposed to have been always committed to such a rule in the past, so it is time consistent. In alternative approaches, a central bank is supposed to commit itself to an optimum rule from period zero on, but it is not time consistent once central bank would have incentives to break its commitment in initial period and such a rule would not be perceived as credible by economic agents.
4 Assessing the role played by the inflation target

Dealing with the pass-through from depreciation to inflation has been one of the main challenges to the inflation-targeting regime in emerging markets economies. Brazil is not an exception, as can be seen by the evolution of the nominal and real exchange rate presented in Figures 3 and 4 respectively\(^\text{15}\). Emerging markets seem to be more sensitive to the effects of financial crises than industrialized countries. Exchange rate market volatility generates frequent revisions of inflation rate expectations and may result in non-fulfillment of inflation targets.

In order to analyze the impact of \(\lambda\) during the inflation targeting period we estimate an open economy NKPC based on the following equation\(^\text{16}\)

\[
\pi_{H,t} - \pi^*_t = \hat{\kappa} x_t + \beta E_t [\pi_{H,t+1} - \pi^*_{t+1}] \tag{13}
\]

This curve can be derived from a small-open economy model analogous to the one presented by Galí and Monacelli (2004). Note that this new specification is very similar to the one valid for closed economies. The only difference is the appearance of \(\pi_{H,t}\), the inflation rate of domestically produced and consumed goods prices due to the fact that domestic firms decide on domestic prices.

Furthermore, one may obtain an expression relating the market inflation rate, \(\pi_t\), that aggregates domestic and imported goods price inflation, to \(\pi_{H,t}\)

\[
\pi_{H,t} = \pi_t - \frac{\delta}{1 - \delta} \Delta q_t \tag{14}
\]

where \(q_t\) is the real exchange rate gap from its steady state value, so \(\Delta q_t\) measures its depreciation rate, and \(\delta \in (0, 1)\) is a parameter inversely related to the home bias on consumer decisions about his consumption basket. The lower is \(\delta\), the less is the consumption of imported goods.

Therefore, one may combine these expressions and obtain

\[
\pi_t = \pi^*_t + \hat{\kappa} x_t + \beta E_t [\pi_{t+1} - \pi^*_{t+1}] + \frac{\delta}{1 - \delta} E_t [\Delta q_t - \beta \Delta q_{t+1}] \tag{15}
\]

Hence, considering the definition of real exchange rate and \(\pi^*_t\), these last expressions may be combined into the following result, where \(\pi^f_t\) represents the imported goods inflation rate, denominated in foreign currency

\[
\pi_t = \lambda \pi^o_t + (1 - \lambda) \pi_{t-1} + \beta E_t [\pi_{t+1} - \lambda \pi^o_{t+1} - (1 - \lambda) \pi_t] + \frac{\delta}{1 - \delta} E_t [\Delta e_t + \pi^f_t - \pi_t - \beta \left(\Delta e_{t+1} + \pi^f_{t+1} - \pi_{t+1}\right)] + \hat{\kappa} x_t \tag{16}
\]

In line with frontier econometric analysis for microfunded nominal rigidities models, we considered a more fundamental specification for our NKPC. Indeed, the output gap term was only shown in our previous equation due to a slightly strong hypothesis regarding to the functional form of firms production function. As a matter of fact, if such an assumption were not made, we would obtain a very similar NKPC in which the output gap term would be replaced by the firms’ average marginal cost, as follows:

\[
\pi_t = \lambda \pi^o_t + (1 - \lambda) \pi_{t-1} + \beta E_t [\pi_{t+1} - \lambda \pi^o_{t+1} - (1 - \lambda) \pi_t] + \frac{\delta}{1 - \delta} E_t [\Delta e_t + \pi^f_t - \pi_t - \beta \left(\Delta e_{t+1} + \pi^f_{t+1} - \pi_{t+1}\right)] + \xi mc_{H,t} \tag{17}
\]

\(^{15}\)For a specific analysis about exchange rate pass-through in Brazil see Belaisch (2003).

