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Inflation Targeting and Exchange Rates in Brazil (1999-2012)

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SUMMARY

INTRODUCTION

Inflation targeting became the first preference of many monetary economists over the 1990's. In this decade and in the beginning of the 2000's, many emerging market economies adopted inflation targeting regimes. Some of them adopted the regime after careful consideration over the possible alternatives, but many adopted it after the successive currency crises broke their exchange rate pegs and left them with no nominal anchor for monetary policy.

After a few years, empirical analysis showed emerging economies, despite achieving lower levels of inflation, could not bring it down to the levels observed in developed economies. This observation gave birth to a rich literature on whether emerging economies should adopt inflation targeting and, if they should, how an inflation targeting regime needed to be designed after considering the distinctive macroeconomic characteristics of this countries.

Among those characteristics were the lack of confidence in both monetary and fiscal authorities and the absence of key fiscal, monetary and financial institutions. There were also currency mismatches and high pass-through to inflation. All of those characteristics suggest emerging market central bankers need to care about exchange rates. But they also suggest central bankers may care too much or they may display "fear of floating", as Carmen Reinhart and Guillermo Calvo (2002) first put it. A central banker with fear of floating usually gives up its inflation target and turns monetary policy towards an implicit (sometimes not so implicit) exchange rate peg.

This paper is an attempt to assess the relationship between monetary policy and exchange rates within the inflation targeting regime in Brazil (1999-2012). This period covers times of relative stability and both domestic and international crises. In the first years of inflation targeting in Brazil, the Central Bank needed to build credibility. Given uncommon exchange rate volatility caused by the energy crisis, the 2002 election and the sovereign crisis in other emerging markets, the Central Bank had to show especial concern with exchange rates. The 2002-2003 confidence crisis created by the presidential election defined a turning point. From that period onwards, exchange rates appreciated steadily and the central bank would - theoretically - have to worry less about exchange rates.

We use two Vector Autoregressive (VAR) models to examine both the aforementioned relationship and also the exchange rate pass-through to inflation. Results suggest that the Central Bank of Brazil did worry about exchange rates prior to March 2003 and that this worry has diminished in following period[1]. The second model suggest a decline of the exchange rate pass-through to inflation, because inflation respond less to shocks on exchange rates and also because the latter explain less of inflation variance.

[1] Current discussions emphasize the comeback of some sort of "fear of floating". Since the most recent sub-sample in our series cover the period ranging from April 2003 to June 2012, this possibility - if real - will be attenuated.

CHAPTER 1 - THEORETICAL FOUNDATIONS OF INFLATION TARGETING

1.1 DEFINING INFLATION TARGETING

Inflation targeting (henceforth, IT) is, as Bernanke *et al* (1999, p. 4) put it, "a framework for monetary policy characterized by the public announcement of official quantitative targets (or target ranges) for the inflation rate over one or more time horizons". However, even though announcing a target for inflation is a necessary condition, it is not a sufficient one. IT is also characterized by

> 2) an institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinated; 3) an information inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments; 4) increased transparency of the monetary policy strategy through communication with the public and the markets about the plans, objectives, and decisions of the monetary authorities; and 5) increased accountability of the central bank for attaining its inflation objectives. (MISHKIN, 2004, p. 1).

The five characteristics listed above and are rooted in theoretical developments of the New Keynesian literature which, in turn, kept some ideas coming from both monetarist and new classical considerations about monetary policy. Those are the neutrality of money in the long-run and the non-neutrality in the short-run as advocated by New Keynesians; the existence of costs created by high inflation; and the problems of time inconsistency and inflationary bias proposed in the "rules vs. discretion" debate.

1.2 THEORETICAL FOUNDATIONS OF INFLATION TARGETING

1.2.1 Money Neutrality and short run non-neutrality

The basic premise supporting Inflation Targeting is inflation is the only variable policy makers can successfully control in the long-run or, in other words, the premise that money is neutral (BERNANKE *et al*, 1999, p. 10). As Walsh (2010, p. 31) put it, there is a

> [C]onsensus from the empirical literature on the long-run relationship between money, prices and output [that] is clear. Money growth and inflation essentially display a correlation of 1; the correlation between money growth or inflation and real output growth

> is probably close to zero, although it may be slightly positive at low inflation rates and negative at high rates.

However, money neutrality in the long-run doesn't rule out concerns about real variables. The empirical literature also suggests that "exogenous monetary policy shocks produce hump-shaped movements in real economic activity" (Walsh, 2010, pp. 31-32), *i. e.*, money is not neutral in the short-run (or at least exogenous policy shocks are non-neutral).

To rationalize this apparent contradiction, New Keynesian literature emphasized the existence of both nominal and real rigidities in the economy which would render money non-neutral. Since it is based in New Keynesian theory, IT takes the considerations displayed above into account and leaves some space for monetary policy to influence real variables as it will be discussed in session 2.3 while pinning inflation as its long-run variable of concern.

1.2.2 Costs and benefits of inflation

IT is based on the idea that high inflation is harmful to economic growth and stability, especially when it is unexpected. For instance, Fischer (1993) presented evidence that even though low inflation is not a *necessary* condition for economic growth, very high inflation reduces growth by reducing investment and productivity growth.

Furthermore, if the tax system is not fully indexed to inflation, there might be distortions. If nominal incomes rise only because inflation is higher and tax brackets are not equally adjusted, people may fall in higher tax brackets than their *real* income growth would imply. On the government side, differences in the level of indexation in taxes and expenditure might also lead to budget distortions[2]. (BLANCHARD, 2007)

Also, if prices rise frequently, the cost of changing prices (menu costs) might become significant. Although this might not be significant at high but still controlled inflation rates, very high rates impose costs of repricing items frequently. Beside menu costs, high (and volatile) inflation causes loss of relative prices information as agents cannot distinguish relative price changes from general rises in the price level.

Finally, inflation promotes redistribution of assets between debtors and creditors. Since debt is usually contracted in nominal terms, inflation erodes the real value of nominal debt and hence

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[2] If taxes are (partially) indexed and expenditures are not, nominal budget surplus will increase with higher inflation. The opposite is also possible: if expenditures are indexed, nominal budget surplus will decrease with higher inflation.

distributes wealth from creditors to debtors. If unexpected inflation occurs too often, the agents might be discouraged from offering credit.

However, the costs shown above should not lead us straightforward to price stability (zero inflation). First, if average inflation is higher than zero, the probability of hitting the zero lower bound (ZLB) of nominal interest rates is lower. When the economy is in the ZLB, central bankers cannot use conventional monetary policy (changes in benchmark interest rates) anymore. Also, as Krugman and Eggertsson (2012) denoted, there are circumstances in which higher inflation might improve economic conditions. For example, if a deleveraging shock hit the economy (the authors argue the current crisis is an example) and nominal interest rates are on the ZLB, higher inflation (or expected inflation) brings the real interest rate down, even though nominal interest rates are already zero[3]. Lower real interest rate will give incentives for creditor households to consume more and replace lower demand coming from constrained households.

In conclusion, the costs imposed by inflation, specially when it is high and variable imply that keeping inflation low but positive is highly recommended. On the other hand, there are reasons for not adopting a zero inflation target. Bernanke *et al* (1999, p. 30) conjectured that "around 1% to 3% per annum" is a good target range. Indeed, many central banks adopted inflation targets close to that range (BERNANKE AND MISHKIN, 1997, p. 99, cf. table 1).

1.1.3 Rules versus discretion and time inconsistency

In the first two decades of the post-war era, conventional economic wisdom coming from the Neoclassical Synthesis held that active policy, either monetary or fiscal (or both) could stabilize economic activity. Indeed, the Keynesian Orthodoxy held that "[a] market economy is subject to fluctuations in aggregate output, unemployment and prices, which need to be corrected , can be corrected and therefore should be corrected", in the words of Franco Modigliani (1977, p. 1), one of it's most prominent members. Therefore, discretionary policy was the order of the day and policymakers followed a straight forward policy routine described by Snowdon and Vane:

> First, the policy maker must specify the targets or goals of economic policy (for example, low inflation and unemployment). Second, given this social welfare function which the policy maker is attempting to maximize, a set of instruments (monetary and fiscal) is chosen which will be used to achieve the targets. Finally, the policy maker must make use

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[3] The Fisher Equation states that $i \cong \pi + r$, so if $i = 0$, $r = -\pi$ and thus higher inflation reduces the real interest rate.

of an economic model so the instruments may be set at their optimal values. (SNOWDON AND VANE, 2005, p. 250)

Policy activism was overthrown by the monetarist - and later New Classical - assault. Milton Friedman (1968, for example) fired two criticisms at policy activism: first, he argued that monetary policy could not peg real variables such as the unemployment rate or the real aggregate income for more than a “very limited periods”. In the long-run, Friedman held that monetary policy could only affect nominal variables. Hence, monetary policy should be used to peg a nominal quantity - the nominal exchange rate, nominal national income, the quantity and money or the price level or the growth rates of those quantities.

However, by stating that monetary policy could not stabilize economic activity, Friedman was far from saying that it could not affect the economy. Quite the opposite, his own historical research (Friedman and Schwartz, 1963) suggested that many economic cycles were either caused by or had been exacerbated by monetary policy. Thus, his second critique to policy activism stated that although monetary policy could affect the real economy in the short-run, attempts to stabilize the economy would most probably end up moving it further away from equilibrium. This critique was based on (i) the propensity of policymakers to overreact to current events; and (ii) the fact that policy decisions made today will only affect the economy in the future. As he argued (Friedman 1968, p. 14): “[w]e do not know enough to be able to achieve stated objectives by delicate, or even fairly coarse, changes in the mix of monetary and fiscal policy. In this area particularly, the best is likely to be enemy of the good.”

In face of this, Friedman (1968, p. 16) prescribed that “the monetary authority go all the way in avoiding such swings by adopting publicly the policy of achieving a steady rate of growth in a specified monetary total”. In other words, he suggested that in order to avoid choosing the wrong policy - which he argued was the most probable outcome, central bankers should instead sit on their hands by just adopting and following a strict rule.

The second wave of critiques on policy activism came from the New Classical school. The new classical critique of discretionary policy was based on Kydland and Prescott’s (1977) arguement that policies based on “optimal control theories” would not maximize the social welfare function. The main problem was that optimal control assumed expectations to be policy invariant. However, rational economic agents’ decisions are based on the expected path of future policy and not on “mechanical” expectations as it was assumed before.

Policy-making becomes a game between the monetary authority and private sector agents. If these agents know something about the policymaker's objective, the optimal policy choice will be incorporated in their current expectations and the short-run tradeoff between inflation and unemployment will vanish. The result is that attempts to push unemployment below its natural level through monetary policy will not only fail, but also generate more inflation than the policymaker desired. Indeed, if policymakers tried to stabilize both inflation and unemployment they would have incentives to cheat and end up on the the bad outcome described above. In other words, discretionary policy had an *inflationary bias*.

The only way monetary authorities could achieve low inflation and the natural level of unemployment at the same time was to pre-commit to a "simple and easily understood" rule. After Kydland and Prescott's contribution, another positive aspect of rules-based has been emphasized: policy commitment can greatly improve the monetary authority's credibility and hence greatly reduce the output loss of disinflating the economy after a cost-push hit the economy (CLARIDA, GALI AND GERTLER, 1999).

1.3 A FRAMEWORK, NOT A RULE

Despite the benefits of rule-based monetary policy, Bernanke *et al* (1999, p. 5) claimed "there is no such a thing in practice as an absolute rule for monetary policy"[4]. They argued that in reality only discretion prevails and "is a matter of degree" (p. 6). Thus it is more appropriate to ask whether monetary policy is conducted within a clear framework stating its objectives and the instruments the policymaker has at her disposal or whether it is done in a relatively undisciplined way, "leading to policies that change with personal views of the central bankers or with the direction of the political winds" (p. 6).

In the context of frameworks for discretionary policy, Bernanke and Mishkin (1997) suggested that Inflation Targeting offers the advantages attributed to strict rules without completely eliminating Central Bank's ability to engage in some sort of short-run stabilization.

First, IT accepts Friedman's proposition that monetary policy cannot affect real variables in the long-run. In this sense, the announcement of an official inflation target (or target range) at a definite time horizon imposes a constraint on short-run discretion. If the policymaker engages in short-run stabilization, he or she must explain to the public how such policy decisions are

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[4]As an example, the authors referred to the gold standard: although it was a rule, the gold standard was interrupted or partially abandoned several times, especially during wars or other emergences.

compatible with the target within the established horizon. Thus, as the authors suggest, IT can be referred to as "framework for monetary policy within which 'constrained discretion' can be exercised" (Bernanke and Mishkin, 1997:106).

Furthermore, IT heavily stresses communication. Central banks adopting inflation targeting usually publish Inflation Reports in a timely base explaining the most relevant issues concerning monetary policy. Also, central bankers operating an IT regime try to make clear how and when the instruments at her disposal will be used. Policy transparency seeks to reduce inflation variability and the inflationary bias of discretionary policy: if agents understand the framework within which the central bank is working and if central bank's announcements are credible, both the inflationary bias and inflation variability might be lower.

On the other hand, IT still leaves room for responsible discretion, "particularly with respect to output and exchange rates" (Bernanke and Mishkin, 1997:101). Practical implementation of IT accommodates short-run stabilization mainly through three means: first, the above mentioned time horizon within which the central bank has to achieve its target is usually broad enough to allow it to smooth shocks on the economy, thus avoiding high volatility in other variables of interest. Also, the monetary authority might choose a target range instead of an specific number. By adopting a target range, the central bank gains further space to accommodate shocks.

Second, IT usually contain escape clauses that allow central banks either not to achieve the target within the determined time horizon or change the the target. These clauses are usually accompanied by public announcements of the reasons supporting the decision and explanations about the path future policy will follow in order to put the economy back on the track. Escape clauses are important when shocks are big enough to require a policy reaction that would throw the economy into a recession; for example, the increase in inflation in the end of 2002 forced the Central Bank of Brazil to change its target for 2003 and 2004 in order to gradually return to its previous inflation target levels. Otherwise it would have been forced to accept an extreme loss of output.

Third, when picking the price index to which it will respond, the central bank can pick an index that excludes common sources of "supply shocks", such as food and energy prices[5]. Even if the central bank chooses a broad index (as is the case in Brazil), core indexes might be referred to as an explanation for the central bank's policy response.

