

# Implementing Inflation Targeting in Brazil

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## Abstract

Brazil has put in place an inflation-targeting framework for monetary policy in mid-1999, less than six months after moving to a floating exchange rate system. This paper presents the macroeconomic background that has led to the shift in monetary policy regime, and describes the general institutional arrangements and operational framework that has been adopted. The paper also discusses the basic modeling approach that has aided the decision-making process in the initial phase of inflation targeting in Brazil. We describe the family of small-scale macroeconomic models that has been used for informing and disciplining discussions about monetary policy within the Central Bank. These models contain few equations and few variables, but carry a considerable theoretical content and provide a stylized representation of the monetary policy transmission mechanism. They are easily understood, and especially suitable for simulation of a wide range of issues. We conclude with the main lessons that may be drawn from the initial Brazilian experience with inflation targeting.

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## 1. Introduction

Brazil has recently put in place a new framework for monetary policy. After moving to a floating exchange rate system, the government defined inflation targets for the coming years and assigned to the Central Bank the responsibility and the operational independence to conduct monetary policy in order to meet the inflation objective.

Inflation targeting requires that monetary authorities adopt a forward-looking attitude and take preemptive action, given the lags between policy decisions and their effect on output and prices. In Alan Greenspan's words, "Implicit in any monetary policy action or inaction is an expectation of how the future will unfold, that is, a forecast". Indeed, we believe that what inflation-targeting central banks actually do is inflation *forecast* targeting. Rather than reacting to present facts, monetary policymakers make decisions based on conditional forecasts of future inflation, conditional on alternative interest rate paths and on the best estimate of the current state of the economy and the probable future development of exogenous variables.

It is crucial to develop a basic modeling framework to allow policymakers to exercise their judgemental analysis in a structured and quantified way. Economic models are just another tool available to guide policy decisions under uncertainty about the state of the economy and the size and nature of the shocks that constantly hit it. Nonetheless, simple models can help clarify economic problems by focusing on a small number of factors thought essential for their understanding. In this paper, we present the basic modeling approach that has aided the monetary policy decision-making in the initial phase of the inflation-targeting regime in Brazil.

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Section 2 describes the general institutional arrangements and operational framework adopted for inflation targeting. Section 3 describes the family of small-scale macroeconomic models that has been used for informing and disciplining discussions about monetary policy within the Central Bank. These models contain few equations and few variables, but carry a considerable theoretical content and provide a stylized representation of the monetary policy transmission mechanism. They are easily understood, and specially suitable for simulation of a wide range of issues. Section 4 deals with the basic requirements for running simulations. Section 5 presents brief conclusions.

## **2. The Brazilian IT framework**

### **2.1 In search of a nominal anchor for monetary policy**

The stabilization process in Brazil, initiated in mid-1994, successfully brought annual inflation down to one-digit figures in less than three years. This process included a wide program of economic reforms. For instance, the size of the public sector was substantially reduced in this period through privatization of state companies operating in sectors like telecommunications, chemistry, railroads, banking and mining. Likewise, the trade liberalization was deepened through reduction of import tariffs and elimination of non-tariff barriers. The financial system was submitted to a full-fledged restructuring with unsound institutions liquidated, merged or restructured and prudential regulation updated.

The main source of inflationary inertia, the automatic indexation of prices, wages and other contracts, was substantially reduced. Annual output growth averaged 3.4% in real terms in 1994-1998, even though unemployment started to rise in 1997.

However, despite its relative success, the stabilization process involved a gradualist approach towards many structural economic problems that remained unsolved. A much-needed definitive fiscal adjustment was continually postponed because, in part, the government coalition was not sufficiently convinced of its urgency. So, Brazil remained

vulnerable to a confidence crisis, which became a reality when the international financial turmoil culminated with the Russian moratorium in August 1998. The confidence crisis generated a large capital flight from emerging markets. Brazil raised short-term interest rates and announced a strong tightening of the fiscal regime. At the same time, the government negotiated a preventive financial support package with the IMF, totaling US\$ 41.5 billion.

The government was initially successful in implementing the fiscal package, but market confidence continued to erode up to January 1999, also reflecting concerns over the newly elected governors' commitments to adjusting their states public finances. Following strong pressures on foreign exchange reserves, the Central Bank was forced to abandon the crawling peg to the dollar<sup>1</sup>. After a brief attempt to conduct a controlled devaluation, the *real* was forced to float on January 15. As a consequence of this abrupt change in regime, most of the Central Bank's Board of Directors was replaced. Due to Brazilian peculiarities, the new Board took office only in the beginning of March.<sup>2</sup>

In the absence of a well-defined guidance for monetary policy, the exchange rate averaged R\$1.52/US\$1 in January and R\$1.91/US\$1 in February, compared with R\$1.21/US\$1 prior to the change in regime. Inflation rose sharply: the wholesale price index increased 7.0% in February, while the consumer price index rose 1.4%. This led private analysts to foresee a huge deterioration of all macroeconomic fundamentals.

The new Board took office on March 4<sup>th</sup> and immediately worked on two main fronts. The first was to calm down the nervous financial markets. The expectation that an inflation hike could bring the real rates of return on public debt instruments to the negative range was the first to be attacked.

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<sup>1</sup> The official exchange rate policy at that time consisted of an intended nominal devaluation of 7.5% p.a., while annual inflation was near 2%.