\(^{16}\)For ease of reference, all data series’ descriptions, together with its sources, are defined in Table 2 in the Appendix.
where \( mc_{H,t} \) is the real marginal cost in terms of domestic consumed products. The relation between \( mc_{H,t} \) and the real marginal cost in terms of the overall consumption basket \( mc_t \) is the following

\[
mc_{H,t} = mc_t + \frac{\delta}{1 - \delta} q_t
\]

Therefore

\[
\pi_t = \lambda \pi_t^o + (1 - \lambda) \pi_{t-1} + \beta E_t \left[ \pi_{t+1}^o - \lambda \pi_{t+1}^o - (1 - \lambda) \pi_t \right] + \frac{\delta}{1 - \delta} E_t \left[ \Delta e_t + \pi_t^f - \pi_t - \beta \left( \Delta e_{t+1} + \pi_{t+1}^f - \pi_{t+1} \right) \right] + \xi mc_t + \xi \frac{\delta}{1 - \delta} q_t
\]

(18)

In order to implement econometric analysis with quarterly Brazilian data, it was necessary to create an inflation target measure for the period ranging 1995Q1 to 1998Q4, previous to the inflation targeting adoption. During such period, the official exchange rate policy consisted of an intended nominal devaluation of 7.5 percent, on an exchange rate crawling peg regime, as explained in Bogdanski et al (2000). Additionally, such period was characterized by a near time invariant real exchange rate. Therefore, it was if there was an official inflation target resulting from maintaining the real exchange rate in a constant level even though nominal exchange rate was set to devaluate at the defined rate. Thus, we could create an inflation target series for the considered period as follows:

\[
\widehat{\Delta q_t} = \frac{1}{4} \log(1.075)
\]

then

\[
\pi_t^o = \frac{1}{4} \log(1.075) + \pi_t^f
\]

(19)

From 1999Q1 and 1999Q2, there was not an official nominal anchor, so we imposed the restrictions \( \lambda_{1999Q1} = 0 \) and \( \lambda_{1999Q2} = 0 \). From 1999Q3 on, Central Bank of Brazil has been pursuing end-of-year inflation targets, so there are no quarterly official inflation targets. Therefore, the simplest solution was to consider that the quarterly inflation targets were fixed, in each year, at a quarter of the corresponding end-of year official values.

As the inflation rate \( \pi_t \), we considered the Brazilian broad consumer price index (IPCA), used to gauge Brazilian inflation targets. In order to filter the strong seasonal pattern present until 1998Q4, we considered a filtered series, obtained by the general full sample asymmetric band-pass (from 3.1 to 4 quarters) frequency filter of Christiano and Fitzgerald (2003). Since Brazilian inflation seasonal pattern seemed to change over time and was difficult to extract due to strong external shocks that affected Brazilian IPCA inflation rate in 2001 and 2002, we believed this filtering process was appropriated due to the fact that this asymmetric filter is time varying with its parameters depending on the data and changing for each observation. Figure 2 shows the obtained filtered inflation.

As the foreign inflation rate measure \( \pi_t^f \), we considered the US export price index variation rate (all Commodities). Therefore, real exchange rates were constructed considering those inflation rates. As in Goldfajn and Werlang (2000), detrended (Hodrick-Prescott Filter)\textsuperscript{17} real exchange rate was considered as a proxy to \( q_t \), as illustrated in Figure 4.

\textsuperscript{17}See Hodrick and Prescott (1997). For an interesting generalization, also see Araújo, Areosa, and Rodrigues Neto (2003).
As a measure of firms aggregated marginal cost, we constructed the proxy $mc_t = w_t L_t / \tau Y_t$, where $w_t$ is the real wage index, $L_t$ is the occupied labor force, $\tau$ is the income labor share and $Y_t$ is the GDP. Since the only uninterrupted Brazilian series of labor force is the one released by Seade\textsuperscript{18} for S\~ao Paulo’s metropolitan region, $mc_t$ was constructed with data proceeding from that region. For quarterly S\~ao Paulo’s GDP measure, we interopolated its annual share to the Brazilian GDP and applied the resulting quarterly share to quarterly Brazilian GDP\textsuperscript{19}. Regarding to the income labor share, we considered $\tau = 0.6$, the Brazilian adjusted estimative made by Gomes et al (2002).

Hence, we estimated the following structural equation with a Two Stage Least Squares procedure, since there were contemporaneous and future regressors that could be correlated with the error term $\varepsilon_t$. The instrumental list included $\{\pi_{t+j}\}_{j=-4}^{1}, \{\pi^i_{t+j}\}_{j=-2}^{1}, \{\Delta \pi_{t+j}\}_{j=-1}^{1}, \{\pi^o_{t+j}\}_{j=0}^{1}, mc_{t-1},$ and $\{S\delta TBond\}_{j=-1}^{-3}$, the Brazilian C-Bond spread over (US) treasury. The intercept coefficient was imposed in order to capture possible estimating level bias in the latent marginal cost and in the real exchange rate gap. If such term was neglected, parameter estimates could be biased due to the omitted variable specification.

