Price Stability under Inflation Targeting in Brazil: an empirical analysis of the monetary policy transmission mechanism based on a VAR model (2000-2008)

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Abstract

With a view to offer a body of empirical evidence to assess the costs and benefits of Brazilian stabilization policy, we undertake an econometric analysis of the transmission mechanism of monetary policy in Brazil during the period from the adoption of inflation targeting regime (IT) to the subprime crisis (2000-2008). Exchange rate was the main channel of monetary policy transmission during that time frame. Furthermore, inflation sensitivity to the interest rate is low. Thus, a raise in the basic interest rate (Selic) generates relatively small benefits (a fall in inflation). However, an interest rate increase generates substantial costs: a slowdown in economic activity, the appreciation of exchange rate and an increase in public debt. Inflation’s low sensitivity to interest rates is seen as a result of problems in the transmission mechanism: a broken transmission mechanism reduces the efficiency of monetary policy. Price stability under IT thus requires an excessively rigid monetary policy. The final outcome is, on the one hand, that inflation hardly gives in. On the other hand, the costs of high interest rates escalate. We conclude that the balance of costs and benefits of price stability under IT is unfavorable.

Keywords: Inflation; Monetary Policy Transmission Mechanism; Selic Rate

JEL Classification: E40, E52, E31.
Resumen

Con el objetivo de producir uno cuerpo de evidencias empíricas que posibiliten evaluar los costos e beneficios de la política brasileña de estabilización hemos hecho una análisis econométrica del mecanismo de transmisión de la política monetaria desde la adopción del régimen de metas de inflación (MI) hasta la crisis de la subprime (2000-2008). La tasa de cambio ha sido el principal canal de transmisión. Además, es baja la sensibilidad de la inflación con respecto a la tasa básica de interés (Selic). Así que una elevación de la Selic genera beneficios (la caída de la inflación) relativamente pequeños. Sin embargo, un aumento en la Selic tiene costos substanciales: la reducción de la actividad económica, la apreciación cambial e un incremento en la deuda pública. La baja sensibilidad de la inflación con respecto a la tasa de interés es interpretada como resultante de problemas en el mecanismo de transmisión: imperfecciones en la transmisión reducen la eficiencia de la política monetaria. La estabilidad de precios, bajo el MI, requiere una política monetaria demasiado rígida. El resultado final es, por uno lado, que la inflación difícilmente cede. Por otro lado, el costo de la alta tasa de interés es intensificado. La conclusión es que es desfavorable el balance entre los costos e beneficios de la política monetaria.

Palabras-chave: Inflación; Mecanismo de Transmisión de la Política Monetaria; Tasa Selic

JEL Classification: E40, E52, E31.
1 Introduction

In an inflation targeting regime (IT), the basic interest rate is the main instrument to control inflation. In fact, ever since IT was adopted in mid-1999, the basic interest rate (Selic) has been the sole instrument used to ensure price stability in Brazil. It is worth to mention that this is not a critique paper on the theoretical foundations and operational procedures of that monetary regime, although a lot could be said about those issues (see Modenesi, 2005; Vernengo, 2008; Haight, 2008; and Epstein and Yeldan, 2009; among many others). The purpose of this paper is to offer a body of empirical evidence to support the assessment of the main costs and benefits arising from the current stabilization policy in Brazil. That shall be accomplished by undertaking an empirical analysis of how variations in Selic affect or are transmitted to the main macroeconomic variables, namely: inflation, exchange rate and economic activity.

On the one hand, an increase in the basic interest rate reduces inflation; as stressed by IT advocates, price stability promotes efficiency, from which the whole functioning of the economic system will benefit – and thus contribute to boost economic growth. On the other hand, an increase in interest rates contributes to slow down the economy, to appreciate the domestic currency and to increase public debt. Hence, a raise in interest rates jeopardizes economic performance.

With the purpose of identifying and assessing the costs and benefits of the monetary policy practiced in Brazil for nearly a decade, we shall undertake an empirical analysis of the transmission mechanism, defined as the process through which variations in the basic interest rate affect the general price level. The sacrifices imposed by stabilization policy, conceived as the social and economic costs resulting from an increase in interest rates, will be evidenced by using a Vector Autoregression (VAR) model.

Traditionally, that kind of exercise is made by estimating the so called “sacrifice ratio”, or the ratio of the output loss (deviation of real GDP from its potential) to the associated changes in inflation. The present study addresses this issue in a broader sense than usual, as it focuses on the concurrence of three detrimental effects of an increase in the basic interest rate: the slowdown in economic activity, the appreciation of the domestic currency and the expansion of public debt. Econometric analysis will allow us to systematize and quantify the main negative outcomes of an increase in Selic, as well as
its impact on inflation. Thus, we will be able to compare the effect of variations in Selic on prices in face of its detrimental effects on exchange rate, economic activity and public debt.

This article is divided in three sections, in addition to this introduction and a conclusion. Next section states that in IT regime the monetary authority sustains an institutional commitment to make price stability the main long-term goal of monetary policy. In the third section, the VAR model is presented. Section four analyzes the transmission mechanism of monetary policy, stressing the interactions between the basic interest rate (Selic), inflation (as measured by the consumer price index, IPCA), the exchange rate, the level of economic activity (using industrial output as a proxy), and public debt (measured by the debt/GDP ratio). The empirical evidence corroborates the – already widespread – thesis that Brazil’s monetary policy has taken a high cost on the country's economy. In short, we will provide a body of significant empirical evidence showing that Brazil's monetary policy under IT, besides having little effect on inflation control, has imposed a high level of sacrifice.

2 Inflation Targeting: the Emphasis on Price Stability

From an operational standpoint, IT is a monetary regime marked by an institutional commitment by the monetary authority to adopt price stability as the main long-term goal of monetary policy – to which all the remaining objectives are subjected.iii IT is characterized by: i) setting a medium-term inflation target; ii) reduced importance of intermediate targets, such as, for instance, monetary aggregates; iii) greater transparency in the conduct of monetary policy, substantiated in the efforts to improve communication between the Central Bank (CB) and economic agents, allowing for a greater accountability of CB; iv) independence of CB instruments (Fischer, 1995) or greater ability to carry out its targets – that is, it is required that the CB be free to determine monetary policy instruments.iv

IT had a sort of golden age from its first adoption by New Zealand in 1990 to the 2008 subprime crisis. According to the so called New Consensus Macroeconomics, IT is the correct way of monetary policy-making, in a way that such regime has been adopted
globally. However, as one of the aftermaths of the subprime crisis in 2008, central banks’ blind faith on IT has been substantially reduced. At the same time, we have witnessed a shy movement by orthodox theory towards the recognition that monetary policy should target other variables than inflation. For instance, Blanchard et al. (2010) and Eichengreen et al. (2011) consider that monetary policy should also target asset prices – in order to prevent financial crisis.