<sup>2</sup> In Brazil, the Federal Senate must formally approve the nominees to the Central Bank's Board. The process consists of two steps. The first is a preliminary open hearing in the Committee of Economic Affairs. The second is a discussing and voting session, where the 81 Senators decide by simple majority whether to approve or reject the nominee. Although the Government coalition has a large majority in the Senate, the process is time consuming.

The Monetary Policy Committee (Copom), whose members are the Governor and Deputy Governors, decided to raise the basic short-term interest rate (*Selic*) from 39% p.a. to 45% p.a., taking into account that the future contracts for the next maturity were already trading at 43.5%. An important novelty was introduced, the bias on the interest rates, which delegated to the Central Bank's Governor the power to change interest rates during the period between two ordinary Committee meetings (they used to be 5 weeks, prior to the adoption of the inflation targeting framework). The Copom established a downward bias, meaning that interest rates could be lowered at any time before the next scheduled meeting<sup>3</sup>.

For the first time, also, the Committee released a brief explanation right after the meeting (the minutes used to be released only after 3 months). Its initial words were "*maintaining price stability is the primary objective of the Central Bank*". And it went on to say that: "*(1) in a floating exchange rate regime, sustained fiscal austerity together with a compatible monetary austerity support price stability; (2) as fiscal policy is given in the short run, the control over inflationary pressures should be exerted by the interest rate; (3) observed inflation is due to the currency depreciation, and markets expect a further rise in the price level this month; (4) the basic interest rate should be sufficiently high to offset exchange-based inflationary pressures; and (5) so, we decided to raise the basic interest rate to 45% p.a., but with a downward bias, for if the exchange rate returns to more realistic levels, keeping the nominal interest rate that high would be unjustified.*" Indeed, the bias was used twice before the next meeting: the interest rate was reduced first to 42% and then to 39.5%, following a reversal of the exchange rate overshooting and a reduction both in observed and expected inflation rates.

The second front was the initiative to propose the adoption of inflation targeting as the new monetary policy regime. Although it is clear from the Copom's press release that IT was already in the minds of the Board's members, there was a lot of work to do in the institutional area. For example, the Central Bank has never been granted formal instrument independence to conduct monetary policy. Moreover, even at the Bank, very

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<sup>3</sup> On the other hand, under a downward bias, if the Governor needs to raise interest rates, an extraordinary Copom meeting must be called to take the decision.

few staff members knew what an IT framework was about. The technical skills needed to develop adequate inflation-forecasting models were scattered unevenly throughout the Bank's departments. In particular, there was no Research Department: each department used to make its own research efforts, usually to solve immediate demands and not devoted to think coherently about the future.

Once these problems were detected, their solution was straightforward. The new floating exchange rate clearly required a new nominal anchor for economic policy. Monetary policy, along with strengthened fiscal adjustment and a firm wage policy in the public sector, would be instrumental in preventing the recurrence of an inflationary spiral and ensuring a rapid deceleration of the rate of inflation. Inflation targeting was the most suited framework to achieve economic stabilization under a flexible exchange rate regime, with the target itself playing the role of the nominal anchor. With sound arguments, it was not difficult to convince the President, the Finance Minister, and their senior economic advisors that IT could work well in Brazil. The IMF staff was most receptive to the proposed new framework for monetary policy, and showed interest in organizing an international seminar on IT, where the discussions could benefit from the experience of a number of central banks and academics.

Within the Central Bank, a Research Department was created by the end of March. Initially, three research areas were opened: IT, financial risk and pricing and microeconomics of banking. The IT group, consisting of 14 researchers, started to study the literature.

Two key books were very useful: Bernanke et al. (1998), *Inflation Targeting: Lessons from the International Experience*, Princeton University Press, and Taylor, John B. (ed.) (1999), *Monetary Policy Rules*, University of Chicago Press. Some other articles and books entered a "minimum kit", a mandatory reading for anyone in the group. (i) General readings and cases: King, Mervyn (1997), *The Inflation Target Five Years On*; Massad, Carlos (1998), *La Política Monetaria en Chile*; Masson, P.R. et al (1997), *The Scope for Inflation Targeting in Developing Countries*; Taylor, John (1999), *A Historical Analysis of Monetary Policy Rules*. (ii) Optimization models: Backus, David et al (1986) *The Consistency of Optimal Policy in Stochastic Rational Expectations*

*Models*; Currie, David et al (1993), *Rules, Reputation and Macroeconomic Policy Coordination*; Svensson, Lars (1998), *Open-Economy Inflation Targeting*. (iii) Applied work: Taylor, John (1993) *Discretion versus Policy Rules in Practice*; Taylor, John (1994), *The Inflation/Output Variability Trade-off Revisited*.

After careful planning, the IT group started to work in the design of the institutional framework and the modeling of the transmission mechanism of monetary policy. Brazil has greatly benefited from the discussions and consultations held during the Seminar on Inflation Targeting, jointly organized by the Central Bank of Brazil and the IMF's Monetary and Exchange Affairs Department, which took place in Rio de Janeiro (May 3-5, 1999)<sup>4</sup>. A general consensus that emerged during that meeting can be summarized as follows:

*“Low and stable inflation was singled out as the primary long-run objective of monetary policy, and inflation targeting was regarded as an effective framework for guiding monetary policy. In particular, inflation targeting was seen as providing a nominal anchor both for monetary policy and inflation expectations, making this anchor identical to the long-run objective of monetary policy; providing more transparency and accountability to the design and implementation of monetary policy; facilitating its communication, understanding, and assessment; and providing effective policy guidance by focusing policymakers’ attention on the long-run consequences of short-term policy actions.”* (Brazil – Selected Issues and Statistical Appendix – International Monetary Fund, July 16<sup>th</sup>, 1999).