$$\pi_t = A_0 + A_1 \pi^o_t + (1 - A_1) \pi_{t-1} + A_2 E_t \left[ \pi^f_{t+1} - A_1 \pi^o_{t+1} - (1 - A_1) \pi^f_t \right]$$
$$+ A_3 E_t \left[ \Delta \varepsilon_t + \pi^f_t - \pi_t - A_2 \left( \Delta \varepsilon_{t+1} + \pi^f_{t+1} - \pi_{t+1} \right) \right]$$
$$+ A_4 mc_t + A_5 q_t + \varepsilon_t \tag{20}$$

The parameters estimates in the full sample are presented in Table 1. As can be seen, the parameter associated with the target is quantitatively relevant and statistically significant, with a value of almost 0.70. Note also that the short-term exchange rate pass-through coefficient is both significant and low, with a value of about 5 percent. This estimative is in line with the values estimated in the recent literature of most countries where a floating exchange regime is adopted. Indeed, it means that Brazilian economy is still essentially closed, due the fact that the home bias parameter $\delta = \frac{0.053}{1 + 0.053} = 0.05$. Another parameter that is also significant is $A_5$, regarded to the real exchange rate gap. Remember that this variable is a component of the real marginal costs in terms of domestic consumed products $mc_{H,t}$. As the results indicate, this variable is relevant to explain Brazilian consumer inflation, although neglected in some empirical works in the literature that are used to consider only the unit labor cost $mc_t$. On the other hand, our econometric procedure rejected the hypothesis that our measure of unit labor cost is relevant, for its coefficient $A_4$ is not significant. Nevertheless, a Wald test do not reject the null hypothesis that $A_4 = A_3 / A_5$ (p-value = 0.25), as should be if the structural Phillips curve presented in equation (18) above performs fine to model actual Brazilian supply side. Note also that the prefersences intertemporal discounting parameter $\beta$, represented by $A_2$, was sub estimated by our regression, since one expected it to be close to the unity. This result may suggest that Brazilian agents are impatient in their consuming decisions, but it may be only a consequence of correlated regressors. Since our empirical evidence points out that inflation target are an important variable in explaining current inflation, future inflation should be also explained by future inflation targets and so should be current expectation regarding future inflation. Hence, $E_t \pi_{t+1}$ must be correlated with $\pi^f_{t+1}$ and some estimation problems may

\textsuperscript{18}Fundação Sistema Estadual de Análise de Dados (www.seade.gov.br). A more traditional measure for labor force is released by Instituto Brasileiro de Geografia e Estatística (IBGE). But its series methodology changed in 2001, and regardless the fact that the old series is updated only until December 2002, the new series was not applied to previous years, starting in January 2001.

\textsuperscript{19}See Appendix for details.
arise. On the other hand, some results points out that using different unit labor cost measures would modify our estimative of $\beta$, due to spurious in-sample correlation between $E_t \pi_{t+1}$ and $mc_t$. Although our estimatives of $\lambda$ seemed to be robust to such sources of problem, future extensions should concern more attention on this issue.

In order to map the evolution of the weight associated with the target we perform recursive estimations of our Phillips curve\textsuperscript{20}. The evolution of the parameter $\lambda$ is showed in Figure 5, with a confidence interval of 2 standard errors. In almost all sub samples, this parameter was significant in explaining inflation.

The recursive estimates of the $\lambda$ indicate that the weight associated with the official inflation target increases in periods when inflation expectations are close enough to the official targets. The period can be separated in three sub-samples: (i) 1999 – 2000, the implementation phase, (ii) 2001 – 2002, the stress test, (iii) 2003 – 2004, the restoration of credibility.

4.1 Implementing IT: 1999 - 2000

During the first two years, $\lambda$ increased with regularity from closed to 0.50 in mid 1999 to approximately 0.75 at the end of 2000. Despite the adoption of IT in Brazil had occurred in the midst of a foreign exchange crisis, the transition to the new regime in 1999 was relatively smooth. Against all pessimistic views, inflation at the end of 1999 reached the one-digit level mark (8.9 percent), while annual GDP grew by almost 1 percent (0.8 percent). The response of the Brazilian government and Central Bank to the crisis combined fiscal consolidation, a strong commitment with price stability, and external financial support.