This late orthodox criticism reinforces a general criticism shared by many heterodox economists. From a theoretical standpoint, most of IT critics rightfully emphasizes that the adoption of IT implies the acceptance of long-run money neutrality – resulting from the assumption of the natural rate of unemployment hypothesis (Friedman, 1968). From a more operational perspective there is plenty of criticism on: i) the use of a single instrument (the interest rate) to curb inflationary pressures; and ii) the belief that any rise (fall) in inflation should always be followed by a rise (fall) in interest rates, regardless of the nature of the inflation – aligned with the Taylor rule.

Those who advocate IT generally justify the emphasis given to price stability on the grounds of an alleged consensus against the use of discretionary monetary policies, with the purpose of reducing unemployment, as proposed by Keynesian macroeconomic tradition, according to which money is not neutral in the long run. There are three paradigmatic moments in the challenge to monetary policy discretion: i) evidence of lags in monetary policy transmission – reported by Friedman (1948); ii) denial of the existence of a long-run trade-off between inflation and unemployment – originally proposed by Friedman (1956, 1968) and Phelps (1967, 1968) and furthered by Lucas (1972, 1973), Sargent (1981) and Sargent and Wallace (1981a, 1981b); and iii) development of the time-inconsistency problem and the resulting inflation bias, by Kydland and Prescott (1977), Calvo (1978) and Barro and Gordon (1983a, 1983b).

Historically, the costs of inflation – as well as the channels through which inflation reduces the level of utility of economic agents and, thus, of social welfare – has been a recurrent theme in orthodox monetary theory. Such literature, which we do not intend to review here, is extremely vast, since its origins date back to the mercantile period. Contemporarily, one could highlight Bailey's contribution (1956) in defining the loss of social welfare to inflation as the consumer surplus that would be generated were the nominal interest rate brought down to zero. Inspired by Bailey (1956), Lucas (2000)
argued, regarding the American economy, that “the gain from reducing the annual inflation rate from 10 percent to zero is equivalent to an increase in real income of slightly less than one percent”.

In accordance with that literature, the following inflation-related issues are worth to mention: i) the super-sizing of the financial system; ii) the economy vulnerability to financial crises – due to the greater fragility of its financial system (compared to economies with stable prices); iii) the deterioration of the tax system – since taxes are usually not indexed –, bringing on several negative consequences such as the Tanzi effect; iv) the occurrence of distributive effects, since indexation mechanisms do not fully protect the income of the different economic groups; v) menu costs from changing prices; and vi) market failures and ineffective resource allocation – due to imperfect signaling of the price system –, which in turn decreases the productivity of production factors and, thus, jeopardizes economic growth.

Among those issues, the latter is particularly relevant, given that it supports the idea that price stability is a necessary condition for economic growth: “As a great deal of prior theory predicts, the results presented here [for the US economy] imply that inflation reduces growth by reducing investment, and by reducing the rate of proclivity growth” (Fischer, 1993: 22).

Bernanke et al. (1999) also stress that inflation decreases economic efficiency, jeopardizing economic growth. According to them, price stability is, thus, a necessary condition for the achievement of other macroeconomic goals, such as high GDP growth and low unemployment. That is one of the main reasons for adopting IT, which, the authors state, could also be justified on the grounds that: i) the inflation target works as a nominal anchor; and ii) money is neutral in the long run. In their words: “[...] there is by now something of a consensus that even moderate rates of inflation are harmful to economic efficiency and growth, and that the maintenance of a low and stable inflation rate is important, perhaps necessary, for achieving other macroeconomic goals” (Bernanke et al., 1999: 10).

The belief that reduced levels of inflation are a fundamental precondition for sustained economic growth is widely spread. According to that belief – which we do not intend to question herein –, price stability is an absolute priority. The fact that Brazil has
experienced a long period of chronic high inflation contributes to the almost unconditional acceptance of that belief by great part of the Academy and a great number of opinion-makers. Thus, little attention has been given to the costs arising from fighting inflation (Epstein, 2003). And that is precisely one of the contributions of this article: to draw attention to the main costs of the current price stabilization policy.

It is not our intention here to address, from a theoretical standpoint, the process through which a raise in the basic interest rate generates social and economic costs – and thus reduces welfare. This mechanism – which finds ample support in economic theory – will be summarized in simple terms as follows. A raise in interest rates: i) discourages private investment, reducing aggregate demand and thus reducing the GDP growth rate; ii) by making financial assets denominated in domestic currency more attractive, it impacts positively on the capital account, causing the domestic currency to appreciate and therefore the competitiveness of domestic output to reduce – which, in turn, deteriorates the balance of payments; and iii) increases debt-servicing expenditure, raising public debt.

For the three reasons previously mentioned, we argue that a raise in the basic interest rate imposes a cost on society. It is worth taking into consideration that this paper in no way intends to explore all the potential negative impacts of a raise in the basic interest rate. For instance, monetary policy may produce perverse distributive effects (Areosa and Areosa, 2006). Nevertheless, for the purpose of this article, the three previously mentioned effects are sufficient.

In short, the adoption of IT is, to a great extent, grounded on the belief that inflation is highly detrimental to economic growth and thus price stability becomes the main objective to be attained by monetary policy. However, little importance is given to the costs of achieving and/or maintaining price stability. Orthodox theory tends to amplify the relevance of inflation costs. However, even if one takes for granted that inflation is detrimental, the net impact on social welfare of a raise in interest rates remains, in principle, undefined.

The balance of costs and benefits related to inflation control depends on the actual manner through which the effects of interest rate movements are transmitted to the remaining macroeconomic variables. A broken transmission mechanism may produce
an unfavorable balance of costs and benefits in monetary policy. In other words, the more sensitive inflation is to interest rates, the less rigid will monetary policy need to be in order to ensure the achievement of a given inflation target. Alternatively, transmission flaws may reduce inflation’s sensitivity to interest rates and, consequently, will jeopardize the efficiency of monetary policy to control inflation. As a result, and aligned to IT framework, it becomes necessary to apply relatively higher doses of interest rates to ensure stability. In that case, the costs arising from the policy tend to escalate. Thus, an evaluation of the current stabilization policy must be based on an empirical analysis of the transmission mechanism of monetary policy. We shall do that in next section.

3 Empirical Evidence

3.1 Database and Unit Root Tests

The implementation of IT in Brazil, on June 21, 1999, represented a significant shift in the monetary regime, as well as a deep change in the conduct of monetary policy, which until then had been based on an exchange rate targeting (Modenesi, 2005: chap. 5 and 6). As a result, to enhance robustness, we excluded the first six months of IT adoption from our sample, which therefore covers the period from January 2000 to August 2008. The subprime crises after the falling down of Lehman Brothers (September, 1998) represents a major structural break. After that, the conduct of monetary policy has changed deeply worldwide – for instance, with the adoption of the so called quantitative easing program by FED – and we have seen an abnormal decline of the main Central Banks' rates (FED, BOE, ECB, BOJ). So we have decided to limit our sample to the pre-subprime crisis period, which includes 104 monthly observations and thus grants robustness to our results.