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<sup>4</sup> The objective of the seminar was to review the experience of a number of developed and emerging economies in implementing inflation targeting, and to provide an opportunity for Brazilian economists and policymakers to discuss plans to implement a similar framework in Brazil. Experts from Australia, Canada, Chile, Israel, Mexico, New Zealand, Sweden, United Kingdom, and United States made presentations on their country's experiences. Researchers from the Central Bank of Brazil presented their initial work on inflation targeting, entitled “Issues in the Adoption of an IT Framework in Brazil”, May 1999.

## 2.1 General setting

On July 1<sup>st</sup>, 1999, Brazil formally adopted inflation targeting as the monetary policy framework. The President of Brazil issued Decree No. 3088 of June 21, 1999, whose key points are listed bellow.

- *The inflation targets will be established on the basis of variations of a widely known price index;*
- *The inflation targets as well as the tolerance intervals will be set by the National Monetary Council on the basis of a proposal by the Finance Minister;*
- *Inflation targets for the years 1999, 2000, and 2001 will be set no later than June 30, 1999; for the year 2002 and subsequent years targets will be set no later than June 30, two years in advance;*
- *The Central Bank is given the responsibility to implement the policies necessary to achieve the targets;*
- *The price index that would be adopted for the purposes of the inflation targeting framework will be chosen by the National Monetary Council on the basis of a proposal by the Finance Minister;*
- *The targets will be considered to have been met whenever the observed accumulated inflation during the period January-December of each year (measured on the basis of variations in the price index adopted for these purposes) falls within the tolerance intervals;*
- *In case the targets are breached, the Central Bank's Governor will need to issue an open letter addressed to the Finance Minister 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 have an effect; and*
- *The Central Bank will issue a quarterly inflation report that will provide information on the performance of the inflation targeting framework, the results of the monetary policy actions, and the perspectives regarding inflation.*

On June 30<sup>th</sup>, 1999, the National Monetary Council (CMN) issued a Resolution<sup>5</sup> on the definition of the price index as well as on the inflation targets. The Broad Consumer Price Index (IPCA) reported by the National Bureau of Geography and Statistics (IBGE) was chosen for the purpose of gauging inflation targets. The targets were set at

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<sup>5</sup> Resolution No. 2615.

8% for 1999, 6% for 2000 and 4% for 2001 – accumulated annual variations by the year-end. Tolerance intervals of  $\pm 2\%$  for each year were also defined.

The selected price index – IPCA – covers a sample of families with personal income between 1 and 40 minimum wages and has a broad geographical basis. It includes 9 metropolitan areas (São Paulo, Rio de Janeiro, Belo Horizonte, Porto Alegre, Recife, Belém, Fortaleza, Salvador and Curitiba) as well as Goiânia and the Federal District

The rationale behind the adoption of decreasing targets between 1999 and 2001 had to do with the nature of the recent inflation in Brazil. It is important to distinguish between an inflationary process and a temporary inflation rise due to a shock. In the first case, there is a continuous acceleration in the price level. In the second, there may be only a once-and-for-all change in the price level, with no further upward pressure. The Brazilian case belongs to the second category: the currency devaluation that started in mid-January 1999 was a shock that forced a realignment of relative prices. Before it occurred, Brazil was experiencing price stability: average CPI inflation was 1.7%<sup>6</sup> in 1998.

As there were no indications of the presence of an inflationary process in Brazil, a gradualist disinflation strategy was not recommendable. The CPI inflation rate should return to its 1998 level as soon as the relative prices realignment is finished. Thus, it was not only possible but also desirable for the government to set a decreasing inflation target path.

An important issue to discuss is the choice of the full inflation rate as reference for the target, and not some core inflation measure. Perhaps, the best technical procedure would have been to purge some items from the full index, exempting it from temporary and once-and-for-all shocks. Nevertheless, adopting a headline index was essential for credibility reasons, at least in the beginning of IT implementation. Unfortunately, Brazilian society has experienced several price index manipulations in a not so distant

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<sup>6</sup> In the case of CPI measured only in São Paulo city by IPC/FIPE, inflation was negative (-1.8%) in 1998.

past, and so would be suspicious about any change related to suppressing items from the target index.

Another related issue is the absence of escape clauses in the institutional arrangement. In the case the targets are breached, the Central Bank Governor will be required to issue an open letter addressed to the Minister of Finance explaining the underlying causes, the measures to be adopted to ensure convergence to the targets and the time period required for these measures to have an effect.

The combination of the use of headline inflation and the absence of escape clauses justifies the adoption of the relatively wide 2-percentage point tolerance interval around the central target, and certainly makes the announced targets much tighter than they may initially appear.

It is important to emphasize that monetary policy decisions should be taken on the basis of the widest information set available. Therefore, a mix of models should be under consideration when looking for an adequate reaction function, and producing inflation forecasts and their probability distributions. It should also include private sector perceptions about the expected path of economic variables, extra-model information, leading indicators and any other judgmental knowledge that helps predict inflation.

A final issue is the transparency of the IT framework. As part of the initial setting, an effective communication process was established so that the population will be able to understand and monitor the decisions of the Central Bank and to know the reasons why forecasted and accumulated inflation may be deviating from target.