The exchange rate was rapidly stabilized, market interest rates fell, and inflation expectations were brought under control, which allowed the Central Bank to lower interest rates quite aggressively (from 45 percent to below 20 percent in a seven-months period). Besides confidence’s strength, the extensive amount of exchange rate hedging, which isolates the non-financial private sector from the exchange rate devaluation, helps to explain the remarkably small impact on output that followed the overshooting of the real. However, the transition to a floating exchange rate regime left some scars: public debt increased and became more sensitive to exchange rate changes.

After the initial transition phase, with the normalization of financial conditions and under the effects of significant interest rate cuts, inflation ended 2000 right at the 6 percent mid-point target, with robust economic growth of 4.4 percent. However, during 2000 a series of important shocks occurred, notably: oil prices had double since 1999 while the prices of technology firms sharply felt, with the meltdown of NASDAQ. At the same time, monetary policy conditions were tightened in the U.S. with fed funds rate being raised to 6.5 percent in May 2000, from 5.5 percent at the end of 1999.

Although the overall performance in 2000 was auspicious, the accelerate rate of growth of the Brazilian economy at the margin combined with US and Global slowdown pointed to difficulties ahead. Brazilian economic recovery that began at the end of 1999, was based on strong credit expansion, increasing exports of industrial goods, and agricultural prices recovery. This recovery, however, combined with increasing oil prices and US slowdown, adversely affected the balance of trade, which entered negative territory (12 months) in September 2000 after a period of recovery following the depreciation of the real in early 1999. Brazilian core IPCA inflation started to show a growth trend after November 2000.

\textsuperscript{20}We considered performing Kalman filter analyses in order to model $\lambda$ as a time varying parameter. However the results were considerably unstable.
4.2 Inflation targeting under stress: 2001 - 2002

After an initial increase in mid of 2001 - almost reaching the theoretical upper limit of 1 - \( \lambda \) suffers two considerable reductions: (i) from 1 to 0.75, at the end of 2001, and (ii) the collapse from almost 0.90 to 0.25 during the second half of 2002.

The year of 2001 was marked by a series of adverse shocks, most notably: the Argentina default, officially announced in 2001Q4, the energy crises in Brazil, and the September 11 attack. In the beginning of the year, consumer price inflation came above expectations, while core inflation trend was incompatible with the 4 percent inflation target for the year. After reducing the Selic rate\(^{21}\) to 15.25 percent in January, Central Bank started in March the first monetary policy tightening cycle of the inflation targeting regime. After an initial 50 basis points increase, the tightening cycle was interrupted only in July, with the Selic rate reaching 19 percent. The policy rate remained unchanged from August 2001 to February 2002, when the Central Bank began the easing process, although just from a brief period of time. The series of adverse events produced during 2001 significant exchange rate depreciation, hovering around 20 percent. At the end of 2001, inflation reached 7.7 percent (3.7 percentage points above the 4 percent target) and the economy grew 1.3 percent.

Even tough the target was not reached, the results obtained in face of an extremely adverse scenario were satisfactory, revealing the inflation targeting regime as an effective and flexible framework to pin down expectations. Inflation expectations for 2002, gauged at the end of 2001, were still below 5 percent. The way monetary policy was conducted with the swift reaction after the September 11 terrorist attacks kept expectations under control and made economic agents believe that the 2001 adverse inflationary shock would be dissipated during the following year.

The year 2002 began with the view that the end of the energy crisis combined with an improved international environment would allow some flexibility in the conduct of monetary policy. In fact, a considerable exchange rate appreciation occurred (from a 2.80 R$/US$ just after September 11 to 2.40 R$/US$ in the beginning of May 2002). In this context, the monetary policy was relaxed in the beginning of the year with the Selic rate being reduced from 19 percent in February to 18 percent in June. However, later in the year, the uncertainty associated with the presidential election sets off an unprecedented confidence crisis leading to sharp exchange rate depreciation and to a very unfavorable debt-dynamics. The economic policy response at the time was constrained by the generalized concern with the public debt sustainability that, although lacking basis, made the monetarist arithmetic operate with no mercy. As a result, any strong monetary policy response instead of controlling expectations throughout its demand and exchange rate effects would most likely have an inverse effect throughout debt dynamics and risk premium. Besides this, with the change in government so close, any monetary or fiscal commitment would just be credible if supported by the new administration.

