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**Working Paper**

## Can Sterilized FX Purchases under Inflation Targeting be Expansionary?

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TEXTO PARA DISCUSSÃO

No. 589

Can Sterilized FX Purchases  
under Inflation Targeting Be  
Expansionary?

Márcio G. P. Garcia





## Can Sterilized FX Purchases under Inflation Targeting Be Expansionary?

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### Abstract:

Contrary to conventional wisdom, sterilized FX purchases under inflation targeting, i.e., those that keep the interest rate at the level targeted by the central bank, generally increase aggregate demand. We develop a simple model with a credit channel to argue that FX purchases, by funding bank credit, end up increasing aggregate and money demand, while expanding loans and deposits, and reducing the loan interest rate. Therefore, restoring the interest rate to the level prior to the FX purchase is not sufficient to prevent an expansionary effect; the new money market equilibrium, at the same interest rate, will entail a larger money supply, higher output and greater money demand. Recent Brazilian evidence is reviewed, showing that this effect may be empirically relevant. If this is the case, inflation targeters may have another reason to be concerned when conducting FX sterilized interventions, besides their high cost and controversial effectiveness in preventing nominal appreciation. Even if FX sterilized purchases are effective in preventing nominal appreciation, they generally boost activity and inflation, thereby appreciating the real exchange rate.

JEL Codes: F3, F4, E5

Keywords: Sterilized Interventions, Capital Flows, and Inflation Targeting

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## 1. Introduction

Given the current period of abundant liquidity in international financial markets, together with the good prospects of many emerging markets, capital has been flowing in large amounts to these economies.

Several emerging markets, like Brazil, have been conducting monetary policy in an inflation targeting framework. Although this framework prescribes a free floating exchange rate, the exchange rate appreciation caused by capital inflows is increasingly being seen as extremely detrimental to long term growth. The specter of Dutch disease has often been invoked. Therefore, several forms of intervention in exchange rate markets without violating the open economy inconsistent trinity have been attempted. The main ones are controls on capital inflows and foreign exchange (FX) sterilized purchases.

In a country with extremely high interest rates, as is the case of Brazil, the foreign exchange (FX) reserves purchased through sterilized interventions are very expensive, thereby generating high fiscal costs.<sup>3</sup> The theoretical and econometric evidence as to the effectiveness of sterilized purchases of FX in depreciating the home currency is also very mixed.<sup>4</sup> Nevertheless, sterilized interventions have been conducted in Brazil for a considerable period of time, generating a very large volume of foreign reserves (around USD 350 bi, or over 15% of GDP).

Despite its flaws, sterilized purchases of FX are widely believed to have **no** effects on economic activity. To illustrate this point, imagine an open economy with unemployment at NAIRU, GDP growth at the normal rate, the real interest rate at the neutral rate and the inflation rate equal to the inflation rate target.

Suddenly, capital starts to flow into this economy because oil, for example, has been found or because risk aversion has decreased worldwide. The inflation-targeting-monetary-policy maker decides to fully sterilize the capital inflow. Under an inflation targeting regime, this means purchasing all the FX inflow with domestic currency, thereby lowering the nominal interest rate, while simultaneously conducting contractionary open market operations that restore the previous nominal interest rate.

Are such sterilized interventions under inflation targeting expansionary? Most economists, at least those I have interviewed, will answer in the negative. This paper argues that the answer is most likely to be positive.

Policy-makers in developing countries have recently been complaining about capital inflows' expansionary effect on credit aggregates. The Brazilian central bank, for example, considers that: "*... the fragility in some mature economies, combined with favorable perspectives for the Brazilian economy, has determined an inflow of foreign resources, part of*

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<sup>3</sup> According to Credit Suisse, "*... evaluating the sterilization cost, according to the main market indicators for the cost of rolling over debt, the fiscal cost of carrying the reserves would be approximately 1.4% of GDP per year from 2004 to 2010. In the 12-month period through June 2011, the cost of carrying the reserves would be 2.7% of GDP, nearly equivalent to the central government's primary surplus in the same period*" (Credit Suisse, 2011).

<sup>4</sup> Dominguez and Frenkel (1993) and Sarno and Taylor (2001).