The list of variables to be applied is as follows: Selic is the basic interest rate (p.y.); IPCA is the consumer price index; Ind is the index of physical output (quantum) of the domestic industries (seasonal adjustments apply); Exchange is the (monthly average) nominal exchange rate (real/USD); and Div is the public debt as a proportion of GDP.
Brazilian Central Bank (BCB) provides the Selic rate and the exchange rate, whereas the Brazilian Institute of Geography and Statistics (IBGE) provides the index of industrial output and also IPCA. The public debt stock is provided by the National Treasury. As for the debt/GDP ratio, it is the authors’ calculation. To all variables the logarithmic scale applies – for instance, the term *Selic* always refers to the *Selic* Neperian logarithm (*logSelic*).

In order to determine whether the variables follow a stationary process, the augmented Dickey-Fuller test (ADF) and the Phillips-Perron (PP) test were carried out in the series at the level and its first difference (Tables 1 and 2).\textsuperscript{xv} The null hypothesis of a unit root (non-stationary) is not rejected for all variables at the 1\% level.

### Table 1 – Augmented Dickey-Fuller Test (ADF): level and first difference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lags</th>
<th>T-statistics</th>
<th>Critic value: 1%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Selic</em></td>
<td>1</td>
<td>-3.0560</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>IPCA</em></td>
<td>0</td>
<td>-1.1834</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>Exchange</em></td>
<td>1</td>
<td>-1.6303</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>Ind</em></td>
<td>0</td>
<td>-2.4792</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>Debt</em></td>
<td>0</td>
<td>-2.1539</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>DSelic</em></td>
<td>0</td>
<td>-3.2368</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>DIPCA</em></td>
<td>0</td>
<td>-4.7657</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>DExchange</em></td>
<td>0</td>
<td>-7.4262</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>DInd</em></td>
<td>0</td>
<td>-11.406</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td><em>DDebt</em></td>
<td>0</td>
<td>-11.035</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
</tbody>
</table>

Note: ADF at level with trend and intercept.
However, the null hypothesis is rejected for all variables at first difference (at the usual levels of significance). Thus we may conclude that the series are integrated of order 1, \( I(1) \).

**Table 2 – Phillip-Perron Test (PP): level and first difference**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lags</th>
<th>( T ) statistics</th>
<th>Critic value: 1%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selic</td>
<td>1</td>
<td>-1.9729</td>
<td>-4.0495</td>
<td>-3.4540</td>
<td>-3.1526</td>
</tr>
<tr>
<td>IPCA</td>
<td>0</td>
<td>-0.8097</td>
<td>-4.0495</td>
<td>-3.4540</td>
<td>-3.1526</td>
</tr>
<tr>
<td>Exchange</td>
<td>5</td>
<td>-1.3849</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>Ind</td>
<td>4</td>
<td>-2.3582</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>Debt</td>
<td>5</td>
<td>-2.8094</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>DSelic</td>
<td>0</td>
<td>-3.2368</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>DIPCA</td>
<td>0</td>
<td>-4.7419</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>DExchange</td>
<td>4</td>
<td>-7.4553</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>DInd</td>
<td>12</td>
<td>-12.110</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
<tr>
<td>DDebt</td>
<td>4</td>
<td>-10.996</td>
<td>-4.0505</td>
<td>-3.4544</td>
<td>-3.1529</td>
</tr>
</tbody>
</table>

Note: PP at level with trend and intercept.

### 3.2 Cointegration

Having determined that the series are non-stationary and \( I(1) \), two cointegration tests shall be performed. The null hypothesis (no cointegration relationship) is not rejected at the 5% significance level, neither for trace statistics, nor for maximum eigenvalue statistics (Table 3).
Given the strong evidence indicating the non-existence of a cointegrating vector, and given that the series are $I(1)$, we will estimate a VAR model for the series at first difference. Figure 1 shows the variables at first difference and allows the series behavior to be visualized.

<table>
<thead>
<tr>
<th></th>
<th>Trace statistics</th>
<th>Max-Eigen statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eigen value</td>
<td>Critical value</td>
</tr>
<tr>
<td>None</td>
<td>6.001.641</td>
<td>6.006.141</td>
</tr>
<tr>
<td>At most 1</td>
<td>3.565.403</td>
<td>4.017.493</td>
</tr>
<tr>
<td>At most 2</td>
<td>1.780.315</td>
<td>2.427.596</td>
</tr>
</tbody>
</table>
3.3 Estimation: Lag Order Selection and Granger Causality

To determine the number of lags to be included in the model, the usual tests apply. The SC and HQ information criteria suggest only one lag, as shown in Table 4. The LR, FPE and AIC criteria suggest the inclusion of three lags.
Table 4 – VAR Lag Order Selection Criteria

<table>
<thead>
<tr>
<th>lags</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1274.098</td>
<td>NA</td>
<td>1.71e-18</td>
<td>-2.671.785</td>
<td>-2.658.343</td>
<td>-2.666.353</td>
</tr>
<tr>
<td>1</td>
<td>1385.360</td>
<td>208.4707</td>
<td>2.79e-19</td>
<td>-2.853.390</td>
<td>-27.72741*</td>
<td>-28.20802*</td>
</tr>
<tr>
<td>2</td>
<td>1410.061</td>
<td>43.68213</td>
<td>2.82e-19</td>
<td>-2.852.761</td>
<td>-2.704.905</td>
<td>-2.793.016</td>
</tr>
<tr>
<td>3</td>
<td>1436.245</td>
<td>43.54774*</td>
<td>2.78e-19*</td>
<td>-2.855253*</td>
<td>-2.640.190</td>
<td>-2.768.351</td>
</tr>
<tr>
<td>4</td>
<td>1458.594</td>
<td>34.81755</td>
<td>3.00e-19</td>
<td>-2.849.672</td>
<td>-2.567.402</td>
<td>-2.735.614</td>
</tr>
</tbody>
</table>

The VAR models with one or three lags show residuals that are strongly autocorrelated, heteroscedastic and non Gaussian. To avoid that problem, a successively larger number of lags was introduced, until a model with well behaved residuals could be obtained. Finally, we decided to estimate the model with six lags, therefore satisfying the basic conditions of robustness (see next item), according to equations 1-5:\textsuperscript{xvi}