The possibilities of executing discretionary policy within an IT regime is especially important for emerging market economies that chose to adopt it after the fall of the fixed exchange

[5] See Table 1 from Bernanke and Mishkin (1997) for information on the choice of price index in different countries.

rate regime in the 1990's. Issues related to the implementation and stability of an IT regime in emerging market economies, most of which are tied to exchange rates, are the subject of the fourth chapter. We now turn to the models of exchange rate determination under "conventional" conditions.

CHAPTER 2 - EXCHANGE RATE DETERMINATION

In this chapter basic theories of exchange rate determination are reviewed. The chapter begins with the parity conditions present in most models of exchange rate determination: uncovered interest parity (UIP) with and without risk premium, covered interest parity (CIP), and purchasing power parity (PPP).

In the second section, a basic version of the monetary approach to exchange rate determination is developed both analytically (following Obstfeld and Rogoff, 1996) and graphically (following Krugman and Obstfeld, 2010). Finally, the third section reviews the basic stylized facts related to exchange rates and to the effects of monetary policy on them. Through this chapter, we aim to provide a framework describing how the relationship between monetary policy and exchange rates is expected to behave. This framework will prove useful as a basis of comparison in the final chapter.

2.1 PARITY CONDITIONS

2.1.1 Uncovered Interest Parity

Uncovered Interest Parity (UIP) is one of the basic building blocks in models of exchange rate determination. Inside the models it is an equilibrium condition for asset markets in two countries. If UIP holds, agents in the foreign exchange market cannot have positive expected returns in "carry trade" operations.

As an example, the interest rate spread between a 3-month Treasury Bill and a 3-month Gilt (considering both are risk-free) must be equal to the expected percentage change in the US Dollar-British Pound exchange rate. If this relation did not hold and, say, the Treasury Bill yielded more than the expected depreciation of the dollar, investors would buy the american security while shorting the british one and earn unlimited profits. Whenever there is a profitable opportunity to do so, investors would quickly close the gap making carry trade operations.

The simple analytical form of UIP is usually given by

$$\Delta_k s^e_{t+k} = i_t - i^*_t \qquad (1)$$

where s_t is log spot exchange rate, i and i^* are the interest rate on the home currency denominated security and on the foreign one, respectively, both with k maturity.

UIP is a statement of the efficient market hypothesis (EMH) with relation to the foreign exchange market. EMH implies that "foreign exchange market participants are, in an aggregate sense a) endowed with rational expectations and b) risk neutral" (TAYLOR, 1995, p.14). In this sense, testing the validity of (1) means one is testing risk-neutrality or rational expectations, or both.

Taylor (1995) reported that the empirical literature could not find convincing evidence of efficiency - according to the definition given above - in foreign exchange markets. As a response, one should depart either from perfect rationality or from risk-neutrality. Departures from rationality were attributed to "peso problems" (probability attributed to extreme events is lower than the rational choice), learning processes and rational bubbles[6].

On the other hand, if agents are not risk neutral, uncovered interest parity must include a risk term, ρ, in the original arbitrage condition given by (1):

$$\Delta_k s^e_{t+k} + \rho = i_t - i^*_t \qquad (2)$$

Risk aversion (rho>0) imply agents will try to profit from arbitrage up to the point when the interest rate differential is equal to the expected percentage change in the relevant exchange rate plus the degree of risk aversion (or the return agents are willing to give up to avoid holding foreign currency).

2.1.2 Covered Interest Parity

Covered Interest Parity (CIP) links interest rates to spot and forward foreign exchange markets. If market participants can make forward currency contracts and CIP holds, the interest rate differential between two similar assets (denominated in different currencies) must be equal to the forward premium, *i. e.*, the spread between the spot exchange rate and the relevant forward exchange rate. (KRUGMAN, 2010)

Mathematically:

$$i_t - i^*_t = f^{(k)}_t - s_t \qquad (3)$$

where $f_t^{(k)}$ is the forward exchange rate *k* time ahead.

Frankel (1985) reports the empirical literature has found evidence supporting CIP for eurodollar and pound deposits in the same financial centre. CIP does not hold well for deposits in

[6]See Taylor, 1995, pp. 17-18 for further informations on the attempts to departure from perfect rationality listed above. It is not on our purpose to deal with deviations from rational expectations in this work.

different political jurisdictions. This can be explained by the existence of uncertainty regarding future government action, especially changes in investment taxation and capital controls.

2.1.3 Purchasing Power Parity

Purchasing Power Parity (PPP) describes the relationship of home and foreign price levels. If PPP holds, the nominal exchange rate should be equal to the ratio of the home price level and the foreign price level (KRUGMAN, 2010, p. 293):

$$P = P^* \times E \qquad (4)$$

In other words, PPP means the foreign price level and the home price level must be equal when measured in the same currency. While the relationship above is named *absolute* PPP, one can derive from it the *relative* PPP:

$$\frac{E_t - E_{t-1}}{E_{t-1}} = \pi_t - \pi_t^* \qquad (5)$$

Relative PPP asserts that the percentage change in the nominal exchange rate is equal to the difference between the home inflation rate and the foreign inflation rate.

Empirical literature did not find support for absolute PPP, as Krugman (2010, p. 298) put it: “absolute PPC is irrelevant: prices of identical goods baskets, when converted to the same currency, differ substantially among countries”. Regarding relative PPP, the author stressed (p. 298) that “[i]n face of protracted deviations of PPP, this theory seems to be of limited use, even as a long run explanation.”

Frankel, Caves and Jones (2001) attributed deviations from the correct PPP to: (1) costs of transport and tariffs (creating a range within which prices can differ without giving arbitrageurs profitable opportunities); (2) permanent changes in terms of trade; (3) existence of non-tradable goods and services in the representative goods basket used to measure the price level; and (4) lags related to information failures, contracts and consumer habits.

Although the empirical literature has thrown some doubts in the parity conditions above, they are still used in models that capture relevant insights into the reaction of exchange rates to monetary policy changes.

2.2 MODELS OF EXCHANGE RATE DETERMINATION

2.2.1 Monetary Model of Exchange Rate Determination

The monetary view is the basic approach to exchange rate determination. Here we use a variant of the log-linear Cagan model of an small, open economy, the same used by Obstfeld and Rogoff (1996, chapter 8). The model consists of three building blocks: purchasing power parity (PPP), uncovered interest parity (UIP) and a money demand function.

In this small, open economy output is assumed to be exogenous. Money demand is given by:

$$m_t^d - p_t = -\eta i_{t+1} + \phi y_{t+1} \qquad (6)$$

Monetary equilibrium requires money demand to equal money supply. Thus, (6) becomes an equilibrium condition:

$$m_t - p_t = -\eta i_{t+1} + \phi y_{t+1} \qquad (7)$$

where p_t is the log price level, y_t is the log of real output and $i \equiv \log(1 + i)$, and (1+i) is the gross nominal interest rate. This money demand function is a log-linear version of the traditional keynesian money demand function, M/P=L(i, Y). Also, in our economy PPP is assumed to hold. Turning (4) into logs:

$$p_t = e_t + p_t^* \qquad (8)$$

where e_t is the log exchange rate and p is the log price level (stars indicate world variables).

Finally, the last building block is the Uncovered Interest Parity:

$$1+i_{t+1} = (1+i_{t+1}^*)\frac{E_t\{\mathcal{E}_{t+1}\}}{\mathcal{E}_t} \qquad (9)$$

E_t indicates the expected value of the variable inside the braces - in this case, the ratio of the exchange rate in time t+1 and the current exchange rate. If we take logs, UIP can be approximated by:

$$i_{t+1} = i_{t+1}^* + E_t e_{t+1} - e_t \qquad (10)$$

To solve the model, one must plug PPP equation (8) and uncovered interest parity equation (10) into the money market equilibrium condition, yielding:

$$(m_t - \phi y_t + \eta i_{t+1}^* - p_t^*) - e_t = -\eta(E_t e_{t+1} - e_t) \qquad (11)$$

The first term in the left-hand side of equation (11) is the exogenous part of the model: the money supply is the policy variable, output is assumed as exogenous and i^*_{t+1} and p^*_t are variables relative to rest of the world. Thus we can solve for the current exchange rate (we skip the details of the recursive solution):

$$e_t = \frac{1}{1+\eta} \sum_{s=t}^{\infty} \left(\frac{1}{1+\eta} \right)^{s-t} \mathrm{E}_t \{ m_s - \phi y_s + \eta i^*_{s+1} - p^*_s \} \qquad (12)$$

Equation (12) shows the current exchange rate depends on the weighted values of current and future money supply, real output and foreign interest rates and inflation rates. Thus, current policy action changes the exchange rate and it is also possible for a credible announcement about future policy decisions to change exchange rates now.

Obstfeld and Rogoff (1996, p. 529) propose a simple exercise to illustrate how monetary policy affects the exchange rate: if we assume that the exogenous variables are constant so that $\phi y + \eta i^* - p^* = 0$ and also assume the money supply to follow a path determined by

$$m_t - m_{t-1} = \rho(m_{t-1} - m_{t-2}) + \varepsilon_t, \qquad 0 \leq \rho \leq 1 \qquad (13)$$

where ε_t is a serially uncorrelated monetary shock with mean zero, it is possible to show that the exchange rate path will be given by

$$e_t = m_t + \frac{\eta\rho}{1 + \eta - \eta\rho}(m_t - m_{t-1}) \qquad (14)$$

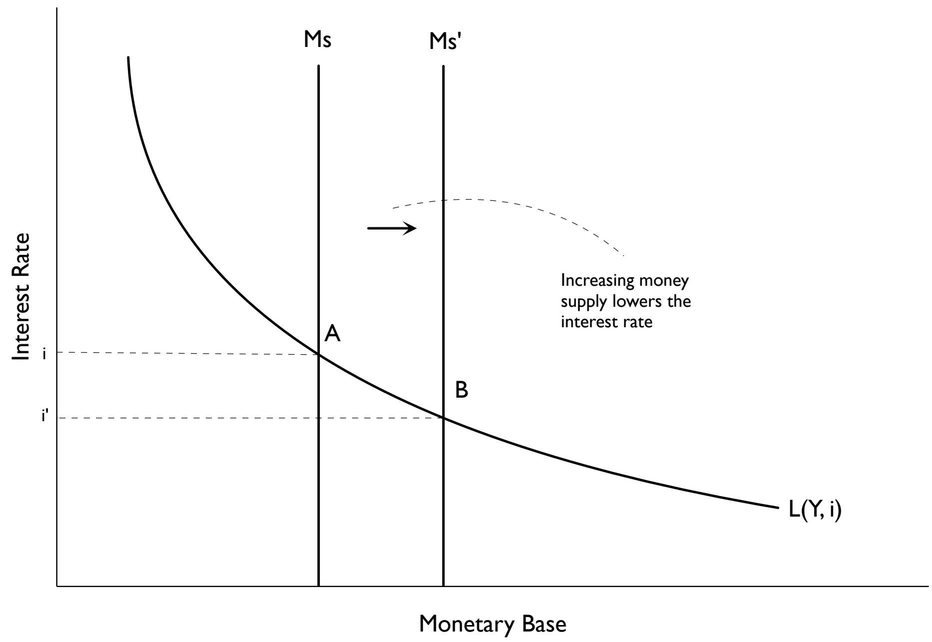
Through (14) we can see that a positive shock in the growth rate of the money supply will cause a depreciation of the exchange rate. There are two transmission channels: the exchange rate will depreciate as a direct consequence of higher current growth of money supply and, if $\rho > 0$, people will also expect higher growth of money supply in the future, since future money supply growth is determined by its previous values. Another interesting feature of this exercise is that shocks to monetary policy increases volatility in the foreign exchange market by more than the volatility in money supply.

It is also possible to understand the monetary approach graphically. Similarly to Obstfeld and Rogoff's (1996) model, the simpler version consists of the same building blocks. However, here we follow Krugman and Obstfeld (2010, chapter 14) and consider the price level and exchange rate expectations as given so we can focus on the short-run.

First, let us assume an aggregate demand for money, $M^d = P*L(r, Y)$, that is positive on real output and negative on the real interest rate. This function is based on the demand for money with transactions purposes - more output represent more transactions and thus people will need more money, and on the cost of holding money - if the interest rate is positive people could hold bonds instead of money and earn the interest income. If we pass P to the left-hand side, L(i, Y) is interpreted as the demand for liquidity, i. e., the demand for real purchasing power.

Equilibrium in the money market requires money supply and demand to be equal. If money supply is exogenously set by the monetary authority, money market equilibrium is illustrated in Picture 3.1:

Picture 2.1

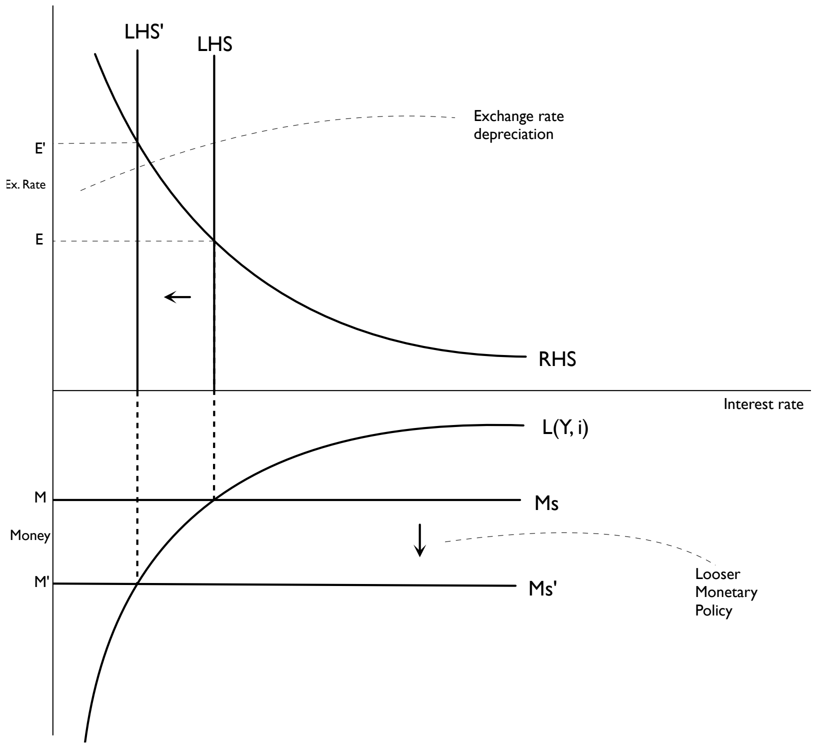


In picture 3.1 equilibrium is represented by the intersection of money demand and supply (point A). Changes in money supply shift the vertical line (M^s) to the right or left, depending on whether policy is expansionary (right) or contractionary (left). Thus, increasing money supply will shift M^s to M^{s}', creating an excess supply of money. In order to eliminate the excess supply interest rates - the cost of holding money - will fall and a new equilibrium will arise at B.