The Copom meets at regular monthly intervals and decisions are taken by majority vote. The decisions are announced immediately after the meeting ends, sometimes followed by a press release explaining briefly the reasons why the decisions were taken. In the second half of 1999, the Copom minutes were published 2 weeks after the meetings. In the beginning of 2000, this interval has been reduced to only one week.

Finally, there is a quarterly inflation report discussing the main issues related to the performance of the inflation-targeting regime<sup>7</sup>. It includes detailed explanations of the results delivered by past decisions and a prospective analysis for future inflation, with special emphasis on the assumptions made in the forecasting process that generated the monetary instrument decisions. Minutes of the previous Monetary Policy Committee meetings are republished in the report.

## **2.2 Operational framework**

The Research Department of the Central Bank of Brazil has developed a set of tools to support the monetary policy decision process. Among them are small-scale structural models of the transmission mechanism of monetary policy to prices, complemented with short-term inflation forecasting models, leading inflation indicators and measures of core inflation. There are also surveys of market expectations of inflation, growth, and other relevant economic variables, collected by the Economic Department.

In order to build small structural macroeconomic models, the Central Bank studied the various channels of transmission of monetary policy. These include the interest rate (a policy instrument), the exchange rate, aggregate demand, asset prices, expectations, credit and money aggregates, wages, and wealth. Given the macroeconomic characteristics of the Brazilian economy, the main conclusions are the following: (i) interest rate affects consumer durables and investment in a period between 3 to 6 months. Moreover, the output gap takes additional 3 months to have a significant impact on inflation. In sum, the monetary policy transmission through the aggregate demand channel takes between 6 to 9 months to fully operate; and (ii) through a direct channel: changes in nominal interest rate affects contemporaneously nominal exchange rate, and the later affects, also contemporaneously, the inflation rate through "imported" inflation; (iii) given historical low leverage of the Brazilian corporate sector along with the very strict credit and monetary policies implemented with the *Real* plan, the credit

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<sup>7</sup> Copom has already issue three Inflation Reports – June 30<sup>th</sup>, September 30<sup>th</sup>, and December 30<sup>th</sup>. They are available at the Central Bank homepage – <http://www.bcb.gov.br>.

mechanism has not operated and its importance in terms of channeling interest rate impacts on inflation has been negligible.<sup>8</sup>

The structural models are complemented by a set of short-term models. These complementary models include Vector Autoregressive (VAR) models and Autoregressive Moving Average (ARMA) time-series models and serve three basic purposes: (i) providing an alternative short-term forecast for the inflation rate and, therefore, permitting a consistency check with the forecasts resulting from the structural models; (ii) permitting the use of the inflation forecast resulting from these models for the purposes of estimating (with the structural model) the *ex ante* real interest rate (which is an explanatory variable in the aggregate demand equation in some of the estimated structural models), as well as in the forward-looking interest rate rule (which is one of the equations in the structural models); and (iii) allowing to simulate shocks to specific components of the IPCA, like for instance, changes in prices set by the public sector.

### **3 The basic modeling approach**

Benefiting from international advice, gathered during the Seminar on Inflation Targeting and on consultations with the Bank of England, the Central Bank has estimated/calibrated a group of structural models with the main objective of identifying and simulating the mechanism of monetary policy transmission in Brazil, including the main channels of transmission as well as the lags involved.

A simple structural model with the following basic equations can summarize this family of models<sup>9</sup>:

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<sup>8</sup> With recent measures aimed at reducing the difference between borrowing and lending rates (bank spreads), the credit channel will certainly become important for the operation of monetary policy under the IT framework. See study published by the Research Department of Central Bank of Brazil "*Juros e Spread Bancário no Brasil*", October 1999 (available at <http://www.bcb.gov.br>).

<sup>9</sup> The same modeling approach is widely used for policy analysis. Ball (1997) presents an illustrative two-equation model; Ball (1998) and Batini and Haldane (1999) show compact extensions to small, open economies, highlighting the main transmission channels at work.

- (i) an IS type equation expressing the output gap as a function of its own lags, real interest rate (*ex ante* or *ex post*), and real exchange rate<sup>10</sup>;
- (ii) a Phillips curve expressing the rate of inflation as a function of its own lags and leads, the output gap, and the nominal exchange rate (and imposing the long-term neutrality condition);
- (iii) an uncovered interest parity condition relating the differential between external and domestic interest rates with the expected rate of devaluation of the domestic currency (the *Real*), and the risk premium; and
- (iv) an interest rate rule, alternatively fixed rules on nominal or real interest rates, Taylor-type rules (with weights for contemporaneous deviations in inflation and output), forward-looking rules (with weights for deviations of expected inflation from the target), and optimal deterministic and stochastic rules.

This family of models allows several reduced-form specifications, depending on which issues the Copom wants to discuss in detail. An example may clarify the modeling approach used in Brazil. Suppose that the government is fully committed to a fiscal adjustment, so that the targets for the primary surplus of the consolidated public sector will be observed. In this case, the fiscal policy will produce important effects on aggregate demand, which should be explicitly taken into consideration.

One possible way to incorporate this information into the model is to include a fiscal variable directly in the IS equation. In this specification, two variables represent policy instruments: the interest rate and the primary fiscal surplus. The first is a Central Bank instrument and the second is a Treasury instrument. The diagram in Figure 1 summarizes these assumptions, showing the basic relationships involved.

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<sup>10</sup> Due to the relevant sample period used in the process of estimation, which involved a managed exchange rate regime, and due to the small relative weight of net exports (when compared to the other components of aggregate demand), the real exchange rate was not found statistically significant.