\begin{align*}
\text{DlogSelic}_t &= \alpha_{10} + \alpha_{11}\text{DlogIPCA}_{t-1} + \alpha_{12}\text{DlogInd}_{t-1} + \alpha_{13}\text{DlogDebt}_{t-1} + \alpha_{14}\text{DlogExchange}_{t-1} + \epsilon_{t-1} \quad (1) \\
\text{DlogIPCA}_t &= \alpha_{20} + \alpha_{21}\text{DlogSelic}_{t-1} + \alpha_{22}\text{DlogInd}_{t-1} + \alpha_{23}\text{DlogDebt}_{t-1} + \alpha_{24}\text{DlogExchange}_{t-1} + \epsilon_{t-1} \quad (2) \\
\text{DlogInd}_t &= \alpha_{30} + \alpha_{31}\text{DlogSelic}_{t-1} + \alpha_{32}\text{DlogIPCA}_{t-1} + \alpha_{33}\text{DlogDebt}_{t-1} + \alpha_{34}\text{DlogExchange}_{t-1} + \epsilon_{t-1} \quad (3) \\
\text{DlogDebt}_t &= \alpha_{40} + \alpha_{41}\text{DlogSelic}_{t-1} + \alpha_{42}\text{DlogIPCA}_{t-1} + \alpha_{43}\text{DlogInd}_{t-1} + \alpha_{44}\text{DlogExchange}_{t-1} + \epsilon_{t-1} \quad (4) \\
\text{DlogExchange}_t &= \alpha_{50} + \alpha_{51}\text{DlogSelic}_{t-1} + \alpha_{52}\text{DlogIPCA}_{t-1} + \alpha_{53}\text{DlogInd}_{t-1} + \alpha_{54}\text{DlogDebt}_{t-1} + \epsilon_{t-1} \quad (5) 
\end{align*}

Where: \(i = 1, 2, 3, 4, 5, 6\); \(D\) indicates the first difference; and \(\epsilon \sim (0, \sigma^2)\) \textsuperscript{xvii}

Table 5 shows the results from the Granger causality test performed to check if a given variable temporally precedes – or causes, in the Granger sense – another.
One should note that there is strong evidence that $D_{Exchange}$ causes, in the Granger sense, $D_{IPCA}$ (at the 1% significance level). Also, there is evidence that $D_{Exchange}$ causes, in the Granger sense, $D_{Selic}$ (at the 1% level). It should also be stressed that $D_{Selic}$ causes, in the Granger sense, $D_{Ind}$ (1%). Finally, one should mention that the

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Obs</th>
<th>F-Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{IPCA}$ does not Granger Cause $D_{Selic}$</td>
<td>100</td>
<td>1.37575</td>
<td>0.25508</td>
</tr>
<tr>
<td>$D_{Selic}$ does not Granger Cause $D_{IPCA}$</td>
<td>100</td>
<td>2.58356</td>
<td>0.05797</td>
</tr>
<tr>
<td>$D_{Ind}$ does not Granger Cause $D_{Selic}$</td>
<td>100</td>
<td>3.01592</td>
<td>0.03386</td>
</tr>
<tr>
<td>$D_{Selic}$ does not Granger Cause $D_{Ind}$</td>
<td>100</td>
<td>4.18677</td>
<td>0.00794</td>
</tr>
<tr>
<td>$D_{Debt}$ does not Granger Cause $D_{Selic}$</td>
<td>100</td>
<td>5.35645</td>
<td>0.00190</td>
</tr>
<tr>
<td>$D_{Selic}$ does not Granger Cause $D_{Debt}$</td>
<td>100</td>
<td>0.32906</td>
<td>0.80434</td>
</tr>
<tr>
<td>$D_{Exchange}$ does not Granger Cause $D_{Selic}$</td>
<td>100</td>
<td>3.69121</td>
<td>0.01464</td>
</tr>
<tr>
<td>$D_{Selic}$ does not Granger Cause $D_{Exchange}$</td>
<td>100</td>
<td>0.72581</td>
<td>0.53911</td>
</tr>
<tr>
<td>$D_{Ind}$ does not Granger Cause $D_{IPCA}$</td>
<td>100</td>
<td>0.29639</td>
<td>0.82792</td>
</tr>
<tr>
<td>$D_{IPCA}$ does not Granger Cause $D_{Ind}$</td>
<td>100</td>
<td>2.63378</td>
<td>0.05446</td>
</tr>
<tr>
<td>$D_{Debt}$ does not Granger Cause $D_{IPCA}$</td>
<td>100</td>
<td>1.91775</td>
<td>0.13209</td>
</tr>
<tr>
<td>$D_{IPCA}$ does not Granger Cause $D_{Debt}$</td>
<td>100</td>
<td>4.90880</td>
<td>0.00328</td>
</tr>
<tr>
<td>$D_{Exchange}$ does not Granger Cause $D_{IPCA}$</td>
<td>100</td>
<td>9.20958</td>
<td>2.1E-05</td>
</tr>
<tr>
<td>$D_{IPCA}$ does not Granger Cause $D_{Exchange}$</td>
<td>100</td>
<td>0.81421</td>
<td>0.48919</td>
</tr>
<tr>
<td>$D_{Debt}$ does not Granger Cause $D_{Ind}$</td>
<td>100</td>
<td>0.13587</td>
<td>0.93840</td>
</tr>
<tr>
<td>$D_{Ind}$ does not Granger Cause $D_{Debt}$</td>
<td>100</td>
<td>1.32037</td>
<td>0.27249</td>
</tr>
<tr>
<td>$D_{Exchange}$ does not Granger Cause $D_{Ind}$</td>
<td>100</td>
<td>0.66098</td>
<td>0.57811</td>
</tr>
<tr>
<td>$D_{Ind}$ does not Granger Cause $D_{Exchange}$</td>
<td>100</td>
<td>0.40047</td>
<td>0.75298</td>
</tr>
<tr>
<td>$D_{Exchange}$ does not Granger Cause $D_{Debt}$</td>
<td>100</td>
<td>1.76989</td>
<td>0.15832</td>
</tr>
<tr>
<td>$D_{Debt}$ does not Granger Cause $D_{Exchange}$</td>
<td>100</td>
<td>6.45619</td>
<td>0.00051</td>
</tr>
</tbody>
</table>
evidence also shows that $DSelic$ causes, in the Granger sense, $DIPCA$ at the 10% significance level. Next section explores these findings.

### 3.4 Robustness Tests

The usual robustness tests were applied. Initially, we checked for autocorrelation in the model’s residuals. There is no evidence to reject the null hypothesis (non existence of serial autocorrelation) after the inclusion of the third lag in the model (Table 6).

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47.54057</td>
<td>0.0042</td>
</tr>
<tr>
<td>2</td>
<td>56.27419</td>
<td>0.0003</td>
</tr>
<tr>
<td>3</td>
<td>31.96744</td>
<td>0.1590</td>
</tr>
<tr>
<td>4</td>
<td>24.29755</td>
<td>0.5022</td>
</tr>
<tr>
<td>5</td>
<td>31.89766</td>
<td>0.1610</td>
</tr>
<tr>
<td>6</td>
<td>23.44589</td>
<td>0.5515</td>
</tr>
</tbody>
</table>

Table 7 highlights the evidence against the rejection of the null hypothesis that residuals are homoscedastic, indicating heteroscedasticity to be non-existent.