If real output increases, the money demand schedule (M^d) will shift to the right. This will happen because higher real output means more transactions will be carried out and hence people will demand more real money balances to make these additional transactions. The opposite is true for a decrease in real output.

The model's second building block is the uncovered interest parity. The left-hand side (LHS) of (9) is the return on deposits denominated in home currency (1+i) and the right-hand side (RHS) is the return on deposits in foreign currency in terms of the home currency. The latter is a decreasing function in the space $\{i;\mathcal{E}_t\}$, while the former is a vertical line (because "i" is determined in the money market). Changes in foreign interest rates will shift the RHS curve rightward and will force a depreciation of the exchange rate (or must be met by an expected appreciation in the future). If for any reason market participants change their beliefs about future exchange rates, the RHS schedule will also shift: an expected depreciation (or larger depreciation than was expected before) will shift RHS to right and the opposite will happen if agents expect a larger appreciation. The resulting equilibrium is depicted in the picture below.

Picture 2.2



The upper right quadrant of picture 3.2 is the UIP condition, while the lower right quadrant is the money market. Combining both markets one can see how monetary policy determines the exchange rate: an expansion of money supply will lower interest rates (the return on home deposits) and hence force a depreciation of current exchange rate (higher $\mathcal{E}_t$).

The basic insights into the effects of monetary policy obtained with this simple model are relatively the same as those obtained with Obstfeld and Rogoff's (1996) more complex one, except the latter 1) deals more carefully with expectations about the future path of money supply and exchange rates and 2) takes into account the existence of volatility in the foreign exchange market.

2.2.2 Fixed Exchange Rate Regime

Hitherto we have only considered flexible exchange rate regimes. We now consider a fixed exchange rate regime according to Obstfeld and Rogoff (1996) analytical model and afterwards follow Krugman and Obstfeld (2010, chapter 17) simple analysis as it was done above.

If the exchange rate is fixed permanently at $\bar{e}$, $e_t = e_{t+1} = \bar{e}$, equation (10) becomes[7]

$$i_{t+1} = i^*_{t+1} \quad (15)$$

If UIP holds and the exchange rate is fixed, home and world interest rates must be equal, because otherwise investors would have a profitable arbitrage opportunity. Also, if we keep the assumption of $\phi y + \eta i^* - p^* = 0$, eq. (11) boils down to[8]

$$m_t - e_t = -\eta(E_t e_{t+1} - e_t) \qquad (16)$$

Since the exchange rate is fixed at ē, we can substitute ē into eq. (16) and get

$$m_t = \overline{m} = \overline{e}_t \qquad (17)$$

That is, given our assumptions, monetary policy will only respond to changes in exogenous variables (the foreign price level, output level, and foreign interest rates) so as to equilibrate the markets. If the exogenous variables are constant - or if their effects on money demand cancel each other out -, the money supply will remain constant. In practical terms, an exchange rate peg usually imply the monetary authority gives up control over the monetary policy and "imports" policy from abroad (in our case, from the "world").

The same effects can be observed graphically through Krugman and Obstfeld's (2010) analysis. Picture 3.3 (next page) shows the effect of an increase in world interest rate: the interest rate on foreign deposits rises (RHS shifts to the right). If the monetary authority wants to keep the exchange rate peg, home deposit must offer higher interest rates so foreign market reaches equilibrium at B. To achieve the desired interest rate, a reduction of the money supply must be carried out, moving the monetary market equilibrium to B (on the lower quadrant).

Despite their simplicity, the models outlined above capture some basic insights into the relationship between monetary policy and exchange rates. In the next section we turn to the empirical literature on this topic, so we can see whether the expected outcomes of this relationship have come true.

Picture 2.3

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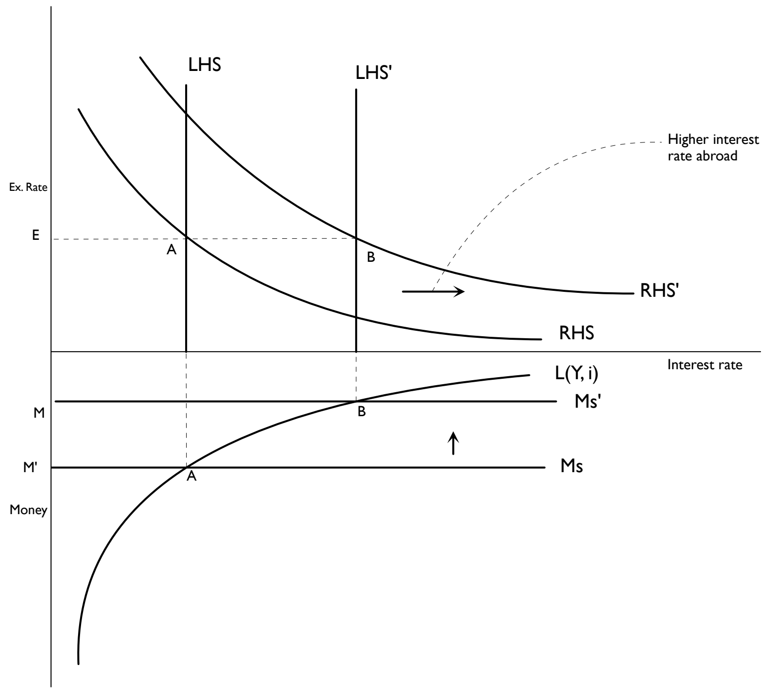
[7] It is important to keep in mind that e is the log exchange rate and thus the fixed rate will be Ɛ=e^e.

[8] We consider the public believes consider the monetary authority's peg as credible.



2.3 EMPIRICAL EVIDENCE ON EXCHANGE RATES AND MONETARY POLICY

Empirical evidence has not been favorable to models of exchange rate determination. As this section will try to show reviewing some seminal papers, many of the building blocks of the traditional approach to exchange rate determination do not resist the test of reality.

Perhaps the most important aspect of exchange rate behavior is "that they follow approximately random walks with little or no drift" (MUSSA, 1984, p. 15). Since the best prediction of a random walk process at time *t* is the value of the same variable at time *t - 1*, it should be clear that economists face a rather challenging task when trying to explain and predict movements in foreign exchange markets with economic fundamentals such as those in the models of the previous section.

Purchasing Power Parity, even in its relative form, has been a constant target of empirical literature. Michael Mussa (1986) analyzed the behavior of nominal and real exchange rates of major industrial economies through the end of the Bretton Woods era (which had fixed exchange rates as one of its cornerstones) and the beginning of the floating period. His findings led him to conclude that

> For pairs of countries with similar and moderate inflation rates, it is shown that there are substantial and systematic differences in the behavior of real exchange rates under the two different nominal exchange rates. (MUSSA, 1986:117)

This difference in real exchange rates behavior was not accompanied by a similar change in the ratio of national price levels. Quite the opposite, rising real exchange rate volatility was accounted for by increased volatility in nominal exchange rates. The latter have behaved much like other *assets* traded in highly organized markets such as long-term bonds and stocks, exhibiting much more volatility than it would be expected for a *price* (the price of foreign currency in terms of home currency) in the floating era (MUSSA, 1984).

Thus, Mussa (1986) affirms there was strong evidence against the idea that exchange rate regimes are neutral and that models that do not embody this feature should be considered. Among those models, perhaps the most famous is Dornbusch's (1976) overshooting model, which captures the consequences of sluggish price adjustment in goods market (and imply an overshooting in foreign exchange markets).

Another aspect emphasized by the empirical literature is the forward premium puzzle. When testing uncovered interest parity by estimating regressions of the form

$$\Delta_k s_{t+k} = \alpha + \beta(f_t^{(k)} - s_t) + \eta_{t+k} \quad (15)$$

where s_t is the log spot exchange rate at time t, $f_t^{(k)}$ is the log forward exchange rate at time t over maturity k and η_{t+k} is the rational expectation error forecast, empirical studies have found a coefficient ß much closer to minus one than to the expected result ß = 1 (TAYLOR, 1995, p. 15). In eq. (15), ß = 1 means the forward exchange rate is a good predictor of future exchange rate movements. Negative coefficients imply forward markets not only mispredict the *size* of future movements, but also their *signals*.

The forward premium puzzle relates to some findings in the relationship between exchange rates and monetary policy. In a seminal empirical paper, Eichenbaum and Evans (1995) investigated the effects of shocks to monetary policy on the exchange rate of the dollar against some other major currencies. Their research found three relevant conclusions discussed below.

First, they found that "contractionary shocks to U. S. monetary policy are followed by persistent increases in U. S. interest rates, and sharp, persistent decreases in the spread between foreign and U. S. interest rate" (Einchenbaum and Evans, 1995, p. 976). Second, the contractionary shock generates a sharp, persistent in U. S. nominal and real exchange rates. The latter is consistent with Mussa's (1986) evidence presented above. Again, models such as Dornbusch's (1976) overshooting model aforementioned are compatible with these pieces of evidence.

Third, the effect of a contractionary shock on U. S. exchange rates reaches its maximum point substantially after the shock happens: the estimates varies from 24 months after the shock for the Japanese yen and 39 for the British pound. This finding is not consistent with overshooting models because they assume foreign exchange markets to overshoot immediately after the shock has happened (foreign markets are assumed to clear instantaneously, while goods market adjust slowly).

Also, the association of lagged exchange rate appreciation and lower spread between U. S. and foreign interest rates is inconsistent with uncovered interest parity: if the exchange does not appreciate immediately, agents must expect a depreciation in the future so as to offset higher interest rates (or smaller spreads) in the U. S. However, as indicated above, an appreciation is expected. Thus, contractionary monetary policy shocks can induce a negative forward premium, as the literature surveyed by Taylor (1995) suggested.

The findings outlined above are partially supported by Faust and Rogers (2003) analysis. The authors' approach was focused on the robustness of "some assumptions that are dubious at best" (p. 1405) made by Einchenbaum and Evans (1995) and some other authors who joined the debate. Their first conclusion is that delayed overshooting depends on the assumptions made and that by allowing simultaneity (interest rates affecting exchange rates contemporaneously) overshooting can occur rather quickly.

On the other hand, Faust and Rogers (2003) still find robust deviations from uncovered interest parity. Results were still robust after relaxing the "dubious assumptions". Indeed, "it is impossible to find a shock that generates small UIP deviations" and also "if exchange rates do peak early in response to policy shocks, this overshooting is apparently not UIP-driven as in Dornbusch (1976)" (p. 1406).

To conclude our discussions, Bouakez and Normandin (2010) summarize the debate acknowledging two open discussions and one consolidated finding: first, the timing of maximum effect of monetary policy shocks on exchange rates is still open, since many results seem to depend on the assumptions made. Second, there isn't a consensus on the importance of monetary policy to explain the variability of exchange rates. Finally, empirical literature seems to agree on the existence of "significant departures from UIP, which imply the existence of predictable excess returns on the foreign exchange market" (Bouakez and Normandin, 2010, p. 139). However, the authors alert "there is little and mixed evidence on the extent to which these departures are due to unexpected changes in monetary policy" (p. 139).

Therefore, the main conclusion one should expect to extract from empirical literature is that

> [N]o simple model of exchange rate determination provides an adequate explanation of most of he observed movement in nominal and real exchange rates under a floating exchange rate regime. (MUSSA, 1984, p. 17)

CHAPTER 3 - INFLATION TARGETING IN EMERGING MARKET ECONOMIES AND THE CASE OF BRAZIL

Inflation Targeting has been widely adopted since the early 1990's. Fraga *et al* (2003) reckoned 12 developed and 8 developing economies inflation targeters. Developed economies started choosing IT as its monetary policy framework mainly in the first half of the 1990's and developing economies did so mostly in the late 1990's and early 2000's. While developed countries adopted IT within a stable context, EMEs faced both higher inflation[9] and a much more complex environment at the time of implementation - many had just been forced to abandon exchange rate pegs in face of sudden stops in capital inflows. After a few years of inflation targeting in EMEs, comparisons had shown that they did not achieve "civilized" levels of inflation, although average inflation within the group did fall. Also, as noted by Fraga *et al* (2003, p. 2), "[i]n these countries, deviations from both central targets and upper bounds are larger and more common."

Such situation led many economists to ask whether there was anything different about EMEs that made IT less suitable for them or even whether they should adopt it at all. The debate focused on the existence and quality of some institutions - mainly fiscal and monetary - and on some macroeconomic characteristics of EMEs - currency mismatches, exchange rate pass-through and vulnerability to external shocks. In the next section we discuss those topics following the literature.

As an almost natural path, the next question one should ask is whether IT was successful in emerging economies despite the initial obstacles. The second section goes through the literature on the success (or failure) of EMEs and tries to assess whether inflation targeting did contribute to reducing the inflation level and its volatility.

3.1 WHAT'S DIFFERENT ABOUT EMERGING MARKET ECONOMIES?

3.1.1 - Credibility and Institutions

Although credibility and institutions are two different matters, they are better understood when analyzed together. Emerging economies lack some basic fiscal, monetary, and financial institutions that are essential for a functional inflation targeting regime. Weak institutions and a

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[9] cf. Table 1 in Fraga *et al* (2003): average and median inflation prior to IT adoption was much higher in EMEs than in developed economies.

history of arbitrary enforcement makes the commitment to an inflation target less credible. Low credibility leave the monetary authority with little room for flexible policies:

> Shocks will raise questions about whether the authorities are prepared to stay the course. Sharp changes in interest rates, exchange rates and international capital flows may feed upon themselves: financial variables will be volatile, with negative implications for the economy (EICHENGREEN, 2002, p. 35)

The first set of institutions EMEs usually lack are fiscal institutions. The persistence of budget deficits can force even an unwilling central banker to monetize deficits if the only alternative is default. There is a well known literature starting with Sargent and Wallace (1981) on fiscal dominance: in a fiscal dominant regime, the seignorage needs of the central government will determine the path of the price level and monetary policy will be passive. Blanchard (2004) proposed another way through which bad fiscal policy can affect monetary policy: if government debt is too high, tightening monetary policy (increasing interest rates) can increase the default risk premium in government debt, leading to capital outflow and currency depreciation. Since a depreciated currency generates higher inflation, the initial hike in interest rates will have perverse effects.