The commitment assumed by the new President to sustain sound macroeconomic policies, combining fiscal discipline, a floating exchange rate regime, and the inflation targeting framework, was crucial to dissipate the fear associated with changes in the course of the economy and related to debt sustainability. From September 2002 to December of the same year the Central Bank increased

\(^{21}\)The Selic interest rate, the Central Bank’s primary monetary policy instrument, is the average interest rate on overnight inter-bank loans collateralized by government bonds that are registered with, and traded on, the Sistema Especial de Liquidação e Custódia (Selic). The Central Bank of Brazil Monetary Policy Committee (COPOM) establishes a target for the Selic interest rate and the Central Bank’s open market desk executes regular liquidity management operations in the domestic money market with the goal of keeping the daily Selic interest rate at the target level.
its policy rate from 18 percent to 25 percent. However, the sharp exchange rate depreciation during the year yielded a considerable increase of inflation, which ended 2002 at 12.5 percent, and a modest GDP growth of 1.9 percent. Although the inflation targeting regime was unable to anchor expectations during that year, the months that followed this episode proved that inflation targeting has been a useful framework to align market expectations with government objectives.

4.3 Reconstructing credibility: 2003 - 2004

Since the beginning of 2003 the target parameter displays a consistent recovery, reaching almost 0.75 at the end of 2004. In January 2003, the Central Bank sent an open letter to the Minister of Finance explaining why the inflation targets were breached, and made explicit estimates of the size of the shocks and their persistence. The Central Bank added to the original inflation target for 2002 (4 percent) part of the breach experienced in the previous year, to account for inertia effects (inflation carryover from the 2002 shock) and for the impact on administered prices that, by contract provisions, are adjusted according to past inflation. These two effects let the Central Bank to adjust the inflation target for 2003 to 8.5 percent. The Central Bank made explicit reference to the fact that, after the sharp increase in inflation in 2002, attempting to achieve the original inflation target of 4 percent for 2003 would require a sizeable output sacrifice. Inflation in 2003 came down by more than 3 percentage points, ending up at 9.3 percent, close to the adjusted target, and GDP declined by a modest 0.2 percent. Of course, the Central Bank has not been able to do this on its own. The new government not only supported the inflation targeting regime but also pursued tight spending policies that have resulted in a primary budget surplus in 2003 of 4.3 percent of GDP.

In 2004 GDP expanded vigorously with growth reaching almost 5 percent and with employment increasing at two-digit rate. However, the strong economic recovery in 2004 required a gradual but firm response of the Central Bank to fight emerging inflationary pressures and prevent these pressures from contaminating inflationary expectations. From September 2004 to May 2005 the Central Bank raised its policy rate by 3.75 percentage points to 19.75 percent. Moreover, the government announced in September 2004 a change in the primary surplus target for 2004, from 4.25 to 4.5 percent of GDP. Inflation, despite some acceleration during the second half of 2004, ended the year at 7.6 percent, above the 5.5 percent target, but within the tolerance interval.

In September 2004, the Central Bank communicated to the public the new operational target for 2005 of 5.1 percent. When it became clear to the Central Bank that the 5.5 percent target for 2004 would not be fulfilled and it was possible to project with greater accuracy the 2004 deviation, the Central Bank established 5.1 percent as its operational target to be pursued in 2005.

5 Concluding remarks and challenges ahead

We develop and estimate a structural model of inflation to measure the relevance of an explicit target for inflation. A New-Keynesian Phillips curve (NKPC) is derived incorporating inflation targets generalizing the Galí and Gertler (1999) hybrid curve.

On the theoretical side it is shown that the inflation target affects the welfare-based monetary policy objective function by penalizing deviations of actual inflation from its implicit target instead of from zero. This result establishes the micro foundation basis for ad-hoc loss functions as indicated in the traditional literature. Therefore, the official inflation target also affects the optimal target criterion.
On the empirical side, we test the model using the Brazilian inflation targeting period (1999-2004). We find that the parameter associated with the target is quantitatively relevant and statistically significant. Recursive estimates indicate that the parameter associated with the target increases in periods when inflation expectations are close enough to the official targets. The empirical evidence also shows that even after major shocks, the weight associated with the target can be restored provided the monetary authorities demonstrate a firm commitment to meet the inflation targets, and the government provides the necessary support through consistent fiscal policy.