<table>
<thead>
<tr>
<th>Chi-sq</th>
<th>DF</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.011.952</td>
<td>900</td>
<td>0.4825</td>
</tr>
</tbody>
</table>

The Jarque-Bera normality test suggests the rejection of the hypothesis that errors follow a normal distribution (Table 8). However, that problem can be minimized on the grounds of the Central Limit Theorem. xviii
Table 8 – VAR Residual Normality Tests (Jarque-Bera)

<table>
<thead>
<tr>
<th>Component</th>
<th>Jarque-Bera</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.79051</td>
<td>0.0045</td>
</tr>
<tr>
<td>2</td>
<td>8.316471</td>
<td>0.0156</td>
</tr>
<tr>
<td>3</td>
<td>11.50875</td>
<td>0.0032</td>
</tr>
<tr>
<td>4</td>
<td>10.27291</td>
<td>0.0059</td>
</tr>
<tr>
<td>5</td>
<td>9.521215</td>
<td>0.0086</td>
</tr>
<tr>
<td>Joint</td>
<td>50.40986</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: 6 lags; 97 observations

Finally, we checked for the model’s stability. According to figure 2, all inverse roots of AR characteristic polynomial lie inside the unit circle, meaning that the VAR system is stable.

In short, robustness tests indicate that in the estimated model (with six lags) residuals are non-correlated and homoscedastic, despite not being normal.
4 The Relationship between Interest Rate, Exchange Rate, Inflation, Output and Public Debt in Brazil: an Empirical Analysis of the Monetary Policy Transmission Mechanism

The estimated model allows us to analyze the interaction between five macroeconomic variables of vital importance. By establishing bilateral relations between all variables, the VAR model is proven suitable to our goals. The intuition behind variable selection is simple.

On the one hand, economic theory shows that the series used herein are related – in some cases the relationship is mutual, in others bilateral, and so on. For instance, a raise in interest rates prompts: i) a decrease in inflation; ii) a slowdown in economic activity; iii) an appreciation of domestic currency; and iv) a raise in public debt. Accordingly, it is reasonable to consider that an exchange rate devaluation: i) is transferred into domestic prices; ii) impacts on public debt, due to the existence of exchange rate indexed bonds; etc. As a conclusion, according to economic theory, the variables in the model are bounded to be widely interrelated.

On the other hand, in accordance with the Taylor rule, BCB reacts to inflation and output levels by setting the basic interest rate. Apart from that, it is reasonable to consider that BCB's reaction function can be widened by including the exchange rate and the debt/GDP relation. Many authors have included the exchange rate on their Taylor rule's estimates. Additionally, the importance given to the exchange rate by BCB's Monetary Policy Committee (COPOM) justifies the inclusion of such variable. According to the COPOM meeting proceedings, Selic is fixed taking a given exchange rate level as a parameter. In other words, BCB reacts to the exchange rate when setting the basic interest rate: depreciation is expected to make BCB raise the basic interest rate with the purpose of inhibiting an exchange rate pass-through.

The relationship between monetary and fiscal policies has been increasingly studied, both in national and international literature. The volume edited by Chrystal (1998) is a good reference, as it compiles articles presented at the Bank of England's seminar on the
theme. Dornbusch (1998) is among the pioneers who stated that public debt management may jeopardize the efficiency of monetary policy. He proposes that debt stock and, notably, debt structure may turn consumption into a positive function of the basic interest rate. In case public debt holders retain a substantial portion of the short-term debt, a raise in interest rates generates an increase in income that, in turn, can be translated into an increase in aggregate demand. In that case, the efficiency of monetary policy is affected. Bell-Keaton and Ballinger (2005) present a post-Keynesian perspective on the theme. They also provide evidence that, in countries highly indebted, interest rates and the GDP are positively correlated.

The great participation of floating Treasury bonds indexed to Selic (known as LFTs) in the total debt stock\textsuperscript{xxi} may create a detrimental transmission channel in monetary policy, or a \textit{financial wealth effect in reverse}, as proposed by Dornbusch (1998). In that case, a raise in the basic interest rate would increase aggregate demand, bumping prices. Based on that premise, Parreiras (2007) includes the relationship between federal domestic debt and the GDP in his estimate of BCB's reaction function.\textsuperscript{xxii} Pires (2008) also addresses the interaction between monetary and fiscal policies in Brazil and provides evidence that “the wealth effect might explain part of the inefficiency of Brazil's monetary policy” (Pires, 2008: 25, our translation).

The extensive literature addressing that issue indicates that BCB may react to fiscal variables, thus justifying the inclusion of the debt/GDP relationship in the estimated model.\textsuperscript{xxiii} The intuition pointing to the existence of a positive relationship between the debt stock and Selic is simple. In face of a deterioration in the National Treasury's ability to make payments – caused by an increase in debt – the agents tend to demand higher interest rates, in order to continue absorbing the offer of government bonds.

\section*{4.1 Costs and Benefits of Monetary Policy}

Figure 3 shows the response of variables $D_{Ind}$, $D_{Debt}$, $D_{IPCA}$, $D_{Exchange}$ to a shock (of a standard deviation and according to the Cholesky Decomposition) in $D_{Selic}$, and thus allows to analyze the effect of a raise in the basic interest rate on the other variables included in the model.
The DIPCA’s response to a shock in DSelic constitutes a typical price-puzzle situation (Walsh, 2003: chap. 1). Initially, inflation accelerates, peaking out in, respectively, two and five months, and then declines, reaching a minimum in 12 to 14 months. After that, inflation accelerates again and, finally, the effect dissipates in about 18 months.

That behavior, though not backed by orthodox theory, has become a sort of rule in VAR models (Eichenbaum, 1992). Such phenomena have also been verified in Brazilian economy by Luporini (2007) for example. The most conventional explanation for that behavior is that it is due to a problem of misspecification: the variables included in the model do not cover the whole package of information at BCB's disposal (Sims, 1992). Based on that premise, Christiano et al. (1996) and Sims and Zha (1998) eliminated the puzzle by introducing a commodity price index.

An alternative motivation, which has gained relevance lately, is that there is a cost channel in the transmission of monetary policy. In other words, a raise in interest rates increases production costs of firms which – depending on their market power and demand conditions – can be transferred into prices. Such view is based on Kalecki's (1978) contribution, who considers that prices are determined by a mark up rule over production costs. A post-Keynesian approach to inflation costs is found in Palley (1996: chap. 11) and Arestis (1992: chap. 6), for example. Podkaminer (1998) develops a theoretical model in which the maintenance of interest rates at a sufficiently high level is enough to generate inflationary pressures.

In accordance with this literature, a monetary contraction prompts, at first, an increase in costs that is quickly transmitted to prices. Later on, a raise in interest rates slows down economic activity and, finally, produces a negative impact on inflation. Therefore, the puzzle might result from a mismatch between the effects of monetary policy on production costs – which are more immediate – and its lagged impacts on aggregate demand and, finally, on prices.
Gaiotti and Sechchi (2006), based on data provided by 2000 Italian companies, found evidence in support of the existence of cost channels. Barth and Ramey (2000) arrived at the same conclusion regarding the American economy. One should also see Hannsgen (2006) for that matter. On the importance of such a channel in the Brazilian economy, see Marques and Fochezatto (2006).