*which has been going to the credit market. In this sense, the excess of external inflows may weak (sic) the credit channel, smooth its contribution to the aggregate demand moderation, as well as cause distortions in the price of domestic assets” (Central Bank of Brazil, 2011). The Chilean central bank warns: “... the main risks for financial stability associated with larger gross capital inflows include the generation of currency and maturity mismatches, credit booms that lead to a deterioration in loan quality, and local asset price misalignment” (Central Bank of Chile, 2011). The Turkish central bank admonishes: “... in emerging economies, short-term capital flows and rapid credit growth feed macro financial risks. ... . The major risk factor for emerging economies is the macroeconomic imbalances driven by rapid capital inflows. Central banks of emerging economies continued to implement macroprudential measures to contain the potential adverse effects of capital flows” (Central Bank of Turkey, 2011).*

All these central banks have adopted the inflation targeting regime. They also intervene in exchange rate markets through sterilized interventions. Therefore, if they are complaining about the expansionary effects of capital inflows on credit aggregates, sterilized interventions are not being effective in isolating the real economy from capital flows. However, current models<sup>5</sup> have no such expansionary effect.

In this paper, it will be shown that sterilized FX purchases, even if they are ineffective in depreciating the exchange rate, do not immunize the domestic economy from the expansionary effects of capital inflows, thereby justifying the policy-makers contentions. Policy-makers, however, may be displeased to learn that, in order to counteract the expansionary effect of sterilized FX purchases, contractionary policies (fiscal and/or monetary) must be conducted. The idea that, by lowering interest rates, less capital will flow into the country, thereby mitigating the expansionary effects of capital inflows is false. This is because the capital inflows attracted to profit from high domestic government bond yields are not the ones that generate the expansionary effect. The expansionary effect is generated by capital that enters the country to finance aggregate demand expansion.

The next section reviews a simple model *à la* IS-LM with a banking sector that introduces a new asset, credit.<sup>6</sup> In Section 3, the model is extended to account for sterilized interventions. The model shows that sterilized interventions under inflation targeting will, in general, be expansionary. This result follows from two key features of the model: the existence of two interest rates, the bond interest rate and the loan rate, as well as a portfolio effect, which

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<sup>5</sup> Signaling models could provide a rationale for sterilized FX purchases being expansionary. According to the signaling mechanism, those sterilized interventions would be a way for the Central Bank to signal future reductions in interest rates. As Obstfeld and Rogoff (1996) recognize, “... *there certainly seem to have been episodes in which sterilized interventions, when concerted among large groups of countries, have clarified governments’ views on exchange rates and shifted market opinion...*” about macroeconomic policies. However, the inflation-targeting (IT) framework has many channels through which the central bank may communicate its intentions to markets: monetary policy committee (MPC) minutes, inflation reports, etc. In fact, increased transparency and accountability are believed to be key improvements of IT over previous monetary policy regimes (Mishkin, 2000). It is very unlikely that any central bank that adopts IT would resort to sterilized interventions to signal a change in monetary policy. Furthermore, it will be shown that, in Brazil, after the increase in sterilized purchases, the basic interest rate was raised, not lowered, as well as the other contractionary monetary quantitative measures (e.g., increases in reserve requirements) taken.

<sup>6</sup> Bernanke and Blinder (1988).

makes the banks increase loans, and reduce the loan rate, when their liabilities grow due to the capital inflows. Section 4 develops elaborates on the model to conclude that FX inflows, and therefore capital inflows, are not homogeneous as to their effects in the credit market. This distinction is key to appreciating why lowering interest rates in times of high capital inflows, with the aim of deterring these inflows, as Turkey did in 2010, may be ineffective and fuel the credit market even more. Section 5 presents empirical evidence from Brazil supporting the view that sterilized interventions under inflation targeting are expansionary. Finally, section 6 concludes with a discussion of the policy implications of the expansionary effects of sterilized interventions under inflation targeting.

## 2. A Simple IS-LM Model with Two Assets

To illustrate how sterilized FX purchases under inflation targeting may be expansionary, we resort to a simple IS-LM model with two assets, akin to the one developed by Bernanke and Blinder (1988), henceforth referred to as the BB model.

In models inspired by the traditional IS-LM model, “... *loans and other forms of customer-market credit are viewed as perfect substitutes for auction-market credit (“bonds”)*”<sup>7</sup>. In the BB model, a third asset, loans, is added to money and bonds.

Borrowers and lenders observe the relevant interest rates ( $i$  on bonds, and  $\rho$  on loans) and decide how to allocate their wealth. The demand for loans is, therefore, represented by equation (1), where  $y$  (GNP) “... captures the transaction's demand for credit”<sup>8</sup>:

$$L^d = L(\underset{-}{\rho}, \underset{+}{i}, \underset{+}{y}) \quad (1)$$

Loans supply is performed through the banking sector. To understand how it works, Figure 1 displays the simplified balance sheet of the representative bank, which is analogous to balance sheet of the entire banking sector.