Better monetary institutions were also needed. Mishkin (2004) distinguished two key monetary institutions EMEs needed to develop. First, “a public and institutional commitment to price stability as the overriding long-run goal of monetary policy” (MISHKIN, 2004, p. 11). Writing this commitment into law may help building credibility, but it is even more important to ensure that politicians and the public understand and support the commitment.

Second, “a public and institutional commitment to instrumental independence of the central bank” (MISHKIN, 2004, p. 12). Instrumental independence refers to the ability of setting policy instruments without intervention from politicians and according to the long-run goals given to the central bank. Again, writing central bank independence into law can contribute to the credibility of monetary institution, but embedding central bank independence into the public debate is far more important.

A stronger financial system is also required if inflation targeting is to be successful. Weak financial institutions may not resist shocks or changes in policy stance and thus can limit the central bank’s ability to appropriately respond to shocks (more in the next sub-session). In this sense, using macroprudential policy and limiting moral hazard can avoid moral hazard problems among banks and other financial institutions. (MISHKIN 2004, p. 9)

Building credibility is a process that necessarily takes time. During this time, Inflation Targeting will offer less advantages as it will have to be conducted with less flexibility. It is then logical to ask whether the above mentioned institutions are a prerequisite to successful inflation targeting or somehow a consequence of it. Mishkin (2004) argued inflation targeting can help emerging countries focus on building stronger institutions by, for example, focusing the debate on price stability. This point (although not regarding EMEs specifically) is also made by Bernanke *et al* (1999). Mishkin (2004) conceded reforms can both precede or follow the adoption of IT: while Chile had a combined strengthening of the IT regime and execution of reforms, Brazil adopted a full fledged IT regime at a time most reforms had not been done (the financial system had undergone some reforms prior to 1999). On the other side, Eichengreen (2002, p. 41) seemed more skeptical: "[i]nflation targeting will be less attractive the dimmer the prospects of the central bank acquiring policy credibility".

3.1.2 Exchange Rates: Dollarization and Pass-Through

Besides the need to build credibility, Minella *et al* (2003) identified high exchange rate volatility as the other key challenge to EMEs adopting Inflation Targeting. First, exchange rate volatility should be a concern for every inflation targeter, as external conditions can affect the internal inflation rate. Eichengreen (2002) points two kinds of external shocks: Calvo and Prebisch shocks.

A Calvo shock is a shock to financial markets. In Eichengreen's (2002, p. 16) model it can be understood as "a change in the direction or availability of capital flows due to, say, a rise in world interest rates". Higher interest rates abroad will start a capital outflow from the home country and hence there will be a depreciation of the exchange rate. This will in turn raise the inflation rate as higher import prices are passed-through into domestic prices. An inflation targeting central bank would thus raise interest rates to contain depreciation and the passed-through increase to inflation. As Eichengreen (2002) noted, the correct response does not mean the central bank will revert the entire depreciation, but only smooth it. That will happen because the hike in domestic interest rates lowers internal demand and also because a weaker currency means more export competitiveness.

The other relevant shock is a disturbance to the "foreign component of aggregate demand" (EICHENGREEN, 2002, p. 19). In this case, lower demand for export products will cause, *ceteris paribus*, an exchange rate depreciation and lower aggregate demand. These two events have opposite consequences to the inflation rate: a weaker currency will cause higher inflation (exchange rate pass-through) and lower demand forces inflation downwards. The author argued the former effects will dominate the latter and hence the appropriate response will be to increase interest rates. If the central bank gives high weight for inflation deviations from the target, it will raise interest rates to counter the depreciation and will gradually let the exchange rate achieve its new long-run equilibrium. This view is not homogenous: Mishkin (2004) stated this shock "is likely to be deflationary" (*i. e.*, the aggregate demand effect dominates) and lowering interest rates is then the correct answer.

The last two paragraphs described the expected response of a central bank to external shocks. Why should one expect it to be different for emerging market economies? Those economies had higher exchange rate pass-through coefficients and higher levels of dollarization. (MISHKIN, 2004; EICHENGREEN, 2002)

Goldfajn and Werlang (2000) estimated the pass-through coefficient for 71 countries covering 20 years of data. They found that it was substantially higher in emerging market economies when compared to OECD countries. Higher pass-through can lead a central bank to overreact to currency depreciations. If the cause of currency depreciation is a real ("Prebisch") shock, tightening monetary policy may be the wrong idea. Mishkin (2004) attributed this mistake to the policy actions of the Chilean central bank in 1998: in face of a terms of trade shock the central bank tightened monetary policy and narrowed the exchange rate band when the correct answer was to accommodate the shock.

Although high pass-through may complicate policy makers' job, some authors have argued that the exchange rate pass-through is not regime-independent. Taylor (2000) was the first to advocate that keeping inflation low can help reduce the exchange rate pass-through. Mishkin (2004) advanced the point saying that a regime focused on price stability, as IT is supposed to be, can help reduce pass-through since agents will expect more aggressive response to external shocks. In this sense, Mishkin argued that higher pass-through should not be taken as a barrier towards adopting IT.

In emerging economies, a significant fraction of firms, banks and government debt is denominated in foreign currency, while most of its revenues are denominated in the national currency. This characteristic "is pervasive in emerging markets" (Calvo and Reinhart, 2002) and generates additional consequences from exchange rate fluctuations: an exchange rate depreciation increases the value of foreign debt while keeping the revenues constant. Weaker balance sheets generate a "balance sheet effect".

This effect was first proposed by Bernanke (1983) as an additional transmission channel from the financial system to the real economy in the Great Depression. It has been applied to the situation of emerging market economies: the balance sheet effect refers to the creation of adverse selection in financial markets during a turmoiled period. After a depreciation there is an increased probability that companies (and governments) seeking financing are those most severely affected by the depreciation. Lenders will thus proceed cautiously and this can trigger a financial crisis (Mishkin, 2004). In the extreme case, the positive effect coming from increased export competitiveness can be canceled out by the harming financial effects of a depreciation. If this is the case, an exchange rate depreciation will lead to lower output. Eichengreen (2002) suggested a non-linear balance sheet effect: small depreciations will not trigger it, but sharp swings in foreign exchange markets because firms and banks are not prepared to face the shock and also because the competitiveness effect can take some time to materialize.

Liability dollarization and high pass-through coefficients can thus lead to "fear of floating", (Calvo and Reinhart, 2002). Countries that exhibit fear of floating give much more weight to exchange rate stabilization than their official policy stances say. In our case, inflation targeters should focus much more in inflation than in exchange rate stabilization, even after conceding to the fact that exchange rate policies can be adequate for an inflation targeter, as discussed before. However, emerging markets risk focusing too much on the stabilization of exchange rates and forget about price stability. Mishkin (2004) suggested EMEs should make their interventions in foreign exchange markets more clear and relate them to the price stability objective of monetary policy. Eichengreen (2002, p. 31) argued "that liability dollarization, as analyzed here, in no sense precludes inflation targeting".

3.2 HAS INFLATION TARGETING BEEN SUCCESSFUL IN EMERGING MARKET ECONOMIES?

After listing all these challenges and observing that EME's have adopted inflation targeting despite of them (or maybe because of them), one should ask whether IT has been successful in those countries. The basis of comparison are the results of IT in industrial economies. Despite the expectation that inflation targeting would help lock in past disinflationary gains or even help reduce inflation itself (Bernanke *et al*, 1999), Ball and Sheridan (2006) found no evidence among 20 OECD countries that those targeting inflation did on average better than the nontargeters. Over the analyzed period both groups achieved lower inflation and interest rate volatility was similar between both groups. They attributed these conclusions to the existence of mean reversion and to the similarity between the implied policy rules of both targeters and nontargeters.

Gonçalves and Salles (2008) applied Ball and Sheridan's method to a sample of 36 emerging market economies with 13 inflation targeters among them. Their results are opposed to those found among industrial economies: inflation targeters did achieve lower inflation than nontargeters (even controlling for mean reversion) and lower output variability. Gonçalves and Salles also found that Inflation Targeting did not reduce economic growth and interpreted this as a benefit of the "constrained discretion" framework explained in the first chapter of our analysis.

Regarding the fear of floating, Aizenman *et al* (2010) found evidence among 16 emerging market economies in the period 1989-2006 that the inflation targeters react less to real exchange rate fluctuations than nontargeters. This finding does not mean that the former group is adopting a "pure" inflation targeting, since they also responded significantly to real exchange rate fluctuations. Among the targeters, the response to real exchange rate fluctuations is greater when they depend more on the export of basic commodities. They also found that the weight attributed to inflation in the reaction function of central banks is greater among targeters than among nontargeters.

Taylor's (2000) hypothesis that low inflation contributes to the reduction of the exchange rate pass-through has also been tested[10]. Nogueira Jr. and León-Ledesma (2008) reported there was considerable evidence in the literature showing that pass-through coefficients have indeed declined in emerging and developed economies. The link between declining pass-through and low inflation environment has shown mixed support in the empirical literature. Many attempts did establish a correlation between pass-through and inflation levels. Attempts to link the aggressiveness of monetary policy response to inflation deviations have not been successful. In their own analysis of a 20-country sample (including developed and emerging inflation targeters), Nogueira Jr. and León-Ledesma found temporal causality running from the exchange rate pass-through to the inflation rate, but failed to find causality in the opposite direction, with a few exceptions.

Considering the debate discussed in this chapter, we proceed with an empirical analysis of the IT regime in Brazil. In the next chapter we estimate two vector autoregressive models (VAR) to

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[10] This paragraph is based on Nogueira Jr. and León-Ledesma (2008) report on the literature. We refer to their work (pp. 4-7) for a more complete report.

analyze the effects of exchange rates on the stance of monetary policy and on the pass-through to inflation.

CHAPTER 4 - MONETARY POLICY AND EXCHANGE RATES IN BRAZIL (1999-2012)

After successful inflation stabilization with the Real Plan in 1994, Brazil adopted a crawling peg to the US dollar as a nominal anchor for monetary policy. The serial fall of exchange rate pegs and sovereign defaults in many emerging economies coupled incomplete structural reforms started eroding confidence in the Brazilian peg (BOGDANSKI et al, 2000). This process culminated in the Russian moratorium in August 1998. At this point, the Central Bank of Brazil reacted to capital outflows and raising interest rates to defend the peg. The IMF also sent a rescue package amounting to US$41.5 billion.

The Central Bank tried to defend the peg until early January 1999, when the newly elected governor of Minas Gerais imposed a moratorium on the state's debt payments and a full-fledged currency crisis started (MISHKIN, 2004). In January 15 the Real was forced to float. After the break of the peg, the Central Bank's board of directors was replaced.

From January 1999 to August 1999 there was no clear monetary policy framework and thus the exchange rate suffered a large depreciation: from 1.32 Reals to the dollar (BRL/USD) on the day before the regime change to a maximum of 2.2 BRL/USD in March 3rd. The Central Bank responded increasing interest rates from 39%p.a. to 45%p.a.. It also started the building process of a fully fledged inflation targeting regime, officially implemented in July 1st.

At the time of implementation, many of the necessary institutions discussed in the previous chapter were not in place: fiscal reform had been at best gradual until the currency collapse, and monetary institutions had been gone with the peg[11] . Thus, the Central Bank had to build what was considered prerequisites to a successful inflation targeting after putting the new framework in place.

Despite the difficult task, inflation targeting managed to achieve some initial success. The National Monetary Council (CMN)[12] set decreasing inflation targets for 1999, 2000 and 2001, because the initial devaluation was interpreted as a temporary shock to inflation (BOGDANSKI *et al*, 2000). The Central Bank managed to keep inflation within the target band while lowering interest rates in 1999 and 2000 (see graph 5.1 and 5.2).

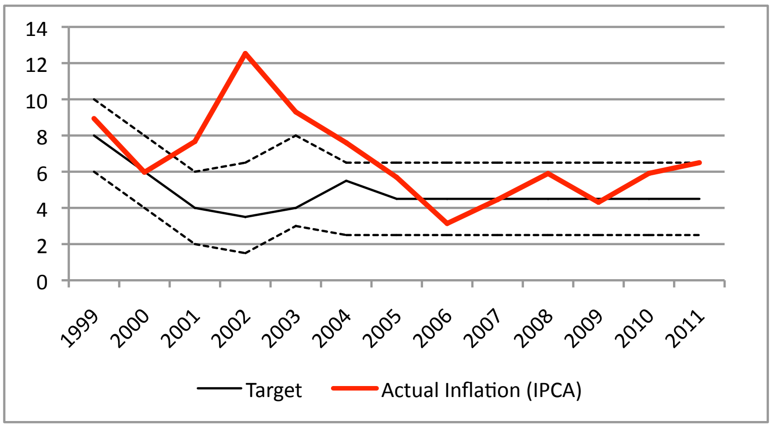
In 2001 several shocks hit the Brazilian economy: a domestic energy crisis, the 11/9 terrorist attacks and the Argentine crisis forced an exchange rate depreciation (Minella *et al*, 2003). The Central Bank missed its target by more than 350 basis points. Exchange rates continued to

[11] The banking reform had already been concluded (cf. Mishkin 2004, pp. 17-18)

[12] The CMN is the highest financial authority in the Brazilian financial system. It is composed by the minister of finance, the minister of planning and the president of the Central Bank. It sets the targets for two years on in the Brazilian inflation targeting regime.

depreciate as the election period started in mid 2002 and as left-wing presidential candidate Luiz Inácio Lula seemed closer to victory. The exchange rate averaged 3.80 BRL/USD in October 2002, the same month president Lula was elected. To contain the effects of such a large depreciation on inflation, the Central Bank was forced to raise interest rates sharply at the end of 2002 and early 2003.

Graph 4.1 - Targets and Actual Inflation[13]



The path of monetary policy until the first months of 2003 suggest a strong focus on exchange rates despite the official adoption of an inflation targeting regime. This stands in contrast with the period starting in early 2003 and going through the present. Since the overshooting of 2002-3, exchange rates have been appreciating continuously with only a few interruptions. As exchange rates appreciate, it eases inflationary pressure and allows the central bank to pay more attention to other components of aggregate demand.