More than the occurrence of a *price puzzle*, it is the inflation low sensitivity to interest rates that has drawn our attention. In that sense, the benefit – in terms of lowering
inflation – of a raise in the basic interest rate proves to be quite small (and of little statistical significance).

The effect of a raise in the basic interest rate on industrial output (as a proxy of GDP) is negative, despite being of little statistical significance. A shock in $DSelic$ causes $DInd$ to fall (though in an erratic manner), reaching a minimum within three months. From that point on, industrial output recovers, the effect of the shock wanes off after about ten months and clears out completely in 20 months. Therefore, the final effect of a shock in interest rates on industrial output is negative.

Exchange rate increases in reaction to a shock in the basic interest rate. Initially, $DExchange$ accelerates marginally. After the fourth period it begins to decline, reaching a minimum in seven months. After that, $DExchange$ slowly increases and the effect of the shock is completely dissipated after 21 months. The final result of a $DSelic$ shock on $DExchange$ is also negative – that is, exchange rate appreciates in response to an increase in the basic interest rate.

Finally, debt increases in response to a raise in interest rates. The impact of a shock in $DSelic$ peaks out in five months. From that point on, $DDebt$ begins to decrease, though in a very erratic manner, and the effect wanes off in about 12 months. The final effect of a shock in $DSelic$ on $DDebt$ is clearly positive – that is, the debt/GDP relationship increases.

Table 9 shows a measure of a monetary policy shock, based on a cumulative response of a Selic shock (at the end of $n$ months) on industrial output, debt/GDP ratio, IPCA and exchange rate.

<table>
<thead>
<tr>
<th>Months</th>
<th>$DInd$</th>
<th>$DDebt$</th>
<th>$DIPCA$</th>
<th>$DExchange$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>-9.57%</td>
<td>8.90%</td>
<td>2.82%</td>
<td>-5.36%</td>
</tr>
<tr>
<td>9</td>
<td>-9.97%</td>
<td>12.06%</td>
<td>2.03%</td>
<td>-17.76%</td>
</tr>
<tr>
<td>12</td>
<td>-11.09%</td>
<td>14.53%</td>
<td>1.30%</td>
<td>-28.56%</td>
</tr>
<tr>
<td>18</td>
<td>-10.12%</td>
<td>18.17%</td>
<td>-0.61%</td>
<td>-28.14%</td>
</tr>
<tr>
<td>24</td>
<td>-10.14%</td>
<td>16.91%</td>
<td>-0.29%</td>
<td>-22.86%</td>
</tr>
</tbody>
</table>
At the end of 24 months, a raise of 1% in Selic results in: i) a decrease of 10.14% in DInd; ii) an increase of 16.91% in DDebt; iii) a fall of 0.29% in DIPCA; and iv) a raise of 22.86% in DExchange. Once again, our attention is drawn to inflation's low sensitivity to interest rates: the final effect of a monetary contraction on IPCA is negative, though very limited in magnitude. Notwithstanding, the cumulative impact of a raise in Selic on the other variables is not negligible.

In sum, the empirical evidence shows us, on the one hand, that a given raise in Selic produces a relatively small benefit – measured by the consequent reduction of inflation; and, on the other hand, shows that it generates costs which should not be underestimated, specially a slowdown in economic activity and an increase in the debt/GDP ratio. Besides that, a rise in interest rates causes domestic currency to appreciate in a way that jeopardizes the competitiveness of domestic industry and, as a result, deteriorates external accounts and slows down economic activity even further (Bresser-Pereira, 2010a; 2010b). So, monetary policy has been imposing a heavy burden on Brazil's economy, as the cost of reducing inflation can be considered high.

Inflation's low sensitivity to interest rates can be interpreted, at least in part, as a result of a broken transmission mechanism: flaws in the transmission of monetary policy are one of the factors that reduce its efficiency (Modenesi and Modenesi, 2012). Consequently, maintaining price stability under IT requires setting the basic interest rate at relatively high levels. Thus, it is fair to argue that the occurrence of flaws in the transmission mechanism makes for a less favorable balance of costs and benefits in monetary policy.

4.2 – Transmission of Monetary Policy

Figure 4 presents DIPCA response to a shock in DExchange and in DInd (by a standard deviation and according to Cholesky decomposition). It shows how the effects of monetary policy are transmitted to inflation.

Inflation rates accelerate immediately after a shock in DExchange, peaking out after seven months. From that point on, inflation slows down gradually, with shock effects in DExchange dissipating only after more than 12 months. The impulse-response function only stabilizes after 22 to 24 months. It is worth mentioning that exchange rate
depreciation is transferred into prices and its inflationary effect is considerably persistent: a year after the shock in \textit{DExchange}, inflation is still above the initial level.

\textit{Figure 4 – Response of DIPCA to DExchange and DInd}

Conversely, inflation's response to an increase in the level of economic activity (measured by industrial output) is practically null. Inflation accelerates and peaks out in the second month after the shock in \textit{DInd}. From the third month onwards, it slows down (in an erratic manner) and by the tenth month after the shock the effect ceases.

On the one hand, the fact that, in general, part of the increase in industry output is translated into an increase in business investment could explain that behavior. A greater amount of investment reflects on the expansion of aggregate supply which, in turn, has a negative impact on the general price level. In sum, the inflationary effect of a higher level of economic activity – measured by industrial output – is almost negligible. That means that inflation does not follow the business cycle.

On the other hand, one might argue that such a result is a consequence, at least in part, of industrial activity not being a good proxy of GDP. The share of industry in GDP is around 30\%, so it might be an unreliable proxy of GDP. Notwithstanding, it is reasonable to suppose that, on average, there is a positive correlation of the level of activity between the primary, secondary and tertiary sectors. But they can also, at certain moments, show diverging, sometimes even conflicting behaviors. In face of
that, a monthly indicator that gives a more accurate picture of GDP is needed. It is worth noting that, even so, the industry GDP is largely applied as a proxy of GDP in Brazilian literature – since those variables are highly correlated. Figure 5 shows the cumulative effects of a shock in $D_{\text{Exchange}}$ and in $D_{\text{Ind}}$ on IPCA.

**Figure 5 – Cumulative Response of DIPCA to DExchange and DInd**

Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.

![Graph showing the cumulative response of DLOGIIPCA to DLOGEXCHANGE and DLOGIND](image)

**4.3 The Relevance of the Exchange Rate Channel**

In previous sections we discussed that a rise (fall) in $D_{\text{Exchange}}$ determines a rise (fall) in DIPCA and that a rise (fall) in $D_{\text{Selic}}$ prompts a rise (fall) in $D_{\text{Exchange}}$. Furthermore, $D_{\text{Exchange}}$ causes DIPCA and also $D_{\text{Selic}}$, in the Granger sense (Table 5). The combination of those empirical relationships makes for a passive monetary policy.