Figure 1: The Simplified Balance Sheet of a Representative Bank

Bank Balance Sheet	
Assets	Liabilities
R (bank reserves)	D (deposits)
$B^b$ (bonds)	
$L^s$ (loan supply)	

Bank's assets are bank reserves ( $R$ ), bonds ( $B^b$ ), and loans ( $L^s$ ). Bank's liabilities are deposits ( $D$ ). Bank reserves ( $R$ ) are composed of required reserves ( $\tau.D$ ) plus excess reserves ( $E$ ). Therefore, from the bank's balance sheet:

$$B^b + L^s + E = D(1 - \tau) \quad (2)$$

The portfolio shares of bonds ( $\beta$ ), loans ( $\lambda$ ) and excess reserves ( $\epsilon$ ),  $\beta + \lambda + \epsilon = 1$ , are determined according to returns (zero for excess reserves):

$$L^s = \lambda(\underset{+}{\rho}, \underset{-}{i})D(1 - \tau) \quad (3)$$

$$B^b = \beta(\underset{-}{\rho}, \underset{+}{i})D(1 - \tau) \quad (4)$$

<sup>7</sup> Bernanke and Blinder (1988), p. 435.

<sup>8</sup> Bernanke and Blinder (1988), p. 435.



$$E = \varepsilon(i)D(1 - \tau) \quad (5)$$

In this model, there is no paper currency. Money comprises only deposits ( $D$ ). Equilibrium in the money market is represented by a conventional LM curve in the  $y \times i$  space. Money supply ( $D$ , the model equivalent of M1) is given by the amount of reserves ( $R$ , the model equivalent to M0), under the control of the central bank, multiplied by the money multiplier ( $m$ ):

$$m(i) = 1/[\varepsilon(i)(1 - \tau) + \tau] \quad (6)$$

Money demand ( $D$ ) is quite conventional, depending on the interest rate and income (total wealth is assumed constant and *ipso facto* eliminated). Therefore, equilibrium in the money market is represented by the following LM curve, sloping upwards in the  $y \times i$  plane:

$$D(i, y) = m(i)R \quad (7)$$

Having determined the money market equilibrium, we turn to equilibrium determination in the remaining markets: loans, bonds and goods. The equilibrium in the **loans market** is given by equation (8):

$$L(\rho, i, y) = \lambda(\rho, i)D(1 - \tau) \quad (8)$$

Given loan demand,  $L(\rho, i, y)$ , and money demand,  $D(i, y)$ , the nonbank public's **demand for bonds** is implicitly defined because total financial wealth is supposed constant. Finally, let's turn to the **goods market** equilibrium. It is summarized by an IS curve where the loan rate,  $\rho$ , also enters:

$$y = Y(i, \rho) \quad (9)$$

The key novelty of the BB model is precisely that  $\rho$  affects the IS curve. Since, by the equilibrium in the loan market (equation (8)),  $\rho$  depends on  $D$ , which, in turn, by the equilibrium in the money market (equation (7)), depends on  $R$ , monetary policy, i.e. the amount of bank reserves ( $R$ ), will also directly influence the goods market equilibrium .

The graphical representation is undertaken in the same familiar  $y \times i$  plane, although a tridimensional  $y \times i \times r$  representation could also be used. To represent the model in the  $y \times i$  plane, we start by replacing  $D$  in the loans market equilibrium (equation (8)) by money supply,  $m(i)R$ , yielding:

$$L = (\rho, i, y) = \lambda(\rho, i)m(i)R(1 - \tau)$$

Then, the resulting equation can be solved to yield  $\rho$  as a function of the other variables:  $i$ ,  $y$ ,  $R$  and  $\tau$ :

$$\rho = \emptyset(i, y, R, \tau) \quad (10)$$

In (10), the derivative of  $\rho$  with respect to  $i$  is usually positive, because when  $i$  increases, banks tend to allocate more of their free deposits to bonds, thereby lowering the amount of

loans. Given a downward sloped demand curve for loans, this will increase  $\rho$ . This effect is akin to the substitution effect in consumer theory.

However, there is another effect, akin to the income effect. When  $i$  increases, the money multiplier also increases, yielding more deposits from the same amount of bank reserves,  $R$ . If this “income” effect is very strong, it may overcome the former “substitution” effect, and make  $\rho$  a negative function of  $i$ .

Substituting the  $\rho$ , given by (10), into the goods market equilibrium condition (9), we get the new IS, which is baptized in BB as the CC (“commodities and credit”) curve, in honor of the late Don Patinkin.

$$y = Y\{i, [\underbrace{\emptyset}_{-}(i, \underbrace{y}_{-}, \underbrace{R}_{+}, \underbrace{\tau}_{+})]\} \quad (11)$$

The CC curve is also downward sloping in the  $y \times i$  plane, for the same reasons as the typical IS curve. However, it now responds to shifts in  $R$ , as well as to shocks in the loan market, affecting either the supply or the demand side. In the next section, this model will be adapted so that it can account for sterilized interventions. It will then be used to evaluate the effects of sterilized interventions under inflation targeting.