As we have seen in chapter four, paying attention to exchange rates is expected from an inflation targeter as changes in exchange rates can pass-through to inflation and also affect external demand. We suspect that there were further reasons for the Central Bank of Brazil to pay extra attention to exchange rates until early 2003 because the brazilian economy had been hit by several - and large - external shocks. After 2003, there seemed to be less reasons for the Central Bank to be concerned about exchange rates. On the opposite direction, we expect exchange rates to respond to the Selic rate mainly in the second period, as the shocks hitting the foreign exchange market in the first period would leave little room for monetary policy to determine the exchange rate.

In the next section we follow Noronha (2007) and try to assess the relationship between monetary policy and exchange rates within those two periods. We run a parsimonious Vector Autoregressive (VAR) model and analyze impulse-response functions and forecast errors

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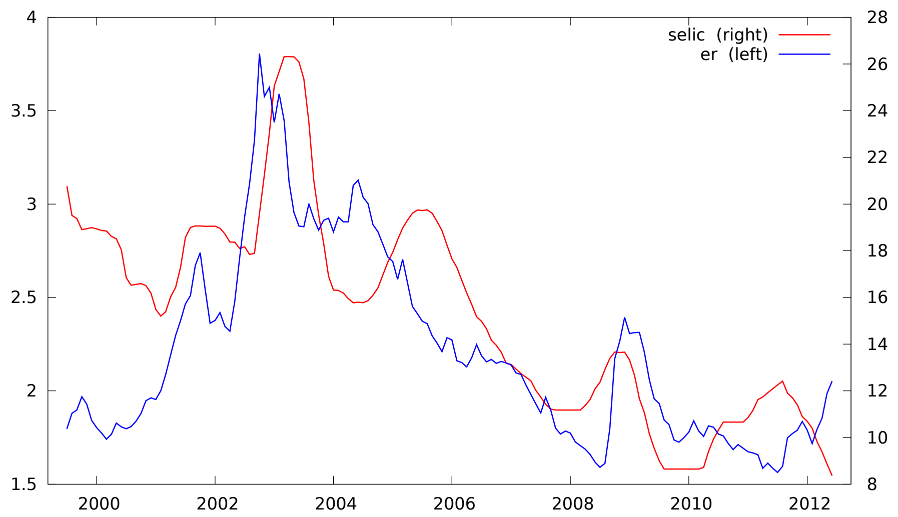
[13] Targets are adjusted for 2003 and 2004 following open letters from the Central Bank's President to the Minister of Finance.

decomposition. We then appraise the pass-through from the exchange rate to inflation using another simple VAR model. In both parts our purpose is not to qualify the responses as, say, "excessive" or "insufficient" and neither to provide a complete theory of monetar but rather to indetify their signals and significance and compare to the expected results according to the previous chapters of this paper.

Graph 4.2 - Selic and Exchange Rate



4.1 - MONETARY POLICY AND EXCHANGE RATES (MODEL 1)

Our first VAR model is composed of three endogenous variables, the Selic rate[14], the Real/ US Dollar exchange rate (er) and the Embi+BR (embi), a country-risk index computed by J. P. Morgan. All time series were extracted from Ipeadata (www.ipeadata.gov.br) taking a monthly average of daily observations. The sample starts in July 1999 and ends in June 2012. The first period finishes in March 2003. Augmented Dickey-Fuller tests for unit root were conducted for each variable and its first difference (see Appendix 1). Following the results all variables will be used in their first differences. VAR order was selected using standard information criteria, for both periods the majority of the criteria suggest using a VAR (1) model (complete lag selection tables are available in Appendix . The structural form of our VAR model is hence given by:

$$d\_embi_t = constant_1 + \beta_{1,1} d\_embi_{t-1} + \beta_{1,2} d\_er_{t-1} + \beta_{1,3} d\_selic_{t-1} + \varepsilon_{t,1} \quad (1)$$

$$d\_er_t = constant_2 + \beta_{2,1} d\_embi_{t-1} + \beta_{2,2} d\_er_{t-1} + \beta_{2,3} d\_selic_{t-1} + \varepsilon_{t,2} \quad (2)$$

$$d\_selic_t = constant_3 + \beta_{3,1} d\_embi_{t-1} + \beta_{3,2} d\_er_{t-1} + \beta_{3,3} d\_selic_{t-1} + \varepsilon_{t,3} \quad (3)$$

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[14] The Selic rate (Sistema Especial de Liquidação e Custódia) is an overnight interest rate determined by the Central Bank of Brazil through its open market operations. It is the benchmark interest rate in the brazilian economy.

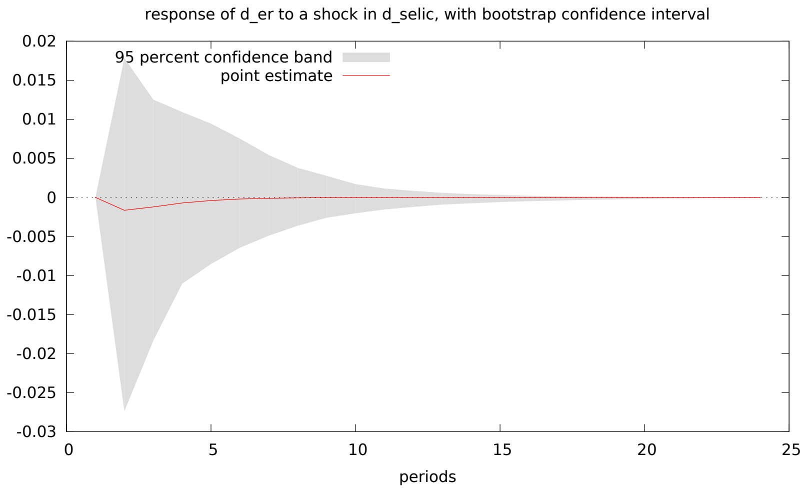
We conducted tests for autocorrelation (Ljung-Box), ARCH effects and residual normality (Doornik-Hansen) for both periods. For period 1, the null hypothesis of no autocorrelation could not be rejected at a 10% significance level. The null hypothesis of no conditional heteroscedasticity could not be rejected for equation 1 and 3 at any usual significance level. The null hypothesis is rejected for equation 2. Normality of residuals was rejected in the Doornik-Hansen test for period 1.

For period 2, the null hypothesis of no autocorrelation could not be rejected for any usual level of significance in all three equations. The same result was observed for ARCH effects. Normality of residuals was rejected again. A summary of the estimated coefficients and of all tests is available in Appendix 3.

4.1.1 - Results

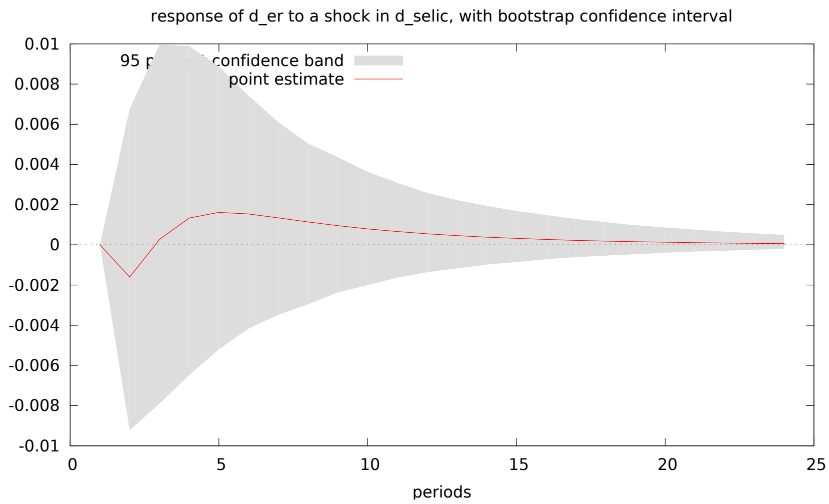
Impulse-response functions were built using the following Cholesky ordering: Embi+BR, exchange rate, and Selic(appendix A3.3). This ordering is based on the theoretical considerations: risk is assumed to be the most exogenous variable and related to variables outside our model, such as political risk (in period 1) and international crises (period 2). Exchange rates is also assumed to be at least partially determined by variables outside the model, mainly commodity prices. Nevertheless, we generated impulse-response functions for each of the six possible orderings and observed qualitatively similar results.

Graph 4.3 - Response of Exchange Rate to a shock in Selic (1999:07-2003:03)



The exchange rate appreciates after a one standard deviation shock on the Selic in both periods but the response is never significantly different from zero (graphs 5.3 and 5.4). Forecast error variance decomposition in a twelve month horizon indicates that the Selic rate can explain only 0,03% of exchange rate variance using our default ordering between July 1999 and March 2003. In the second period the Selic rate explains 0,23% of exchange rate variance (see Appendix 3). Exchange rates are explained mainly by their own lag and the risk premium. Alternative Cholesky ordering produce results ranging from 0,03% to 8,33% in the first period and from 0,23% to 2,49% in the second period[15]. The observed response of exchange rates to shocks on the Selic rate gives support to the view that exchange rates are determined by factors other than monetary policy. The impulse-responses are also in contrast with the traditional monetarist view of exchange rates, where the path of monetary policy is expected to determine exchange rates.

Graph 4.4 - Response of Exchange Rate to a shock in Selic (2003:04-2012:06)



The response of the Selic rate to is different in each period. In the first period the Selic rate is increased after a one standard deviation shock in the exchange rate (graph 5.5). The response is significant between the second and fourth months after the shock has happened. Variance decomposition indicates the exchange rate can explain 49,96% of variance in the Selic rate within a 12 month horizon. Alternative Cholesky orderings range from 11,96% to 68,32%. This results are expected given the context of confidence building and increased interest rate volatility in the first period (as seen in Minella *et al*, 2003).

Results obtained for the second period point to the opposite direction. Between April 2003 and June 2012 the Selic rate decreased in response to postive shocks to the exchange rate though it is never significantly different from zero (graph 5.6). Variance decomposition showed exchange rates can explain only 2,22% of Selic variance in a twelve month horizon. Changing the Cholesky

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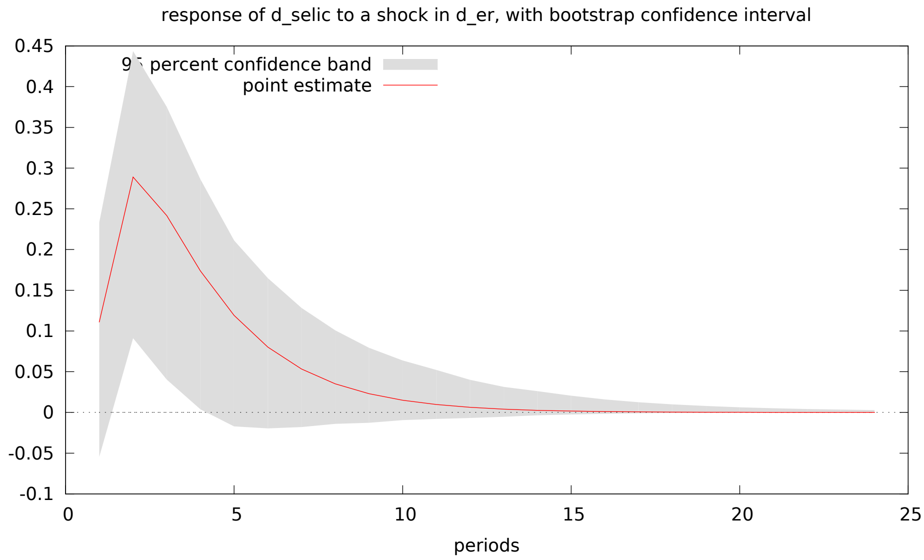
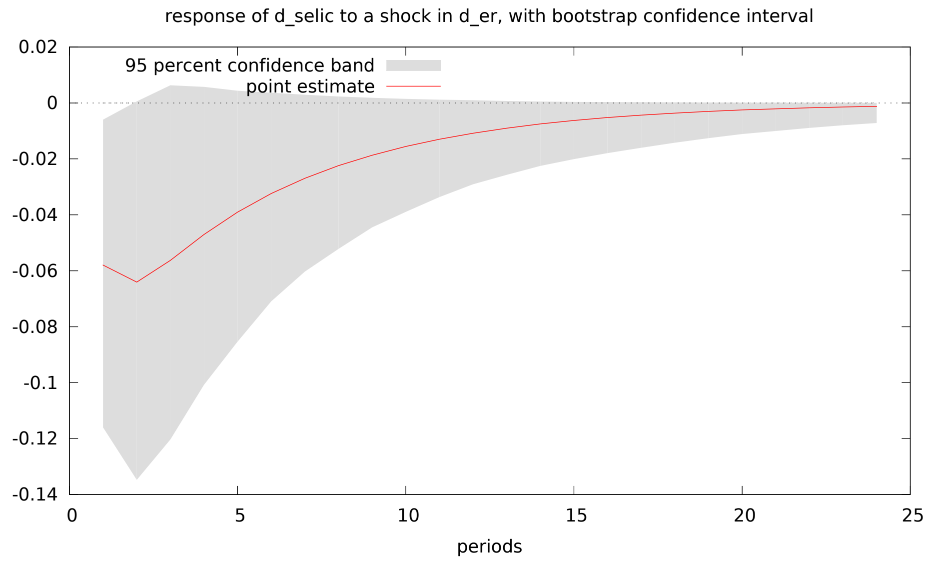
[15] Alternative Cholesky orderings and variance decomposition results for each of them can be seen in Appendix 4.

ordering resulted in a maximum of 7,5% of Selic variance explained by the exchange rate. The Selic rate variance is explained mainly by its own lag (more than 90% for all Cholesky orderings).

Graph 4.5 - Response of Selic to a shock in Exchange Rate (1999:07-2003:03)



Graph 4.6 - Response of Selic to a shock in Exchange Rate (2003:04-2012:06)



Finally, we also ran two alternative models, one including the level of international reserves held by the central bank and the other considering risk perception as an exogenous variable. The results did not render any additional relevant insight for our purposes and are not reported here (available upon request).