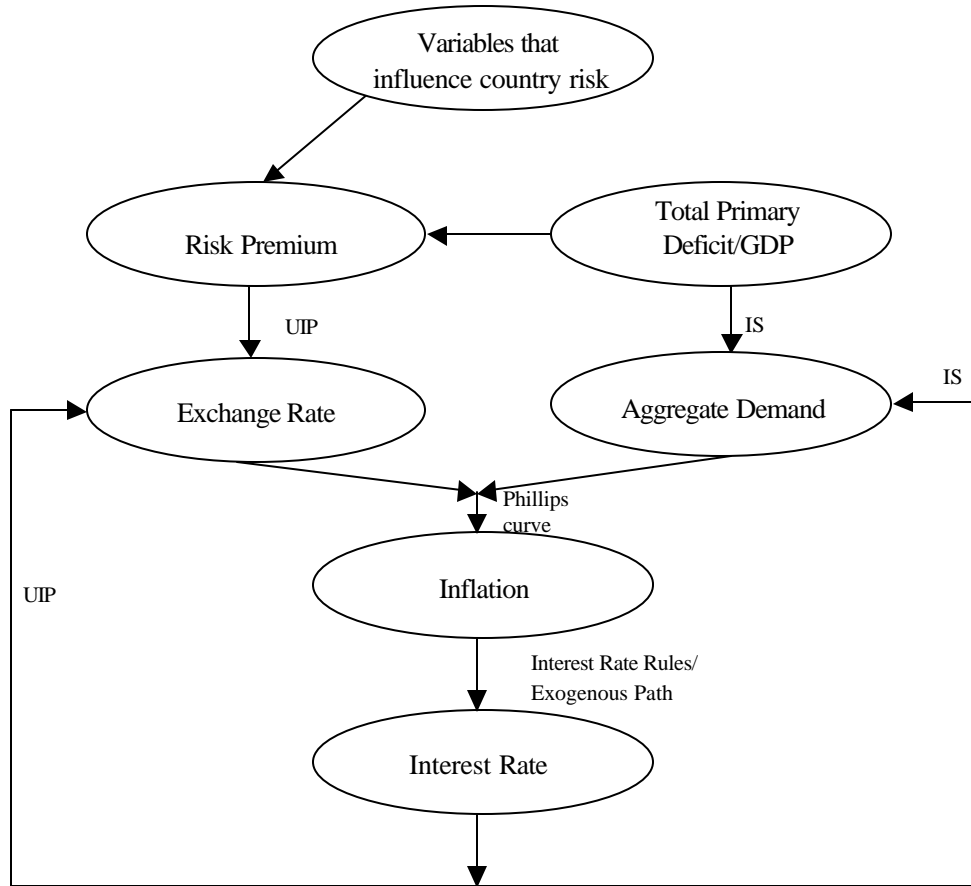


Figure 1: Model diagram.

### IS curve

The standard specification of an IS curve could be, in a quarterly frequency:

$$(I) \quad h_t = \mathbf{b}_0 + \mathbf{b}_1 h_{t-1} + \mathbf{b}_2 h_{t-2} + \mathbf{b}_3 r_{t-1} + \mathbf{e}_t^h$$

where:

$h$  → log of output gap

$r$  → log of real interest rate [ $\log(1+R)$ ]

$\mathbf{e}^h$  → demand shock.

The addition of a fiscal variable can be accomplished by including the term  $pr$  → log of (1+) public sector borrowing requirements (PSBR), primary concept, as a percentage of GDP:

$$(II) \quad h_t = \mathbf{b}_0 + \mathbf{b}_1 h_{t-1} + \mathbf{b}_2 h_{t-2} + \mathbf{b}_3 r_{t-1} + pr_{t-1} + \mathbf{e}_t^{hf}$$

$\mathbf{e}^{hf}$  → demand shock.

First of all, the output gap historical series should be constructed. It is usual to start with a measure of potential output. Several techniques are commonly used to calculate potential output: 1) the extraction of a linear time trend from historical GDP data; 2) smoothing out the GDP series through filters like Hodrick-Prescott; 3) Kalman filters; and 4) estimates of production functions. In the Brazilian case, the linear trend and HP filter were preferred since both produced similar results. The output gap was then obtained by the difference between actual and potential GDP, allowing a direct estimate of the “fiscal” IS curve.

### **Long run calibration of the IS curve**

In order to estimate the demand side of the reduced-form structural model, a quarterly data sample between 1992:I and 1999:III was selected. Hence, the estimation results were heavily influenced by post-*Real Plan* data (1994:III to 1998:IV). It should be noted that the *Real Plan* was implemented along with a managed exchange-rate regime that was very instrumental in reducing inflation and keeping it low. However, domestic interest rates were basically set with the objective of maintaining the managed exchange-rate parity.

In this “old regime”, the exchange rate had the role of a nominal anchor to stabilize inflation, while monetary policy was conducted to attain a balance of payments position compatible with the desired parity. In sum, without judging the success of this old regime in terms of inflation stabilization and its sustainability over time, it is reasonable to conclude that equilibrium real interest rate were necessarily high. This is not necessarily the case in an environment of high international liquidity. Nevertheless, between the end of 1994 and the beginning of 1999 emerging economies faced several episodes of worsening in the external financial conditions.

Under the floating exchange rate regime (in place since January, 1999) and the inflation-targeting framework (as of July, 1999), it is reasonable to state that equilibrium real interest rates should differ substantially from what they were in the previous regime. The transition effects due to the new equilibrium level of real interest rates called for a long-term calibration of the demand side reduced-form model.