### 3. Effects of Sterilized Interventions

The BB model represents a closed economy, while the subject of this paper, sterilized interventions, naturally suggests an open economy model. However, the introduction of a full blown open economy model would distract us from the main goal of the paper: to show that sterilized interventions (FX purchases) are generally expansionary even when they do not affect (depreciate) the exchange rate. As already mentioned (see references in footnote 4), both the theoretical and empirical evidences regarding the effectiveness of sterilized interventions in affecting the nominal exchange rate are dubious. Of course, if sterilized FX purchases depreciate the domestic currency, they would be, in most models, expansionary. But what we aim to show here is another effect of sterilized interventions; even if FX sterilized purchases do not depreciate the nominal exchange rate, they tend to be expansionary. The expansionary effect studied in this paper is additional to the one derived from the possible depreciation caused by sterilized FX purchases.

With that caveat in mind, we will proceed with minor adaptations of the BB model, without explicitly introducing a foreign country or an exchange rate. The implicit assumption will be that sterilized interventions will not affect the level of the floating exchange rate. As previously noted, if they do, the expansionary effect of FX sterilized purchases would be even stronger.

Sterilized interventions are usually defined as purchases or sales of FX that do not affect the monetary base ( $R$ ). However, in the inflation targeting framework, or any other monetary policy framework in which the instrument is the interest rate ( $i$ ) instead of a monetary aggregate, the term sterilized interventions usually refers to FX transactions that do not alter the interest rate that prevailed before the sterilized intervention ( $i^*$ ).

Often, it is implicitly assumed that both definitions are equivalent, but it will be shown that this is not the general case in models with a richer asset choice than the usual IS-LM one between bonds and money.

Let us examine the mechanics of a sterilized FX purchase. For that, banks will be allowed to have an alternative source of funding, foreign loans ( $FL$ ), already denominated in domestic currency units. For simplicity, these bank liabilities will not be subject to reserve requirements.

In order to account for foreign loans, equations (2), (3), (4), (5), (8), (10) and (11) of the original model have to be modified in the following way.

$$B^b + L^s + E = D(1 - \tau) + FL \quad (2')$$

$$L^s = \lambda(\rho, \underline{i})[D(1 - \tau) + FL] \quad (3')$$

$$B^b = \beta(\rho, \underline{i})[D(1 - \tau) + FL] \quad (4')$$

$$E = \varepsilon(\underline{i})[D(1 - \tau) + FL] \quad (5')$$

$$L(\rho, i, y) = \lambda(\rho, i)[D(1 - \tau) + FL] \quad (8')$$

$$L(\rho, i, y) = \lambda(\rho, i)[m(i)R(1 - \tau) + FL] \quad (8a')$$

$$\rho = \emptyset(i, y, R, \tau, FL) \quad (10')$$

+ + - + -

$$y = Y\{i, [\emptyset(i, y, R, \tau, FL)]\} \quad (11')$$

- - + + - + -

The interpretation of the expansionary effect of a sterilized FX purchase is the following. Assume that a FX inflow enters the economy as foreign loans to banks.  $FL$  is the equivalent amount of the foreign loans in domestic currency at the prevailing exchange rate, assumed to be unaltered by the sterilized purchase. As previously explained, if sterilized purchases were effective in depreciating the exchange rate, their expansionary effect would be even stronger.

First, the CB purchases all the foreign currency and issues domestic currency ( $R$ ). Second, the CB soaks up the newly issued domestic currency, exchanging it for government bonds. The resulting bank sector balance sheet is shown in Figure 2.