4.2 EXCHANGE RATE PASS-THROUGH TO INFLATION (MODEL 2)

Our second model is an attempt to assess the exchange rate pass-through to inflation. Again, since our goal is not to provide a theory of inflation, but only to evaluate the contribution of changes in the exchange rate to changes in inflation, we estimate a parsimonious VAR model with three variables: the output gap, the exchange rate and the inflation rate (Broad Consumer Price Index - IPCA).

The output gap was obtained using the Hodrick-Prescott filter on monthly observations of the seasonally adjusted industrial production index (published by the Brazilian Institute of Geography and Statistics - IBGE) and dividing the fluctuation by the trend (hence it is measured in percentage points). The exchange rate is the same as before. The inflation rate is the IPCA percentage change over twelve months. Again, all series were extracted from Ipeadata. The exchange rate and the inflation rate will be used in their first differences following the results of unit root tests (Appendix A1).

Lag selection through standard criteria (Appendix 5) pointed to a first order VAR for both periods. The model is hence given by:

$gap_t = constant_1 + ß_{1,1}gap_{t-1} + ß_{1,2}d\_er_{t-1} + ß_{1,3}d\_ipca_{t-1} + \varepsilon_{t,1}$ (1)

$d\_er_t = constant_2 + ß_{2,1}gap_{t-1} + ß_{2,2}d\_er_{t-1} + ß_{2,3}d\_ipca_{t-1} + \varepsilon_{t,2}$ (2)

$d\_ipca_t = constant_3 + ß_{3,1}gap_{t-1} + ß_{3,2}d\_er_{t-1} + ß_{3,3}d\_ipca_{t-1} + \varepsilon_{t,3}$ (3)

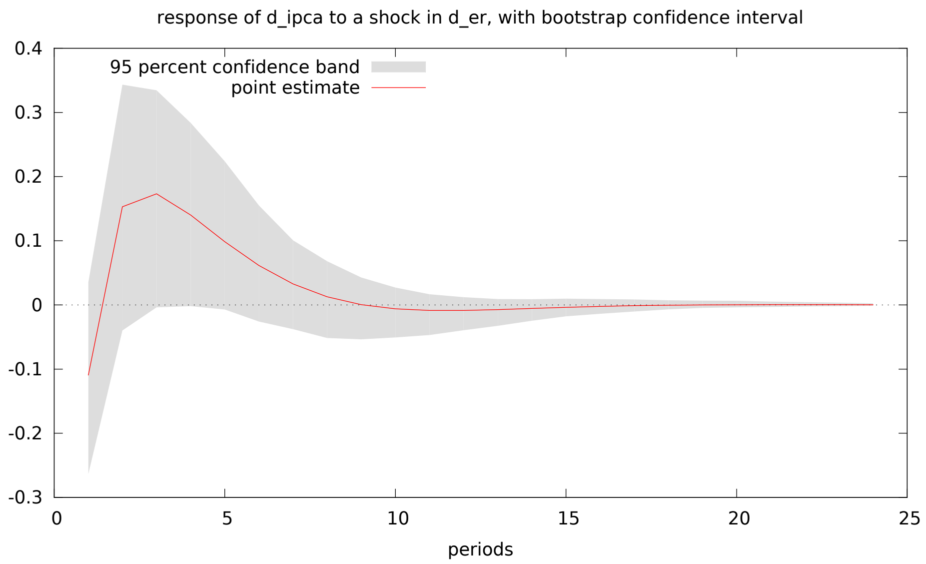
Routine autocorrelation, ARCH, and normality of residuals tests were conducted for each period. We rejected the null hyphoteses of no autocorrelation and of no conditional heteroscedasticity are present in the third equation. For the sake of simplicity we will ignore those results. Normality of residuals was rejected for both periods in a 5% significance level (full results are available in appendix A6).

4.2.1 - Results

Considering the lack apparent independence of exchange rates noted in model 1 discussion, we produced impulse-response functions using the following Cholesky order: exchange rate, output gap and inflation (appendix A6.3). Because we are interested in the exchange rate pass-through to inflation, we will focus on the third equation of model 2.

Graphs 5.7 and 5.8 below show the impulse-response function for each period. The response of inflation to a shock in the exchange rate is greater in the first period, within which the largest deviations of inflation from the target are contained (2002). In the first period the 95% confidence interval is slightly different from zero in the third an fourth months after the shock. The coefficient in the estimated regressions also differ greatly: the coefficient $\beta_{3,2}$ in the first period is about twice as large as in the second period and more significant as well (appendix A6.1).

Graph 4.7 - Response of Inflation to Exchange Rates (1999:07 - 2003:03)

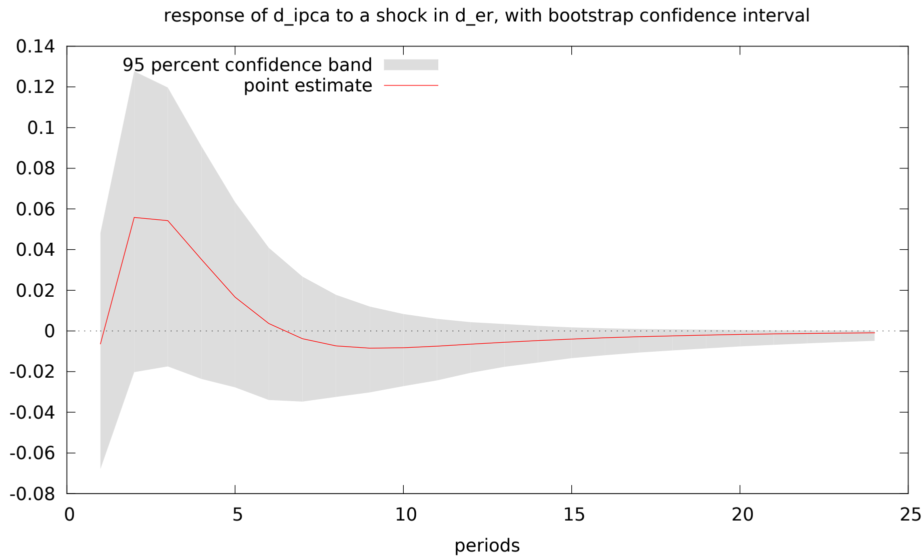


Variance decomposition add more strength to the results: exchange rates explain 19,25% of inflation variance in the first period and only 3,14% in the second period. The difference between the two period shifts to an increased weight of inflation in its own explanation (from 72,29% to 90,58%. The output gap explains only 8,44% in the first period and 6,26% in the second period. Exchange rate and lagged inflation coefficients are significant in both periods while output gap coefficient is never significant.

The results suggest a reduction in the exchange rate pass-through to inflation. This result is compatible with the result in the previous model and with the literature explored in the previous chapter. If the pass-through did decline between the two periods, there would be a reason for the central bank to worry less about exchange rate fluctuations - as we detected with the first model.

Although arguing over whether the pass-through declined because of increased trust in the Brazilian inflation targeting regime is not in the scope of this paper, we can speculate about it. Mishkin (2004, p. 20) recognized the procedure followed by the Central Bank during the 2002-2003 crisis were accurate, it was “a textbook case for central bank response response to shocks in emerging market economies”. If this was the case, it is possible to argue that the accurate response led to increased credibility and consequently to lower pass-through. Since increased credibility can be interpreted as a propensity of the Central Bank to respond to exchange rate shocks in a clear manner, agents may have less incentives to pass higher (but temporary) import costs do domestic inflation. As consequence, the Central Bank would also have less incentives to be concerned about exchange rate fluctuations when deciding its policy actions.

Graph 4.8 - Response of Inflation to Exchange Rates (2003:04 - 2012:06)



This is just one of the possible explanations to findings. Because our models are parsimonious, so must be the sharpness of our conclusions. Some findings will be left for further research to explain. For instance, the apparent lack of influence of monetary policy on the exchange rate (found in both periods) and the inverted response of the selic rate to a shock in the exchange rate (graph 5.6) are on this group.

Our analysis did not seek to provide a theory of the relationship between monetary policy and exchange rates within the Brazilian inflation targeting. But it seems fair to conclude that exchange rates did become less important in the making of monetary policy and that one reasonable possibility is that it has been caused by a decline in the exchange rate pass-through to inflation.

CONCLUSION

In order to analyze the Brazilian inflation targeting regime, we first sought to set our theoretical framework. The first chapter defined how conventional economic theory expects an inflation targeting regime to be set and on which theoretical developments it is based. Inflation targeting combines the benefits of a rule-based regime with the flexibility of discretionary monetary policy in a framework for "constrained discretion".

It was also understood how monetary policy determines the exchange rate. It has been shown that expansionary (contractionary) monetary policy is followed by an exchange rate depreciation (appreciation). In the fourth chapter it was also explained that even a strict inflation targeting regime should care about exchange rate fluctuations, because shocks in foreign markets can reflect on domestic inflation. For a flexible inflation targeter (*i. e.* concerned with output fluctuations), there are additional (and sometimes conflicting) reasons to care about exchange rate fluctuations.

When inflation targeting was adopted in emerging countries, it became necessary to discuss if it was the appropriate monetary regime given their distinct macroeconomic characteristics. Lack of credibility in policy authorities and of fiscal, monetary, and financial institutions could impair the inflation targeting regime. Reforming key institutions was necessary but it was not clear at the time whether reforms should precede or come along with the regime implementation. Chilean and Brazilian experience provided arguments for the feasibility of both cases.

Finally, emerging economies had additional macroeconomic features that could harm the newly implemented monetary regime: currency mismatch and high exchange rate pass-through. While the former has not been analyzed here (and that is not to say it is unimportant), the latter was considered empirically.

Our two models suggested that pass-through has indeed declined between the two periods in our sample (July 1999 - March 2003; April 2004 - June 2012). The response of inflation to shocks on the exchange rate is smaller in the second period and the 95% confidence interval always include zero. Variance decomposition showed exchange rates explained a smaller part of inflation variance in the second period than it did in the first period. The coefficient of the exchange rate in the inflation equation was always significant.

This finding can help explain the findings of the first model. Our attempt to the relate exchange rate and the policy interest rate showed monetary policy responded significantly to exchange rates prior to March 2003. This response is not observed in the second part of our series, where interest rates respond to shocks on the exchange rate with the wrong signal. Variance decomposition add further strength to this point: exchange rates accounted for more than 40% of interest rate variance in the first period and for less than 10% in the second period, although those results varied with changes in the Cholesky ordering.

Finally, we found that the exchange rate does not react significantly to shocks in the Selic rate. Variance decomposition confirmed this position. Interest rates never account for more than 9% of exchange rate variance and for most Cholesky orderings the result is below 1%. As seen in the second chapter, it was expected that exchange rates were influenced by monetary policy, but this proposition was not observed in the data.

This paper was concerned mainly with the observed relationship between monetary policy and the exchange rate. It was not our aim to explain the causes behind the changes in this relationship, but our analysis of exchange rate pass-through to inflation did give a hint towards a possible explanation that is also aligned with the literature reviewed.

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APPENDIX 1: UNIT ROOT TESTS

The table below shows p-values for Augmented Dickey-Fuller (ADF) tests. We report tests for all variables and their first differences for both subperiods (1999:07 - 2003:03; 2003:04 - 2012:06) and also for the whole sample.

Table A1.1 - Unit Root Tests

	1999:07 - 2003:03		2003:04 - 2012:06		1999:07 - 2012:06	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
embi	0,8466	0,1611	0,004192	0,005863	0,3027	0,001083
er	0,9384	0,0272	0,08799	3,70E-08	0,4234	1,96E-08
selic	0,1365	0,0766	0,002737	1,19E-08	0,08563	4,24E-07
ipca	0,8607	0,05612	0,0004667	8,01E-06	0,02838	1,25E-06
gap	0,1101	0,0001	0,01281	2,88E-10	0,00133	4,42E-14

APPENDIX 2: LAG SELECTION (MODEL 1)

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

1999:07 - 2003:03

lags	loglik	p(LR)	AIC	BIC	HQC
1	-32.17905		2.265592	2.777457*	2.449245*
2	-23.75336	0.05109	2.295044	3.190808	2.616437
3	-10.87771	0.00224	2.096293	3.375956	2.555425
4	0.86770	0.00518	1.955502*	3.619064	2.552374
5	7.90654	0.11959	2.056075	4.103535	2.790686

2003:04 - 2012:06

lags	loglik	p(LR)	AIC	BIC	HQC
1	118.27799		-1.914919*	-1.621997*	-1.796089*
2	122.04611	0.58147	-1.820651	-1.308037	-1.612698
3	129.78962	0.07840	-1.798011	-1.065706	-1.500936
4	141.36589	0.00586	-1.844430	-0.892433	-1.458233
5	148.64958	0.10353	-1.813506	-0.641817	-1.338186

APPENDIX 3: MODEL 1 SUMMARY AND TESTS

A3.1 - Model Summary

Table A3.1 - Model 1 Summary

(1999:07 - 2003:03)				2003:04 - 2012:06			
	d_embi	d_er	d_selic		d_embi	d_er	d_selic
Constant	0.189474 -0.183025	0.0398786 (0.208080)*	-0.0102517 (0.0684130)	Constant	-0.230389 (0.0394109)	-0.00553966 (0.00737328)	-0.380902 0.0266211
d_embi(-1)	0.937559 (0.193005)***	0.0393178 (0.219428)*	-0.216026 (0.0721437)***	d_embi(-1)	0.464136 (0.119462)***	0.0628846 (0.0223499)***	0.0175434 (0.0806939)
d_er(-1)	-5.83055 (2.04226)***	-0.122142 (0.232184)	2.73890 (0.763378)***	d_er(-1)	-0.678530 (0.676097)	0.130039 (0.126489)	-0.309361 (0.456687)
d_selic(-1)	-0.0319427 (0.265504)	-0.00444875 (0.031851)	0.575743 (0.0992430)***	d_selic(-1)	0.115407 (0.0788084)	-0.00641186 (0.0147440)	0.833360 (0.0532331)***
Statistics				**Statistics**			
	d_embi	d_er	d_selic		d_embi	d_er	d_selic
Observations	43	43	43	**Observations**	111	111	111
R-squared	0.435808	0.125297	0.653071	**R-squared**	0.217670	0.215347	0.718582
Adj. R-squared	0.392408	0.058012	0.626384	**Adj. R-squared**	0.195735	0.193347	0.710691
SSR	46.96608	0.607055	6.562096	**SSR**	16.31104	0.570912	7.442176
F(3,39)	10.04179	1.862188	24.47165	**F(3,107)**	9.923625	9.788646	91.07224
p-value F	0.000049	0.151984	4.50E-09	**p-value F**	7.92E-06	9.23E-06	2.45E-29