The calibration is straightforward. In the long-run steady state, the ratio of government debt to GDP should remain constant, along with a balanced budget (zero primary fiscal surplus) and zero output gap. This implies that the long-term equilibrium real interest rate must equal the potential GDP growth rate. In the “fiscal” IS curve specification, this is equivalent to  $\bar{r} = -b_0/b_3$ . So, the long-run calibration can be done by estimating the “fiscal” IS curve with the additional restriction on the pair  $(b_0, b_3)$ , whose ratio must equal the long-term equilibrium real interest rate.

### Phillips curve

The supply side of the economy is usually modeled with a Phillips curve specification, directly relating price inflation to some measure of real disequilibrium (typically the output gap), inflation expectations, and real exchange rate changes. Three variants are presented below. The coefficients  $a$  on the right side of all equations, except for the output gap one, are constrained to sum to unity to ensure the long-run verticality of the Phillips curve, i.e. that inflation is neutral with respect to real output in the long run.

Backward-looking specification

$$(III) \quad p_t = a_1^b p_{t-1} + a_2^b p_{t-2} + a_3^b h_{t-1} + a_4^b \Delta(p_t^F + e_t) + e_t^b$$

Forward-looking specification

$$(IV) \quad p_t = a_1^f p_{t-1} + a_2^f E_t(p_{t+1}) + a_3^f h_{t-1} + a_4^f \Delta(p_t^F + e_t) + e_t^f$$

Combined (average) specification

$$(V) \quad p_t = \frac{(a_1^f + a_1^b)}{2} p_{t-1} + \frac{a_2^f}{2} E_t(p_{t+1}) + \frac{a_2^b}{2} p_{t-2} + \frac{(a_3^f + a_3^b)}{2} h_{t-1} + \frac{(a_4^f + a_4^b)}{2} \Delta(p_t^F + e_t) + e_t^n$$

where:

$p$  → log of price inflation

$h$  → log of output gap

$p^F$  → log of foreign producer price index

$e$  → log of exchange rate

$\Delta$  → first-difference operator

$E_t(\cdot)$  → expectation operator, conditional on information available at time  $t$

$e^b, e^f, e^n$  → supply shock.

The backward-looking specification can be motivated by the assumption of adaptive inflation expectations. It is simple to estimate and, with only two lags, it is able to reproduce fairly well the rich inflation dynamics of past data. However, it is vulnerable to the Lucas critique. Its predictive power should be weak due to the recent changes in monetary policy and exchange-rate regimes, which probably have altered the formation of inflation expectations and the short-run inflation/output tradeoff.

The forward-looking specification is an attempt to overcome the parameter instability commonly found after structural breaks. It is also motivated by the natural assumption that, as the inflation targeting regime gains credibility, expectations tend to converge to the targeted value. However, it raises difficult estimation issues about the appropriate measures of expectations, especially when reliable survey data are not available.

Different assumptions about the expectations mechanism were tested, but in general the estimations led to a weighted average of past and future inflation, with at least 60% on the forward-looking component. Neither the research staff nor the Copom members were comfortable with these results for two reasons. First, they implied a degree of credibility that was not expected to be achieved so early and they did not match the current surveys of market expectations. Second, they generate an inflation/output dynamics with almost no inertia and consequently a fast adjustment of both real and nominal variables, which is not believed to yield a reasonable representation of reality.

A solution to balance out the forward and backward-looking variants was to combine them. The average of the previous two specifications of the Phillips curve (together with the other equations in the complete model) exhibits the desired dynamic properties of the economy, with inflation persistence due to sluggish adjustment forced by the backward-looking terms, while keeping a forward-looking component thought to be increasingly important in the transition period after the changes in monetary policy and exchange-rate regimes.

For the purpose of running simulations to investigate the implications for inflation and output of different monetary policy rules, it is easy to experiment with alternative assumptions about the expectations' formation mechanism. For example, expectations

can be taken exogenously from a market survey, together with an additional hypothesis about how they react to new information. Or expectations can be calculated recursively in order to be model-consistent.

### The passthrough

The passthrough of exchange rate changes to domestic inflation is a key issue in the Phillips curve set-up. Several linear and non-linear specifications for the passthrough coefficients have been tested, reducing to four the alternatives implemented in the preferred simulation tool. The first one is a standard constant coefficient; simply estimated from a suitable sample of past data. The second one is a quadratic transfer from exchange rate variations to inflation. The third one is a level-dependent coefficient. It is estimated under the assumption that the passthrough depends also on the level of the (log) nominal exchange rate. The last one is a quadratic function of the nominal exchange rate level, motivated by a simple partial equilibrium model in which exchange-rate devaluations shift the supply curve of competitive producers of tradable goods<sup>11</sup>. All non-linear variants intend to capture more precisely the effects of a temporary exchange rate overshooting<sup>12</sup>. For the small number of observations available in a quarterly frequency, however, their results were very close to the linear variant and consistent with international evidence that the passthrough coefficient is inversely proportional to the degree of real exchange rate appreciation at the moment prior to the devaluation. The equations below summarize the four alternative specifications.

$$\mathbf{a}_4 = \text{constant}$$

$$\mathbf{a}_4 = (\mathbf{a}_{41} + \mathbf{a}_{42}\Delta(p_{t-1}^F + e_{t-1}))$$

$$\mathbf{a}_4 = (\mathbf{a}_{41} + \mathbf{a}_{42}e_{t-1})$$

$$\mathbf{a}_4 = \mathbf{a}_{41} \frac{E_{t-1}^2 - \mathbf{a}_{42}}{E_{t-1}^2 + \mathbf{a}_{42}}$$

where:

$p^F$  → log of foreign producer price index.