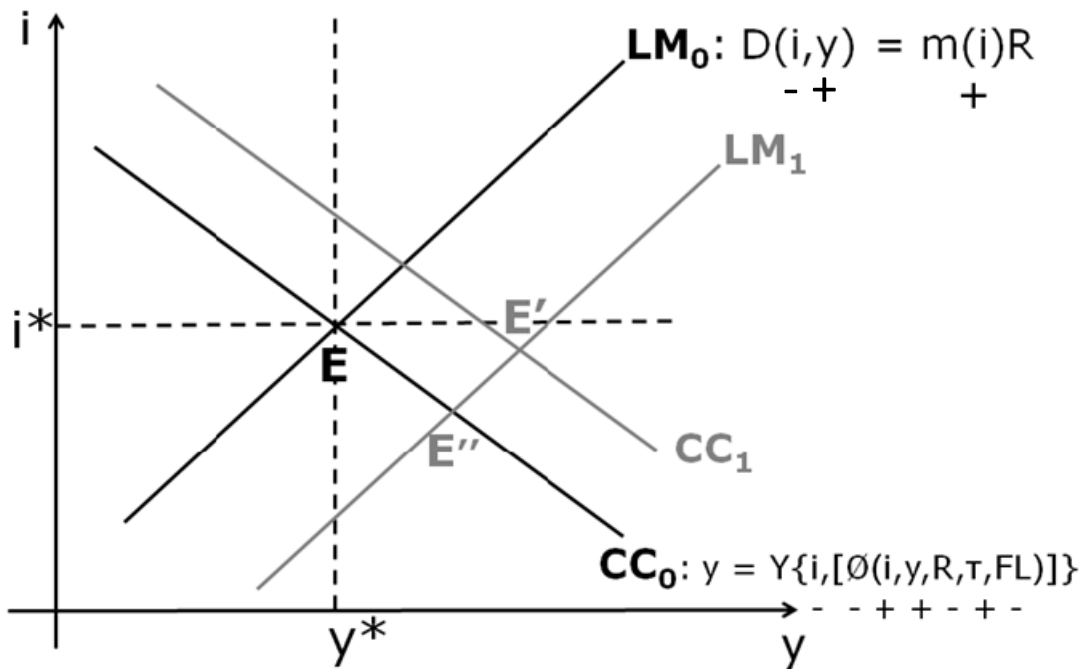
Figure 2: Representative Bank Balance Sheet After the Sterilized FX Purchase

Bank Balance Sheet	
Assets	Liabilities
R (bank reserves)	D (deposits)
$B^b + FL$ (bonds)	FL (foreign loans)
$L^s$ (loan supply)	

Remember that the sterilized FX purchase under inflation targeting is supposed to restore the interest rate to its previous level. Therefore, the asset allocation in Figure 2 cannot represent an equilibrium for the bank with the same rates  $i$  and  $\rho$  that prevailed before the sterilized FX purchase. To view this, compare Figure 2 with Figure 1. Figure 2 shows that the new bank liabilities,  $FL$ , were fully allocated to bonds. None was allocated to loans. For this to be an equilibrium for the bank, at the previous interest rate,  $i$ , the loan interest rate,  $\rho$ , must have fallen. And, with a fall in the loan interest rate,  $\rho$ , loan demand must have expanded. In equilibrium, loan supply would also expand, provoking an expansion in output.

In fact, the sequence of events is the following: In the first stage of the sterilized FX purchase, the CB purchases the foreign exchange and delivers the equivalent amount in domestic currency (at the prevailing exchange rate) to the bank. This money injection causes both  $i$  and  $\rho$  to fall, shifting both the LM and the CC curves to the right, with  $[E']$  being the new equilibrium, as shown in Chart 1. Given this displacement of the CC curve, the resulting interest rate is always higher than would be the case in the traditional IS-LM model ( $[E'']$ ), where the IS curve does not respond to changes in  $R$ .

Chart 1



As defined in most textbooks, a sterilized intervention would be completed by a contractionary open market operation that would fully offset the increase in  $R$ , bringing back the equilibrium to  $[E]$ . However, in the inflation targeting framework, what the CB has to do is to restore  $i$  to its previous level. Given the change in the CC curve, this is obtained with a smaller sale of bonds than would be the case in the IS-LM model.<sup>9</sup> Chart 2 displays the equilibrium ( $[E''']$ ) at the end of the sterilized FX purchase that restores the previous interest rate ( $i^*$ ). Note that  $LM_2$  remains to the right of the original  $LM_0$ , showing that not all money issues were removed by the sterilization procedure that restored the original interest rate.

The size of the contractionary open market operation needed to shift the interest rate ( $i$ ) back to the level determined by the MPC is always smaller than the amount necessary to bring  $R$  back to its previous level. One way to understand why is to note that, in the second stage of the sterilized FX purchase, the sterilization itself, what the CB does is to replace reserves by bonds in banks' assets. This operation contracts both the LM and the CC curves. However, given their larger liabilities, the banks, facing the same  $i$  as before the sterilized FX purchase, now provide more (and cheaper) loans, thereby expanding output. The final asset allocation for the bank will have higher loan supply, as well as higher bank reserves.