One can reasonably assume that BCB is aware that variations in exchange rate precede in time changes in inflation. Thus, in face of an exchange rate depreciation – with a view to hold down the consequent pass-through to prices –, monetary authority raises the basic interest rate. The following diagram illustrates the essence of the monetary policy operation in the time frame in question:
$\uparrow Exchange_{t} \Rightarrow \begin{cases} \uparrow IPCA_{t+1}, \\ \uparrow \text{Selic}_{t}, \rightarrow \downarrow Exchange_{t+2}, \rightarrow \downarrow IPCA_{t+3} \end{cases}$

Figure 6 shows the cumulative response of $DSelic$ to a shock in $DExchange$ (by a standard deviation and according to the Cholesky decomposition). Right after the shock, $DSelic$ is raised, and the accumulated effect peaks out by the tenth month after the shock. From there onwards, $DSelic$ falls, with the shock effects clearing out after 20 months. It is, therefore, one more piece of evidence that, in face of an exchange rate depreciation, BCB raises the basic interest rate.

As discussed before, monetary policy in Brazil is reasonably passive: BCB has reduced autonomy to determine the basic interest rate, which responds to variations in exchange rate – given the relevance of that channel in the transmission mechanism of monetary policy. In fact, the importance of exchange rate in the transmission mechanism has been
noted in other works, such as Kregel (2004), Serrano (2006), Oreiro et al. (2008) and Serrano and Summa (2011).xxviii

As a consequence, exchange rate appreciation cannot be considered an undesired byproduct of setting the interest rate at a high level, as many point out. On the contrary, empirical evidence shows that this is the essence of the current stabilization policy: a rise in Selic appreciates Brazilian real. Given the importance of exchange rate in the evolution of IPCA, an appreciation of real reduces inflation. This piece of evidence, together with the others already presented, reveals that the exchange rate is the main transmission mechanism of monetary policy.

Table 10 presents $DIPCA$ variance decomposition, which reinforces the importance of exchange rate in defining inflation behavior. $DIPCA$ variance is to a great extent explained by the variance in $DExchange$: at the end of 12 months, the evolution of exchange rate explains nearly a half (45%) of inflation's behavior, which confirms the importance of exchange rate in the transmission mechanism of monetary policy. By contrast, the economic activity explains only 6% of $DIPCA$ variance. In other words, the analysis of variance decomposition reinforces the results obtained by impulse-response functions (Figures 3, 4, 5) presented in previous sections.

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>$DInd$</th>
<th>$DDebt$</th>
<th>$DIPCA$</th>
<th>$DSelic$</th>
<th>$DExchange$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.01666</td>
<td>6.657372</td>
<td>1.204679</td>
<td>69.0753</td>
<td>3.70379</td>
<td>19.35881</td>
</tr>
<tr>
<td>6</td>
<td>0.01766</td>
<td>4.422845</td>
<td>14.02493</td>
<td>41.8611</td>
<td>3.83659</td>
<td>35.85453</td>
</tr>
<tr>
<td>9</td>
<td>0.01819</td>
<td>5.668733</td>
<td>14.17741</td>
<td>32.1743</td>
<td>3.21771</td>
<td>44.76180</td>
</tr>
<tr>
<td>12</td>
<td>0.01838</td>
<td>5.760120</td>
<td>14.05483</td>
<td>31.4895</td>
<td>3.55498</td>
<td>45.14053</td>
</tr>
</tbody>
</table>

Cholesky Ordering: $DSelic$, $DIPCA$, $DInd$, $DDebt$, $DExchange$. 

Table 10 – Variance Decomposition of $DIPCA$
Table 11 shows the variance decomposition of $D_{Selic}$. It also corroborates the importance of exchange rate in determining the basic interest rate. $D_{Selic}$ variance is to a great extent explained by $D_{Exchange}$ variance: at the end of 12 months about 30% of the basic interest rate behavior is explained by the exchange rate evolution.

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>$D_{Ind}$</th>
<th>$D_{Debt}$</th>
<th>$D_{IPCA}$</th>
<th>$D_{Selic}$</th>
<th>$D_{Exchange}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.016666</td>
<td>2.735550</td>
<td>13.27749</td>
<td>2.056785</td>
<td>79.66592</td>
<td>2.264252</td>
</tr>
<tr>
<td>6</td>
<td>0.017662</td>
<td>4.154006</td>
<td>17.10794</td>
<td>2.539432</td>
<td>56.19791</td>
<td>20.00071</td>
</tr>
<tr>
<td>9</td>
<td>0.018199</td>
<td>4.209698</td>
<td>17.01129</td>
<td>3.434756</td>
<td>49.25619</td>
<td>26.08807</td>
</tr>
<tr>
<td>12</td>
<td>0.018381</td>
<td>4.148671</td>
<td>16.79445</td>
<td>5.162524</td>
<td>48.03867</td>
<td>25.85569</td>
</tr>
</tbody>
</table>

Cholesky Ordering: $D_{Selic}$, $D_{IPCA}$, $D_{Ind}$, $D_{Debt}$, $D_{Exchange}$.

In sum, the evidence suggests that the exchange rate has been the main channel of monetary policy transmission: in face of an inflationary surge, BCB raises the basic interest rate with a view to appreciate the currency (real) and thus curb prices. Therefore, the exchange rate appreciation is not an undesirable result of monetary policy, but the essence of inflation control.

5 Conclusions

We have performed a sufficiently robust econometric analysis of monetary policy transmission mechanism. The results of such analysis are a broad body of evidence which allows us to evaluate the main costs and benefits of the stabilization policy adopted in Brazil since 2000.
The exchange rate has proven to be the main channel of monetary policy transmission. Appreciation of real cannot be considered an undesirable byproduct of interest rate fixation at high levels. On the contrary, empirical evidence reveals the essence of Brazilian current stabilization policy: Selic high rate appreciates the real. Given the importance of exchange rate in the evolution of prices, exchange rate appreciation reduces inflation.

Empirical evidence also shows that inflation's sensitivity to interest rates is low. On the one hand, a raise in Selic rate generates a relatively small benefit – as measured by the consequent decrease in inflation. On the other hand, an interest rate rise produces considerable costs, notably when it causes economic activity to slow down and the debt/GDP ratio to increase. Furthermore, a raise in Selic leads to an appreciation of the real which, whilst undermining the competitiveness of domestic industries tends to deteriorate external accounts and jeopardize economic activity. One should note that monetary policy imposes a great sacrifice on Brazilian economy: the cost of reducing inflation is considerably high.

Inflation’s low sensitivity to interest rates can be interpreted as resulting, at least in part, from a broken transmission mechanism: flaws in the transmission mechanism of monetary policy contribute to reduce its efficiency. Price stability under IT thus requires an excessively rigid monetary policy. The final result is, on the one hand, that inflation hardly gives in. We conclude that the balance of costs and benefits of price stability under IT is unfavorable.