There are three possible extensions where future investigation would be quite useful. First, the same analysis should be performed based on other countries data in order to verify if the result that the official target is relevant for inflation is robust. Second, if firms pay close attention to the inflation target, the timing and magnitude of an individual firm’s price adjustment depends on the monetary authority actions. The effects of nominal disturbances on aggregate real activity will also be policy-dependent, since the price level depends on the weight firms associate with the targets. As a result the weight associated with the target should not be time-dependent but instead state-dependent. The challenge is how to make such transition in a tractable manner. Finally, the model ignores the role of fiscal policy in the process. Only a model that consider the interrelation between monetary and fiscal policies can draw a comprehensive picture of the credibility mechanism. In particular, the consequences for monetary policy of an adoption of a fiscal target can be directly assessed.
Figure 1: Brazilian inflation targets, tolerance bands, and outcomes

Figure 2: Quarterly Brazilian IPCA
Figure 3: Evolution of the nominal exchange rate (Brazilian R$ / US$)

Figure 4: Evolution of the real exchange rate in Brazil
Table 1: Structural Estimates

<table>
<thead>
<tr>
<th>Method</th>
<th>2SLS; 1996Q1 to 2004Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef</td>
</tr>
<tr>
<td>$A_0$</td>
<td>0.002</td>
</tr>
<tr>
<td>$A_1$</td>
<td>0.689</td>
</tr>
<tr>
<td>$A_2$</td>
<td>0.297</td>
</tr>
<tr>
<td>$A_3$</td>
<td>0.053</td>
</tr>
<tr>
<td>$A_4$</td>
<td>-0.113</td>
</tr>
<tr>
<td>$A_5$</td>
<td>0.049</td>
</tr>
</tbody>
</table>

$R^2 = 0.557$  
$R^2 Adj = 0.484$

Breusch-Godfrey LM Test$^{22}$ (2 lags): $n \cdot R^2 = 3.86$; $p = 0.15 \{Dist. \chi^2(2)\}$
White Heteroskedasticity Test: $F = 0.53$, $p = 0.91 \{Dist. F(24, 11)\}$

---

\[22\] Our LM test was carried out regressing (OLS) the residuals against lags (t-1) and (t-2) of the residuals and the resulting vector of regressors from Eq. 20, replacing expectation variables with the corresponding lagged variables:

$p_t = \pi_{t-1}, p_{t+1} = \pi, \Delta e_{t-1} + \pi_t - \pi_{t-1}, m_{e(t-1)}, q_{t-1}$.
<table>
<thead>
<tr>
<th>Serie</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_t^o$</td>
<td>Inflation targets</td>
<td>BCB &lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>$e_t$</td>
<td>Nominal exchange rate (R$/US$)</td>
<td>BCB &lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>$\pi_t$</td>
<td>Inflation rate series</td>
<td>IBGE &lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>São Paulo’s metropolitan region GDP</td>
<td>IBGE &lt;sup&gt;b&lt;/sup&gt;                          (Quarterlized)</td>
</tr>
<tr>
<td>$L_t$</td>
<td>Labor force series for São Paulo</td>
<td>Seade &lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>$w_t$</td>
<td>Average real wage series for São Paulo</td>
<td>Seade &lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>$\pi_t^f$</td>
<td>Foreing inflation rate</td>
<td>U.S. Department of Labor &lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>$SoT_t^{CBond}$</td>
<td>Brazilian C-Bond spread over US treasury</td>
<td>Ipea Data &lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

\[
\Delta q_t = \Delta e_t + \pi_t^f - \pi_t
\]

<sup>a</sup>Banco Central do Brasil (www.bcb.gov.br)
<sup>b</sup>Instituto. Brasileiro de Geografia e Estatística (www.ibge.gov.br)
<sup>c</sup>Fundação Sistema Estadual de Análise de Dados (www.seade.gov.br/produtos/ped)
<sup>d</sup>Bureau of Labor Statistics (www.bls.gov)
<sup>e</sup>Ipea Data (www.ipeadata.gov.br)

**Obtaining Quarterly São Paulo's GDP**

IPEA and IBGE released annual GDP (1970, 1975, 1980, 1985, 1996, 1999, 2000, 2001 and 2002) from several cities in Brazil. In particular, we could aggregate GDP from São Paulo’s metropolitan region<sup>23</sup> and determine its share to Brazilian GDP, for each year. Since this indicator are not supposed to present a volatile pattern from a particular quarter to the following one, except from seasonal idiosyncrasies, we generated quarterly shares minimizing the sum of squared second differences constrained to the restriction that their annual average should equal the previously estimated occurred shares for each one of the cited years. Following, we applied this estimated quarterly shares to actual seasonally adjusted quarterly Brazilian GDP. For years 2003, 2004 and 2005, for which such cities GDP were not released, we considered the same quarterly share estimated to 2002Q4.

<sup>23</sup>São Paulo’s metropolitan region encompasses 38 cities. The complete list of cities is available at www.seade.gov.br.
References