Another way to appreciate how the interest rate rule leads to this incomplete sterilization is the following. Imagine that, after the sterilized FX purchase is completed, the bank sector balance sheet looked like the one in Figure 2. As argued before, this cannot qualify as

<sup>9</sup> In fact, BB calls attention to the possibility that "... a rise in bank reserves might conceivably raise the rate of interest in the credit model" (Bernanke and Blinder (1988), p. 437). If this were the case, the central bank would have to conduct an expansionary open market operation to shift the interest rate ( $i$ ) back to the level determined by the MPC.

equilibrium with the same rates  $i$  and  $\rho$  that prevailed before the sterilized FX purchase. Therefore, banks will sell bonds to generate funds to make more loans. This portfolio adjustment tends to increase the interest rate and decrease the loan rate. As the inflation-targeting CB counteracts the interest rate increase with expansionary open market operations, the amount of bank reserves is increased.

This latter interpretation has the advantage of better conveying the timing of the expansionary effect in this static model. After all, sterilized interventions are financial procedures that are conducted in a matter of minutes. Therefore, it is not reasonable to assume that output would expand and contract in such a short period of time. However, this is not the correct interpretation of the timing behind this static model. As explained in the previous paragraph, once the sterilized FX purchase has been completed, and  $i$  is restored to its previous level, the bank is not in equilibrium (see Figure 2), and will substitute loans for bonds in its portfolio. As it does that, it pushes  $i$  up and  $\rho$  down. The inflation-targeting CB purchases the bonds and issues money to keep  $i$  at its target level, thereby monetizing the economy. All these events, that may take days or weeks, eventually bring the economy to its new equilibrium ( $E'''$ ) in Chart 2). In summary, the timing of the effect, displayed in Chart 2, has to do with the speed with which banks reallocate their portfolios from bonds to loans, not with the speed of the sterilized intervention itself.

Bank reserves increase because, as output increases, the previous rate of interest is restored at a higher level of money demand, which, in equilibrium, equals money supply. In other words, the higher money supply is needed, in equilibrium, because, with higher  $y$  and the same  $i$ , money demand increased after the sterilized FX purchase. That is, with a higher  $y$ , the CB does not have to mop up all the money it had previously issued to restore the interest rate,  $i$ . After the sterilized intervention,  $i$  is back to its previous level, but  $y$  is larger. This occurs because there is more and cheaper credit in the economy. Given the shift in CC, due to more and cheaper credit, to restore the initial level of output,  $y^*$ , the CB would have to raise  $i$  above the initial level  $i^*$ .

Even if the CB were to remove all the money used to purchase the FX inflow, a small expansionary effect would still occur. This may be seen in Chart 3. If the sterilization were to remove all money issued, the previous LM curve would be restored. This is why  $LM_3$  lies on top of  $LM_0$ . However, given increased bank liabilities, the portfolio effect makes the  $CC_3$  curve remain to the right of the original one,  $CC_0$ , before the FX inflow, with more and cheaper loans being provided. Therefore, output still expands when compared to its original level (compare the new equilibrium,  $E^{IV}$ , with the original one,  $E$ ).