$e$  → log of exchange rate.

$E$  → exchange rate ( $R\$/US\%$ ).

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<sup>11</sup> See Goldfajn and Werlang (1999), Appendix.

<sup>12</sup> Dornbusch (1976) presents the overshooting result in a different context.

### Exchange Rate - Uncovered Interest Parity

The nominal exchange rate is determined by the uncovered interest parity condition, which relates expected changes in the exchange rate between two countries to their interest rates differential and a risk premium:

$$(VI) \quad E_t e_{t+1} - e_t = i_t - i_t^F - x_t$$

where:

$e$  → log of exchange rate

$i$  → log of domestic interest rate

$i^F$  → log of foreign interest rate

$x$  → log of risk premium

Taking the first difference  $E_t e_{t+1} - E_{t-1} e_t - \Delta e_t = \Delta i_t - \Delta i_t^F - \Delta x_t$  and assuming for simplicity that the expectation change follows a white noise process<sup>13</sup>  $E_t e_{t+1} - E_{t-1} e_t = \mathbf{h}_t$ , it is possible to specify the exchange rate dynamics as:

$$(VII) \quad \Delta e_t = \Delta i_t^F + \Delta x_t - \Delta i_t + \mathbf{h}_t.$$

There are two exogenous variables in this equation: the foreign interest rate and the risk premium. Given the relative stability of foreign interest rates, reasonably accurate projections can be obtained from contracts traded in international futures markets. However, the risk premium – which can be measured by the spread over Treasury bonds of Brazilian sovereign debt – has presented high volatility in the last years. The risk premium is usually associated to macroeconomic fundamentals and a number of other subjective factors that are not easily anticipated. Hence, two alternative approaches have been considered. The first is to gather the opinions of Copom members about the future evolution of the country's risk premium, conditional on the overall scenario and based on anecdotal evidence, translating it to an exogenous expected path that will be used in simulations. The second approach is to make assumptions linking the risk premium behavior to the main objective factors thought to influence it, letting it be endogenously determined by the model.

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<sup>13</sup> This is equivalent to a random walk with monetary surprise, where a surprise is characterized by changes in interest rate differentials or in risk perception.

An assumption consistent with the “fiscal” IS curve is that the risk premium will respond to the fiscal stance, with any perceived improvement in the consolidated public sector fiscal position reducing the premium accordingly. Additionally, a number of other factors may have a considerable influence on expectations and hence, on the risk premium. A list of these factors would typically include international liquidity conditions and interest rates, foreign capital markets performance, commodities prices, current account balance perspectives, and country rating. The link with the UIP condition is through the following equation:

$$(VIII) \quad \Delta X_t = g_1 \Delta X_{t-1} + g_2 \Delta PR_{t-3} + \sum_{j=3}^n g_j \Delta Z_{j,t-t_j}$$

where:

$X$  → risk premium in basis points (SoT)

$PR$  → PSBR, primary concept, as a percentage of GDP

$Z$  → variables that influence country risk.

### **Monetary policy rules**

The primary instrument of monetary policy is the short-term interest rate set by the Central Bank. To run a simulation in any of the model variants<sup>14</sup>, it is necessary to choose a monetary policy rule. The rules can be divided in three basic families: fully exogenous interest rate paths, linear combination of system variables and optimal response functions.

### **Fully exogenous interest rate path**

This family of rules provides a direct way to input any interest rate path in the model. This is useful to analyze the consequences of an expected interest rate trajectory, such as that implied by financial market instruments or the implicit path considered in the government budget.

A particular rule of this family can be very helpful for institutional communication. The quarterly Inflation Report traditionally presents inflation and output growth forecasts constructed under the assumption that the short-term interest rate will remain constant at

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<sup>14</sup> See Blanchard and Kahn (1980) for references on solving forward a system of difference equations under rational expectations.

the current level along the projection period. This projection is made clear by means of an inflation fan chart, which shows the probability distribution around the central forecast for each quarter. By visual inspection, it is possible to infer whether monetary policy should be altered and in which direction<sup>15</sup>.

### **Linear combination of system variables**

The interest rate rule in this family is a linear function of some system variables. For example, monetary policy can react contemporaneously to output gap and deviations of inflation from target, as shown in the equation below. When  $\lambda=1$ , this is equivalent to a standard Taylor rule, while when  $\lambda \in (0,1)$  this is a Taylor rule with interest rate smoothing. The  $\alpha$ 's can be set arbitrarily or using specific optimization procedures available in the simulation tool.

$$(IX) \quad i_t = (1 - \lambda)i_{t-1} + \lambda(\alpha_1(\mathbf{p}_t - \mathbf{p}^*) + \alpha_2 h_t + \alpha_3)$$

where:

$\mathbf{p}$  → log of inflation.

$\mathbf{p}^*$  → log of inflation target.

$h$  → log of output gap.

$i$  → log of interest rate.

This type of rule is instrumental to analyze the system behavior under the choice of a particular set of  $\alpha$ 's. However, the set of  $\alpha$ 's obtained by optimization procedures can frequently be very unintuitive<sup>16</sup>.