A3.2 - Tests

Table A3.2 - Model 1 Tests

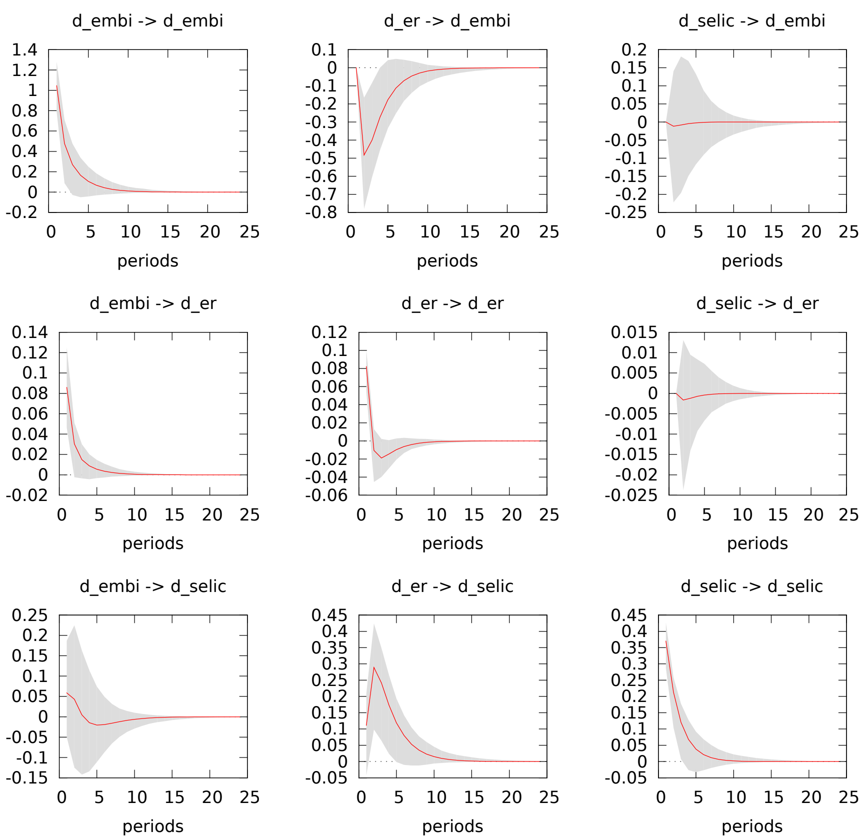
Autocorrelation Test (Ljung-Box)			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No residual autocorrelation		
Alternative Hypothesis	Residual autocorrelation		
Test Statistic	Q’= 9.89495	Q’= 17.438	Q’=5.24877
P-value	0,625	0,134	0,949
Normality Test (Doornik-Hansen)			
Null Hypothesis	Residuals are normally distributted		
Alternative Hypothesis	Residuals are not normally distributed		
Test Statistic	25.2012		
P-value	0.0003		
ARCH Test			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No ARCH effect is present		
Alternative Hypothesis	ARCH effect is present		
Test Statistic	LM=12.7297	LM=27.1051	LM=5.0031
P-value	0.388986	0.00746242	0.957875

Table A3.3 - Model 1 Tests (2003:04 - 2012:06)

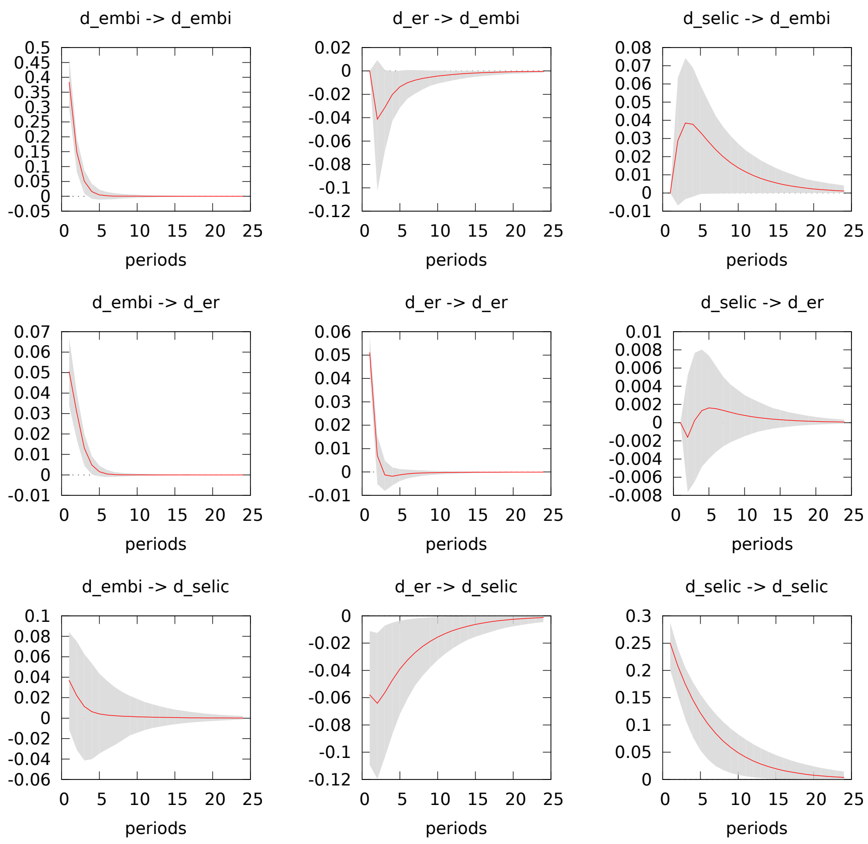
Autocorrelation Test (Ljung-Box)			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No residual autocorrelation		
Alternative Hypothesis	Serial autocorrelation		
Test Statistic	Q'=14.0674	Q'= 16.4168	Q'= 16.0871
P-value	0,296	0,173	0,187
Normality Test (Doornik-Hansen)			
Null Hypothesis	Residuals are normally distributted		
Alternative Hypothesis	Residuals are not normally distributed		
Test Statistic	60.5064		
P-value	0,0000		
ARCH Test			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No ARCH effect		
Alternative Hypothesis	ARCH effect		
Test Statistic	LM = 14.7555	LM = 9.86886	LM=3.10415
P-value	0.25508	0.627465	0.994763

A3.3 - Impulse-response Functions

Graph A3.1 - Model 1 Impulse-response Functions (1999:07 - 2003:03)



Graph A3.2 - Model 1 Impulse-response Functions (2003:04 - 2012.06)



A3.4 - Forecast Error Variance Decomposition

1999:07 - 2003:03

Table A3.5 - Decomposition of variance for d_embi

period	std. error	d_embi	d_er	d_selic
1	1.0451	100.0000	0.0000	0.0000
2	1.24618	85.0051	14.9859	0.0090
3	1.33628	77.9882	22.0002	0.0117
4	1.37377	75.2431	24.7448	0.0121
5	1.389	74.1707	25.8171	0.0121
6	1.39514	73.7472	26.2407	0.0121
7	1.39762	73.5787	26.4093	0.0121
8	1.39862	73.5114	26.4765	0.0120
9	1.39902	73.4846	26.5034	0.0120
10	1.39918	73.4738	26.5141	0.0120
11	1.39924	73.4695	26.5184	0.0120
12	1.39927	73.4678	26.5201	0.0120

Table A3.6 - Decomposition of variance for d_er

period	std. error	d_embi	d_er	d_selic
1	0.118817	52.2193	47.7807	0.0000
2	0.123092	54.7316	45.2506	0.0179
3	0.125436	54.1112	45.8622	0.0265
4	0.126575	53.6194	46.3513	0.0292
5	0.127067	53.3930	46.5770	0.0300
6	0.127271	53.2989	46.6709	0.0302
7	0.127355	53.2608	46.7090	0.0302
8	0.127389	53.2456	46.7242	0.0302
9	0.127402	53.2394	46.7304	0.0302
10	0.127408	53.2370	46.7328	0.0302
11	0.12741	53.2360	46.7338	0.0302
12	0.127411	53.2356	46.7342	0.0302

Table A3.7 - Decomposition of variance for d_selic

period	std. error	d_embi	d_er	d_selic
1	0.390649	2.2502	8.0937	89.6561
2	0.532263	1.8688	33.8274	64.3037
3	0.596927	1.4924	43.2954	55.2122
4	0.625552	1.4139	47.1316	51.4545
5	0.638256	1.4588	48.7574	49.7837
6	0.643902	1.5222	49.4531	49.0247
7	0.646402	1.5701	49.7495	48.6805
8	0.6475	1.5993	49.8745	48.5261
9	0.647978	1.6153	49.9268	48.4579
10	0.648184	1.6235	49.9485	48.4281
11	0.648272	1.6274	49.9574	48.4152
12	0.648309	1.6293	49.9610	48.4097

2003:04 - 2012:06

Table A3.8 - Decomposition of variance for d_embi (2003:04 - 2012:06)

period	std. error	d_embi	d_er	d_selic
1	0.383336	100.0000	0.0000	0.0000
2	0.413976	98.5206	0.9950	0.4844
3	0.419991	97.1679	1.5225	1.3096
4	0.422469	96.1728	1.7325	2.0947
5	0.424038	95.4752	1.8223	2.7025
6	0.425116	94.9932	1.8684	3.1384
7	0.425862	94.6612	1.8959	3.4429
8	0.426378	94.4322	1.9139	3.6539
9	0.426736	94.2740	1.9261	3.7999
10	0.426984	94.1645	1.9345	3.9011
11	0.427157	94.0886	1.9403	3.9711
12	0.427276	94.0360	1.9443	4.0197

Table A3.9 - Decomposition of variance for d_er (2003:04 - 2012:06)

period	std. error	d_embi	d_er	d_selic
1	0.0717172	49.4235	50.5765	0.0000
2	0.0782349	56.6561	43.3020	0.0419
3	0.0793382	57.8264	42.1318	0.0419
4	0.0795151	57.9357	41.9944	0.0699
5	0.0795562	57.9154	41.9735	0.1110
6	0.0795761	57.8902	41.9617	0.1481
7	0.0795893	57.8714	41.9521	0.1765
8	0.0795983	57.8583	41.9450	0.1968
9	0.0796046	57.8492	41.9398	0.2110
10	0.079609	57.8428	41.9363	0.2209
11	0.079612	57.8385	41.9338	0.2278
12	0.0796141	57.8354	41.9320	0.2325

Table A3.10 - Decomposition of variance for d_selic (2003:04 - 2012:06)

period	std. error	d_embi	d_er	d_selic
1	0.258934	2.0310	5.0068	92.9621
2	0.338992	1.6016	6.4925	91.9059
3	0.385516	1.3260	7.1511	91.5229
4	0.414932	1.1681	7.4591	91.3728
5	0.434229	1.0754	7.6183	91.3063
6	0.447149	1.0186	7.7090	91.2724
7	0.455907	0.9825	7.7645	91.2529
8	0.461891	0.9590	7.8002	91.2408
9	0.466001	0.9434	7.8238	91.2328
10	0.468834	0.9328	7.8397	91.2275
11	0.470791	0.9257	7.8505	91.2239
12	0.472145	0.9207	7.8579	91.2214

APPENDIX 4: ALTERNATIVE CHOLESKY ORDERING AND FORECAST ERRORS VARIANCE DECOMPOSITION (MODEL 1)

Table A4.1 provides the forecast error variance decomposition for model 1. Each 3x3 matrix contains the variance decomposition for one of the six possible Cholesky orderings in the twelfth month. The rows of each matrix represent the explanatory variable. The columns contain the variables whose forecast error is explained. Highlighted values are the portion of d_selic variance explained by d_er (red) and the portion of d_er variance explained by d_selic (yellow).

Table A4.1 - Alternative Cholesky ordering and forecast errors variance decomposition

	1999:07 a 2003:03				2003:04 - 2012:06		
ER-Embi-Selic	d_er	d_selic	d_embi	**ER-Embi-Selic**	d_er	d_selic	d_embi
d_er	88,4842	27,5811	29,9039	d_er	41,9320	7,8579	1,9443
d_selic	0,0302	48,4097	0,120	d_selic	0,2325	91,2214	4,0197
d_embi	11,4856	24,0092	70,0841	d_embi	57,8354	0,9207	94,0360
Embi-ER-Selic	d_er	d_selic	d_embi	**Embi-ER-Selic**	d_er	d_selic	d_embi
d_er	46,7342	49,9610	26,5201	d_er	93,2852	2,2225	43,0168
d_selic	0,0302	48,4097	0,120	d_selic	0,2325	91,2214	4,0197
d_embi	53,2356	24,0092	73,4678	d_embi	6,4822	6,5561	52,9635
Embi-Selic-ER	d_er	d_selic	d_embi	**Embi-Selic-ER**	d_er	d_selic	d_embi
d_er	42,6754	68,3217	24,0208	d_er	39,6697	0,4333	0,9809
d_selic	4,0890	30,0490	2,5114	d_selic	2,4949	98,6459	4,9831
d_embi	53,2356	1,6293	73,4678	d_embi	57,8354	0,9207	94,0360
Selic-Embi-ER	d_er	d_selic	d_embi	**Selic-Embi-ER**	d_er	d_selic	d_embi
d_er	42,6754	30,0490	24,0208	d_er	39,6697	0,4333	0,9809
d_selic	8,3362	69,0214	2,1726	d_selic	0,6926	99,0281	8,1387
d_embi	48,9884	0,9296	73,8066	d_embi	59,6378	0,5386	90,8804
ER-Selic-Embi	d_er	d_selic	d_embi	**ER-Selic-Embi**	d_er	d_selic	d_embi
d_er	88,4842	27,5811	29,9039	d_er	93,2852	2,2225	43,0168
d_selic	0,2850	52,6363	0,9664	d_selic	0,5598	97,7562	9,5376
d_embi	11,2308	19,7826	69,1297	d_embi	6,1550	0,0212	47,4456
Selic-ER-Embi	d_er	d_selic	d_embi	**Selic-ER-Embi**	d_er	d_selic	d_embi
d_er	80,4330	11,9600	28,6977	d_er	93,1524	0,9507	44,4157
d_selic	8,3362	69,0214	2,1726	d_selic	0,6926	99,0281	8,1387
d_embi	11,2308	19,7826	69,1297	d_embi	6,1550	0,0212	47,4456