Chart 2

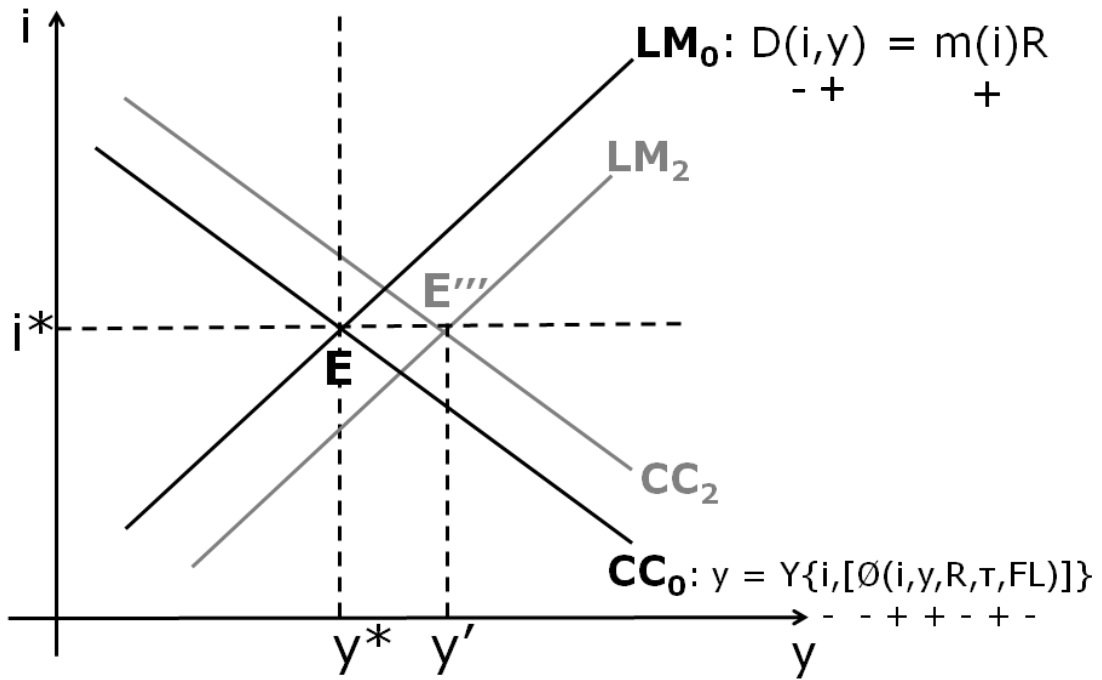
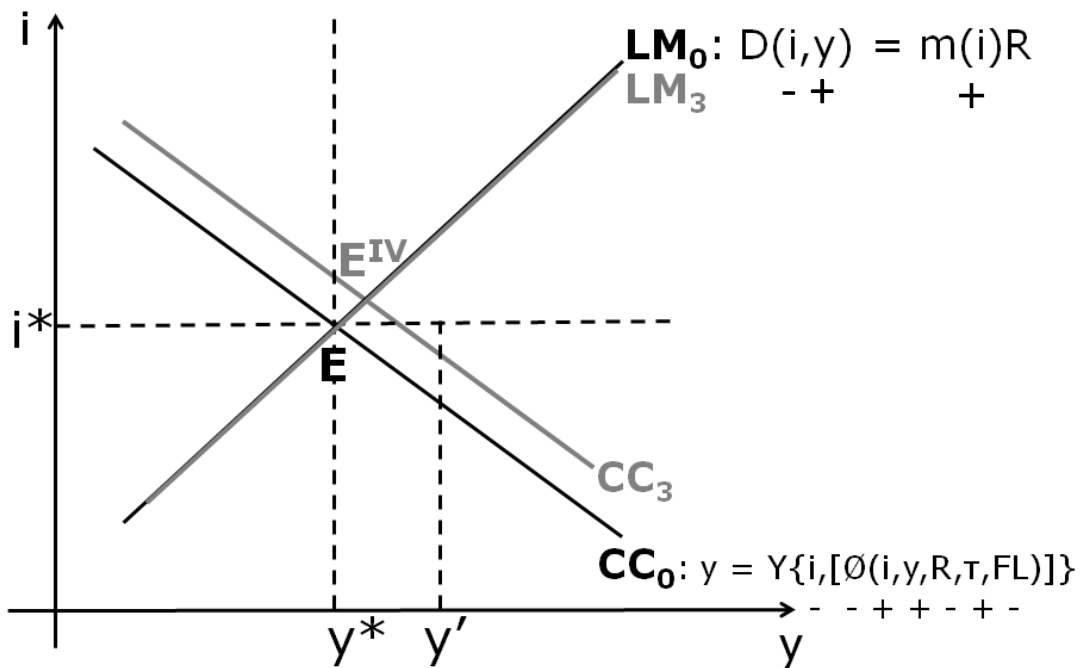


Chart 3



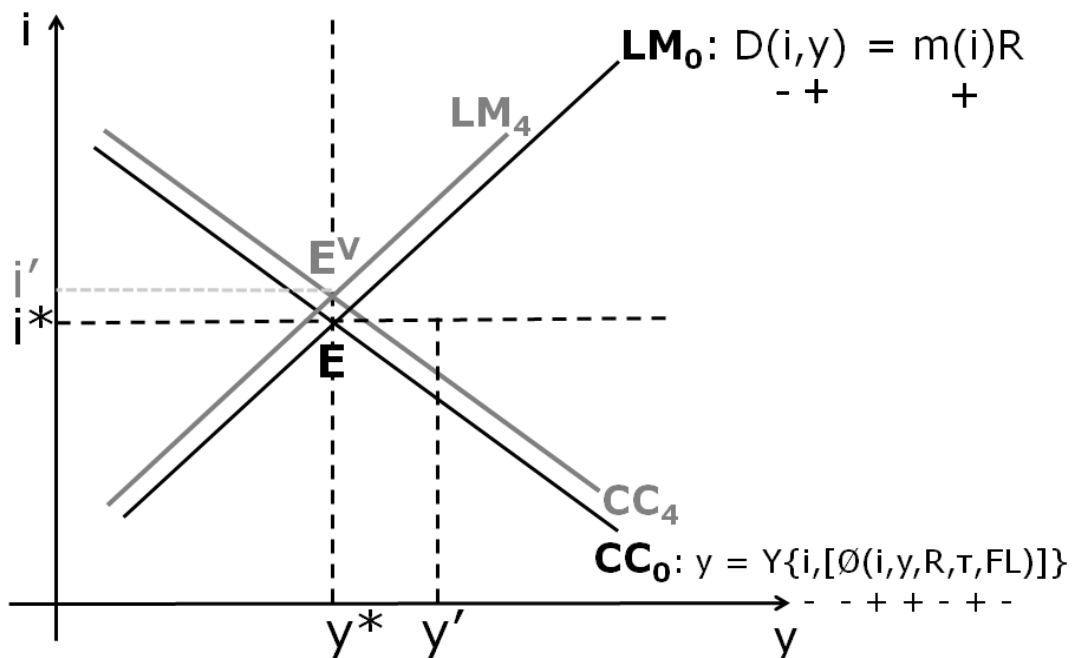
For the sake of thoroughness, it is useful to examine one last case, when the CB contracts monetary policy in order to eliminate any expansionary effect on output. As shown in Chart 3, because larger bank liabilities increase the amount of loans and decrease the loan rate, the CC