### **Optimal Trajectories**

An optimal rule can be found using two basic optimization methods available for simulation. The first one is a deterministic optimization made considering the expectation for the system variables equivalent to the model own realizations. The second uses stochastic simulation. In the deterministic case, the objective function is given by equation (X), and in the stochastic case it is given by equation (XI). Notice

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<sup>15</sup> Britton, Fischer and Whitley (1998) explain how to interpret inflation forecasts presented as fan charts. Haldane (1997) discusses how the introduction of a partially subjective probability distribution may help clarify the policy maker's assessment of the current economic stance.

<sup>16</sup> See Svensson (1997).

that due to the certainty equivalence principle, for linear constraints, equations (X) and (XI) are equivalent.

$$(X) \quad L = \sum_{r=1}^N [I_1(E(\mathbf{p}_{t+r}) - \mathbf{p}_{t+r}^*)^2 + I_2[E(h_{t+r})]^2 + I_3(\Delta i_{t+r})^2]$$

$$(XI) \quad L = \sum_{r=1}^N [I_1 E[(\mathbf{p}_{t+r} - \mathbf{p}_{t+r}^*)^2] + I_2 E(h_{t+r}^2) + I_3 (\Delta i_{t+r})^2]$$

These two optimization methods may be used with a fully arbitrary interest rate trajectory<sup>17</sup> or with a trajectory given as function of inflation, output gap and the lagged interest rate.

The deterministic case is useful for simulating alternative scenarios during a forecast team meeting since this procedure is fast. On the other hand, the stochastic case is more accurate and gives the confidence intervals for the implied interest rate trajectory, though it requires substantial computation time, making this procedure unfeasible during a Copom meeting.

### **Basic structure**

Combining equations (II), (V), (VII), and (VIII), along with a choice of formation mechanism of inflation expectations, passthrough specification, and a monetary policy rule, the basic framework for simulation and forecasting is determined, which is consistent with the relationships shown in Diagram 1.

## **4. Requirements for simulation**

The Copom members exchange views with the staff and choose relevant possible shocks. These shocks are then stylized and introduced into the structural models. It is important to note that given the simplified nature of the macro models, the staff is required to carefully identify the form, the intensity, as well as the timing of the interventions.

The introduction of shocks in the simulation process involves a previous work on how much the economic agents have already anticipated them. This is particularly true for nominal variables. The Copom members have to carefully assess the set of shocks proposed in the simulation exercises.

Once the Copom defines the relevant shocks and the staff prepares them for introduction in the macro models, some additional definitions are required for simulation purposes. For instance, it is necessary to make the following choices: the interest rate rule (a fixed nominal rate or a Taylor-type rule or a rule based on the deviations of expected inflation from target or a predetermined trajectory for nominal or real rates); and (ii) a mechanism for the formation of inflation expectations.

Given these definitions, the following results can be obtained: (i) inflation forecasts (central path and confidence intervals around the median) with definitions of a measure of dispersion (variance) and of risks (asymmetries); (ii) forecasts for output; (iii) the trajectory for interest rates (both nominal and real) resulting from the various reaction functions; and (iv) dynamic simulations of exogenous shocks.

Simulations permit the visualization of the transmission mechanism of monetary policy implicit in these simplified models, with the interest rate affecting the nominal exchange rate contemporaneously and the output gap with a lag; the nominal exchange rate affecting the imported inflation and, thus the inflation rate contemporaneously; and the output gap affecting the inflation rate with a lag.

The simulation of the structural models is based on the selection of a core scenario that involves the most likely hypothesis and a set of alternative scenarios representing the perceived risks of departure from the basic hypothesis. A careful assessment of the various hypotheses is a necessary condition for balanced decisions on the instrument of monetary policy.

Naturally, the results from the simulation exercises are combined with other elements in making policy decisions. In particular, forecasts cannot be limited to those produced by

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<sup>17</sup> In both cases the optimization is constrained to the model in use.

models. Alternative sources such as market surveys and forecasts, and information on inflation expectations embodied in financial instruments need also be considered in the decision process.

## **5. Concluding remarks**

Brazil has implemented its inflation-targeting framework in a very short time. Even though the target for 1999 has been met, it is too early to discuss its success, but there are some crucial points that deserve mentioning. First, IT involves several elements that must be properly addressed: a well defined quantitative target for the inflation rate in the medium term; an institutional commitment to this target as the overriding objective of monetary policy; increased transparency of the monetary policy strategy through communication with the public and the markets about the plans of monetary authorities; and increased central bank's accountability for achieving its inflation targets.

Second, the central bank staff engaged in monetary policy advice should focus initially in the following issues: get a clear view of the monetary policy transmission mechanism and decide which channels are best suited to be explored in order to meet the inflation target; develop simple and small structural models of these channels of transmission, being able to understand and explain the behavior key macro variables; use a preferred model to discipline the discussion with the policymakers; monitor incoming data and use judgmental analysis in the first forecasting quarters.

Communication efforts in an IT framework are vital. It is fundamental to explain clearly to the public at large, to financial market participants, and to the politicians the goals and limitations of monetary policy (what the central bank can do in the long run is to control inflation; what it cannot do is to raise economic growth through monetary expansion); the numerical values of the inflation targets and on which grounds they were selected; and how the targets are to be achieved, given current economic stance and expected future developments.

In Brazil, the monetary authorities chose the full disclosure strategy, in the same line as the Bank of England. The publication of Inflation Reports is an integral part of the communication efforts, allowing the general public to understand and assess the quality of the monetary policy decisions, in a continuous process that ultimately leads to earning credibility and permits achieving the inflation targets with lesser costs.

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