APPENDIX 5: LAG SELECTION (MODEL 2)

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

1999:07 - 2003:03

lags	loglik	p(LR)	AIC	BIC	HQC
1	113.49193		-5.204714*	-4.692849*	-5.021062*
2	118.57887	0.33659	-5.004045	-4.108281	-4.682652
3	125.72089	0.11257	-4.908763	-3.629101	-4.449631
4	134.67417	0.03627	-4.906368	-3.242806	-4.309496
5	141.53670	0.13245	-4.796754	-2.749293	-4.062143

2003:04 - 2012:06

lags	loglik	p(LR)	AIC	BIC	HQC
1	380.97365		-6.648174*	-6.355252*	-6.529344*
2	385.44288	0.44297	-6.566538	-6.053924	-6.358586
3	394.74541	0.02877	-6.571989	-5.839684	-6.274915
4	399.94613	0.31897	-6.503534	-5.551537	-6.117337
5	411.67642	0.00524	-6.552728	-5.381040	-6.077409

APPENDIX 6: MODEL 2 SUMMARY AND TESTS

A6.1 - Model Summary

Table A6.1 - Model 2 Summary

(1999:07 - 2003:03)				2003:04 - 2012:06			
	gap	**d_er**	**d_ipca**		**gap**	**d_er**	**d_ipca**
Constant	0.00213394 (0.00254314)	0.0375367 (0.0225329)	-0.0347771 (0.0840189)	Constant	-0.000742256 (0.00179940)	-0.0107326 (0.00710722)	-0.0266000 (0.0367062)
gap(-1)	0.668299 (0.108045)***	0.388224 (0.957314)	4.42010 (3.56955)	gap(-1)	0.871803 (0.0486157)	0..524785 (0.192021)***	0.587849 (0.991717)
d_er(-1)	0.0155935 (0.0185983)	0.134838 (0.164786)	1.82741 (0.614440)***	d_er(-1)	-0.0605337 (0.0215874)***	0.340501 (0.0852653)***	0.862659 (0.440364)*
d_ipca(-1)	-0.00729360 (0.00310440)**	-0.302524 (0.0275059)	0.755239 (0.102561)***	d_ipca(-1)	0.00237096 (0.00351999)	-0.0353710 (0.0139032)**	0.669676 (0.0718046)***
Statistics				**Statistics**			
	gap	**d_er**	**d_ipca**		**gap**	**d_er**	**d_ipca**
Observations	43	43	43	**Observations**	111	111	111
R-squared	0.573363	0.066655	0.598843	**R-squared**	0.765742	0.235927	0.475353
Adj. R-squared	0.540545	-0.005141	0.567985	**Adj. R-squared**	0.759174	0.214505	0.460644
SSR	0.008251	0.647753	9.005910	**SSR**	0.035635	0.555938	14.82875
F(3,39)	17.47089	0.928398	19.40627	**F(3,107)**	116.5873	11.01300	32.31559
p-value F	2.39E-07	0.436163	7.34E-08	**p-value F**	1.39E-033	2.32E-06	5.96E-15

A6.2 - Tests

Table A6.2 - Tests for Model 2 (1999:07-2003:03)

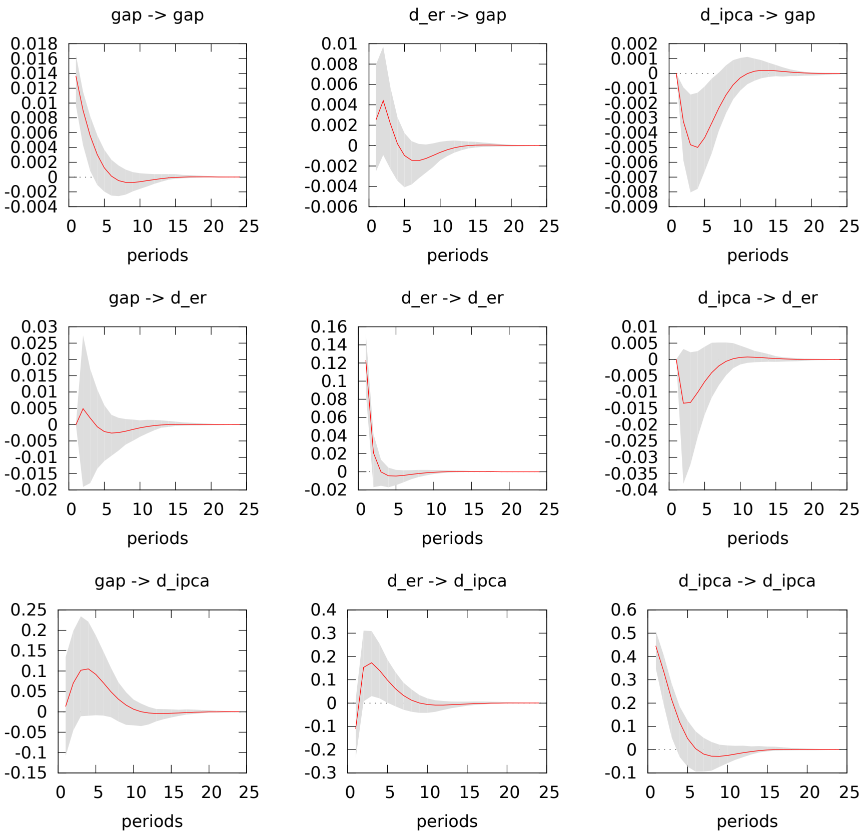
Autocorrelation Test (Ljung-Box)			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No residual autocorrelation		
Alternative Hypothesis	Residual autocorrelation		
Test Statistic	Q'= 9.40357	Q'= 16.6238	Q'=15.4023
P-value	0,668	0,164	0,22
Normality Test (Doornik-Hansen)			
Null Hypothesis	Residuals are normally distributted		
Alternative Hypothesis	Residuals are not normally distributed		
Test Statistic	14.1674		
P-value	0.0278		
ARCH Test			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No ARCH effect is present		
Alternative Hypothesis	ARCH effect is present		
Test Statistic	LM=11.096	LM=28.9281	LM=4.31121
P-value	0.520713	0.00403798	0.977144

Table A6.3 - Tests for Model 2 (2003:04-2012:06)

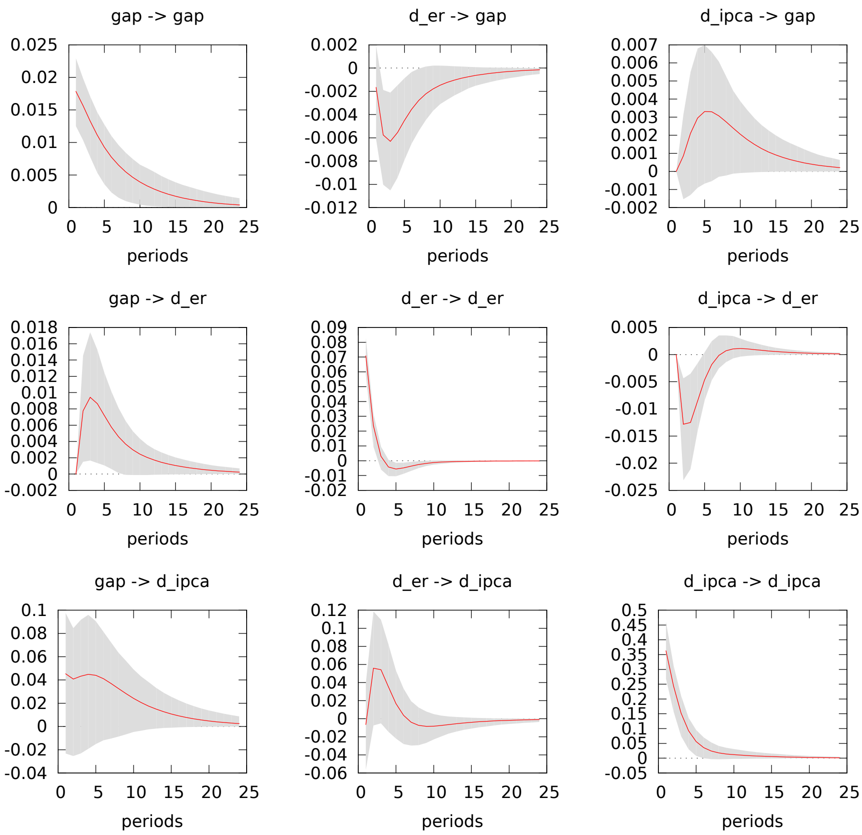
Autocorrelation Test (Ljung-Box)			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No residual autocorrelation		
Alternative Hypothesis	Serial autocorrelation		
Test Statistic	Q'=5.71017	Q'= 11.8389	Q'= 37.1254
P-value	0,93	0,459	0,000213
Normality Test (Doornik-Hansen)			
Null Hypothesis	Residuals are normally distributted		
Alternative Hypothesis	Residuals are not normally distributed		
Test Statistic	107.388		
P-value	0,0000		
ARCH Test			
	Equation 1	**Equation 2**	**Equation 3**
Null Hypothesis	No ARCH effect		
Alternative Hypothesis	ARCH effect		
Test Statistic	LM =4.07473	LM = 5.2578	LM=55.2771
P-value	0.98205	0.948809	1.61424E-07

A6.3 - Impulse Response Functions

Graph A6.1 - Model 2 Impulse Response Functions (1999:07 - 2003:03)



Graph A6.2 - Model 2 Impulse Response Functions (2003:04 - 2012:06)



A6.4 - Forecast Error Variance Decomposition

1999:07 - 2003:03

Table A6.3 - Decomposition of variance for gap (1999:07 - 2003:03)

period	std. error	gap	d_er	d_ipca
1	0.0138523	96.6287	3.3713	0.0000
2	0.0174019	87.9740	8.5599	3.4662
3	0.0190212	82.2238	8.4498	9.3265
4	0.0198959	77.4472	7.7310	14.8218
5	0.0204253	73.8499	7.5622	18.5879
6	0.0207498	71.5621	7.8112	20.6267
7	0.0209382	70.3313	8.1672	21.5015
8	0.021039	69.7742	8.4534	21.7724
9	0.0210884	69.5687	8.6265	21.8048
10	0.0211107	69.5115	8.7092	21.7793
11	0.0211203	69.5010	8.7395	21.7595
12	0.0211246	69.4982	8.7464	21.7553

Table A6.4 - Decomposition of variance for d_er (1999:07 - 2003:03)

period	std. error	gap	d_er	d_ipca
1	0.122736	0.0000	100.0000	0.0000
2	0.12531	0.1510	98.6990	1.1500
3	0.126022	0.1748	97.5879	2.2373
4	0.126508	0.1761	96.9609	2.8630
5	0.126799	0.2029	96.6571	3.1401
6	0.126953	0.2436	96.5226	3.2338
7	0.127026	0.2804	96.4655	3.2542
8	0.127059	0.3052	96.4401	3.2547
9	0.127073	0.3186	96.4271	3.2543
10	0.127079	0.3245	96.4193	3.2562
11	0.127082	0.3265	96.4142	3.2592
12	0.127085	0.3270	96.4111	3.2619

Table A6.5 - Decomposition of variance for d_ipca (1999:07 - 2003:03)

period	std. error	gap	d_er	d_ipca
1	0.457646	0.0910	5.6991	94.2100
2	0.591933	1.4774	10.0891	88.4335
3	0.66089	3.5674	14.9575	81.4751
4	0.693601	5.5464	17.6601	76.7935
5	0.708129	6.9983	18.8788	74.1229
6	0.714322	7.8618	19.2917	72.8465
7	0.717026	8.2765	19.3543	72.3692
8	0.718357	8.4287	19.3142	72.2571
9	0.719126	8.4625	19.2729	72.2645
10	0.71961	8.4591	19.2541	72.2868
11	0.719912	8.4520	19.2520	72.2960
12	0.720088	8.4496	19.2567	72.2937

2003:04 - 2012:06

Table A6.6 - Decomposition of variance for gap (2003:04 - 2012:06)

period	std. error	gap	d_er	d_ipca
1	0.0179176	99.1321	0.8679	0.0000
2	0.0244978	93.8925	5.9844	0.1232
3	0.0286472	90.1506	9.2209	0.6285
4	0.031362	87.7658	10.8248	1.4094
5	0.0331761	86.2335	11.5129	2.2535
6	0.0344113	85.2249	11.7626	3.0125
7	0.0352653	84.5496	11.8247	3.6257
8	0.0358627	84.0927	11.8168	4.0905
9	0.0362844	83.7813	11.7888	4.4299
10	0.036584	83.5674	11.7597	4.6728
11	0.0367979	83.4192	11.7356	4.8452
12	0.0369512	83.3156	11.7171	4.9673

Table A6.7 - Decomposition of variance for d_er (2003:04 - 2012:06)

period	std. error	gap	d_er	d_ipca
1	0.0707704	0.0000	100.0000	0.0000
2	0.0760457	1.0415	96.1136	2.8450
3	0.077698	2.4667	92.2173	5.3160
4	0.0787546	3.6063	90.0451	6.3485
5	0.0794137	4.3657	89.0521	6.5823
6	0.0797905	4.8444	88.5831	6.5725
7	0.0800044	5.1448	88.3174	6.5378
8	0.0801323	5.3369	88.1385	6.5247
9	0.0802139	5.4631	88.0085	6.5284
10	0.0802686	5.5485	87.9129	6.5386
11	0.0803064	5.6078	87.8431	6.5491
12	0.0803329	5.6496	87.7926	6.5578

Table A6.8 - Decomposition of variance for d_ipca (2003:04 - 2012:06)

period	std. error	gap	d_er	d_ipca
1	0.365503	1.5342	0.0304	98.4354
2	0.444236	1.8823	1.5985	96.5192
3	0.474635	2.4783	2.7049	94.8168
4	0.486874	3.2049	3.0926	93.7024
5	0.49236	3.9341	3.1387	92.9272
6	0.495369	4.5762	3.1062	92.3176
7	0.497357	5.0953	3.0873	91.8175
8	0.498798	5.4928	3.0910	91.4162
9	0.499867	5.7877	3.1062	91.1061
10	0.500659	6.0025	3.1235	90.8740
11	0.501239	6.1577	3.1384	90.7039
12	0.501663	6.2693	3.1499	90.5808