Finally we must acknowledge that our results still need to be furthered. The body of evidence presented, though robust, needs to be improved. Therefore, a note of caution is warranted concerning the conclusions herein presented: in face of the importance of the consequences involved, further studies are still called for.
6 References


______. (2010b), *Doença holandesa e indústria* (org.) Rio de Janeiro: Editora FGV.


EICHENGREEN, B; EL-ERIAN, M.; FRAGA, A.; ITO, A.; PISANY-FERRY, J.;
“Rethinking Central Banking”. *The Committee on International and Policy Reform*,
September.


central banking. *Mimeo*. University of Massachusetts, Amherst.

_________. (2003), “Alternative to inflation targeting monetary policy for stable and
egalitarian growth: a brief research summary”. *Political Economy Research Institute

EPSTEIN, G. and SCHOR, J. (1990), “Macropolicy in the rise and fall of the golden
age”. In: S. Marglin and J. Schor (Eds.), *The Golden Age of Capitalism: Reinterpreting

EPSTEIN, G. and YELDAN, E. (Ed.) (2009), *Beyond Inflation Targeting: Assessing the

ERBER, F. (2008a), “Development projects and growth under finance domination – the
case of Brazil during the Lula years (2003-2007)”. *Revue Tiers Monde*, 194 (no prelo).

ERBER, F. (2008b) “The Evolution of Development Conventions”. Instituto de
Economia, Universidade Federal do Rio de Janeiro. *XII ISS Conference*, Rio de Janeiro,
Julho.

ERBER, F. (2008c), “As convenções de desenvolvimento no Brasil: um ensaio de
economia política”. In: Anais do 5º *Fórum de Economia da FGV-SP*, São Paulo (SP).

comparação das estimativas de equilíbrio parcial e geral”. *Economia Aplicada*, v.7(3),
pp. 461-490.


HAMILTON, J. D. (1994), Time series analysis. Princeton University Press,


SARGENT, T. e WALLACE, N. (1981b), “‘Rational’ expectations, the optimal monetary instrument, and the optimal money supply rule”. In: R. LUCAS e T. SARGENT (Eds.), *Rational Expectations and Econometric Practice*. Mineapolis: The University of Minnesota Press.


*Center for Economic and Policy Research*, June.


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IE-UFRJ DISCUSSION PAPER: MODENESI; ARAÚJO, 2012 – TD 003.
VERNENGO, M. (2007). “Money and inflation”. In: P. Arestis and M. Sawyer (Eds.),

pp. 95-110.

In Brazil, the basic interest rate goes by the acronym (Selic) for Sistema Especial de Liquidação e de Custódia (Special System for Settlement and Custody), the settlement system for most domestic securities of Brazilian central government.


It is not this paper's intention to make an exhaustive exposition on the IT. For more details see Modenesi (2005: cap. 3), who discusses the advantages and disadvantages of IT and its theoretical foundations. See also Lima (2008).

For instance, we may say that for most Post Keynesians using the interest rate to fight inflation is deemed problematic. For instance, fighting cost push inflation by managing aggregate demand is inadequate, since it affects only the symptoms, instead of the causes of that kind of inflation (Davidson, 1978; 2003). See also Vernengo (2007; 2008) and the book edited by Epstein and Yeldan (2009), according to whom: “modern central banking ought to have more policy space in balancing out various objectives and instruments. In particular, employment creation, poverty reduction and more rapid economic growth should join inflation stabilization and stabilization more generally as key goals of central bank policy” (p. 7).

the proposition that interest rates should always be raised (reduced) proportionally more than a given rise (fall) in inflation rate.

vii See also Mishkin and Posen (1997) and Modenesi (2005: chapters 2 and 3).


ix It is worth noting that, according to Bacha (1994; 1995), this was not a problem in pre-Real Brazil. On the contrary, whereas tax revenue was indexed, expenses were not, generating a reverse Tanzi effect.

x As expressed in the 1995 North American Economic Growth and Price Stability Act: “[B]ecause price stability leads to the lowest possible interest rates and is a key condition to maintaining the highest possible levels of productivity, real incomes, living standards, employment, and global competitiveness, price stability should be the primary long term goal(…)” (US Congress, 1995).

xi See Epstein and Schor (1990) and Epstein (2000) for a political economy perspective on monetary policy-making.

xii A raise in Selic increases the debt stock in two manners: i) directly, considering that a significant portion of the debt is composed of floating Treasury bonds (known as LFTs), indexed to Selic; and ii) indirectly, given that, upon a raise in Selic, bond demanders tend to require higher returns in order to buy pre-fixed bonds.

xiii Indeed there are many others problems with IT. For instance, Braunstein and Heintz (2009) investigate “gender-specific impacts of policy responses during inflation reduction episodes” (p. 110).
Bernanke (2007) postulates that: “price stability(...) is a good thing in itself” and “in the long term, low inflation promotes growth, efficiency and stability – which, all else being equal, support maximum sustainable employment” (pp. 1-2).


This is the normal procedure, commonly found in literature; for example, Luporini (2007) uses eight lags.

The order chosen for the VAR model is: Selic, IPCA, IND, DIV and Exchange. SELIC was chosen as the most exogenous variable, since it is the instrument of monetary policy and (as a rule) is adjusted only eight times per year at COPOM meetings. The exchange rate was chosen as the most endogenous variable, given that through the expectations channel, it can be affected contemporaneously by all other variables. Inflation contemporaneously affects DEBT because a portion of debt stock is indexed to IPCA. It is more difficult to justify the effect of inflation on GDP; however, Table 5 shows that IPCA precedes IND. Identifying the ordering of variables by means of Granger causality test might not be appropriate in principle. Cholesky ordering indicates a contemporary causality between the variables, whereas Granger indicates a temporal precedence. However, Granger can be used as a method to sort the variables within Cholesky ordering, considering that there is a positive correlation between Granger causality probability and contemporary causality. DEBT is affected contemporaneously by SELIC and IPCA because debt stock is in part indexed to IPCA (NTN-B) and in part to SELIC (LFT). The contemporary effect of IND on DEBT can be explained by DEBT being the ratio Debt/GDP.

Accordingly, as the size of the sample of any given variable increases, the sample distribution average will tend to normal.

According to the BCB reports of 2002 and 2009, the percentage of exchange-rate-indexed public bonds added up to 28.6% in 2001; 22.4%, in 2002 and 0.7%, in 2009.

For a review of the Taylor rule, see Modenesi et al. (2012).

During the period, LFT amounts from nearly a half to more than one third of the total debt stock.
It is worth noting that the author does not prove the existence of such a mechanism in Brazilian economy.


For a historical perspective, see Humphrey (1986). Tooke (1838) and Laughlin (1909; 1911) are among the precursors of this conception.

Since a negative relationship between GDP and interest rate is widely supported by literature, this little significance might be in part a result from industrial production not being such a good proxy of GDP (more details on page 15-6).

Belaisch (2003) uses this methodology to estimate the impact of exchange-rate depreciation on inflation in Brazil.

For example, the inventory cycle makes the industrial sector's activity level more volatile than the service sector.