remains to the right of the original one when the original LM is restored. Therefore, in order to restore the original output level, it is necessary to over-sterilize, as displayed in Chart 4. Note that  $LM_4$  lies to the left of the original  $LM_0$ . The new equilibrium,  $E^V$ , has the original output restored. The interest rate is higher than the original one. It is also higher than the one that would have prevailed had the CB fully sterilized, in the textbook sense of mopping up all money issued.

In sum, with monetary policy being conducted via an interest rate rule, as is the case in the inflation targeting framework, sterilized FX purchases are expansionary. Even if the CB were to fully offset the money issuance, a residual expansionary effect would still occur, because of the portfolio effect on banks' balance sheets.

Of course, whether or not such effects are of practical importance is an empirical issue. In Section 5, empirical evidence will be provided in order to argue that this mechanism may have played an important role in propping up aggregate demand in Brazil. However, before we examine the empirical evidence, Section 4 develops the model in order to derive another important policy conclusion regarding policy measures to counteract the detrimental effects of capital inflows.

Chart 4





## 4. Different Types of Capital Inflows and Policy Measures

In the discussion regarding how to react to excessive capital inflows, it has been argued that receiving countries would do well to reduce interest rates, in order to attract less so-called hot money. In fact, the Central Bank of Turkey, on December 16, 2010, cut interest rates amid rising inflation and a low output gap. The deputy governor of the Central Bank of Turkey, Erdem Basci, argued that gradual rate cuts were the best way to prevent excessive capital inflows fuelling asset bubbles and currency appreciation.<sup>10</sup>

The model described in the previous section may be used to analyze whether or not such policy prescriptions are warranted. In order to do so, it is useful to differentiate two kinds of capital inflows: those destined to the direct purchase of domestic government bonds and the others. The latter category includes all kind of inflows that, one way or another, will fund increases in aggregate demand. Those flows will be absorbed by private firms and financial institutions or even public institutions (including government-owned banks). Those are the flows that were analyzed in Section 3's model. The inflows that enter the country to purchase government bonds do not have the expansionary effect described in this paper, since they neither generate an expansion in base money, nor the portfolio effect necessary to move the CC curve. A good example would be a special fund (SIV) set up exclusively to buy government bonds for foreign investors. These inflows represent an external source of demand for government bonds, thereby creating a downward pressure on interest rates (therefore increasing government bond prices). This could, indirectly, increase aggregate demand if the CB did not act to keep interest rates constant, but it does not create the expansionary effect through the expansion of bank liabilities.

Both kinds of inflows are associated with currency appreciation, but only the latter form cause credit to expand. And the capital inflows that fund bank credit are attracted by the high  $\rho$ , not the high  $i$ . Therefore, advocating reductions in interest rates to deal with an excessive capital inflow situation may help to deter only the capital flows that are attracted by the high interest rate differential of government bonds.

However, the lower interest rate will probably worsen the expansionary effects of the inflows that fund bank credit, because the lower interest rate will fuel aggregate demand, increase the loan rate, and help attract even more flows to fund credit. Remember that in this model, the decline in the interest rate is brought about by an increase in base money,  $R$ , which expands both the LM and the CC curves, leading to a larger expansion in output,  $y$ . The fall in  $i$  tends to reduce  $\rho$ , but the expansion on  $y$  will probably create a much stronger effect that will increase  $\rho$ , keeping capital flowing in. As shown in Chart 4, to eliminate the expansionary effect of sterilized FX purchases, in the absence of a fiscal contraction, it is necessary to increase interest rates, not reduce them.

Even if so-called macroprudential measures (increases in  $\tau$ , in the model) are deemed adequate for deterring credit expansion, the fall in interest rates will increase macroeconomic policy's reliance on them. Therefore, the move by the Central Bank of Turkey was unwarranted.

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<sup>10</sup> Financial Times (2010).

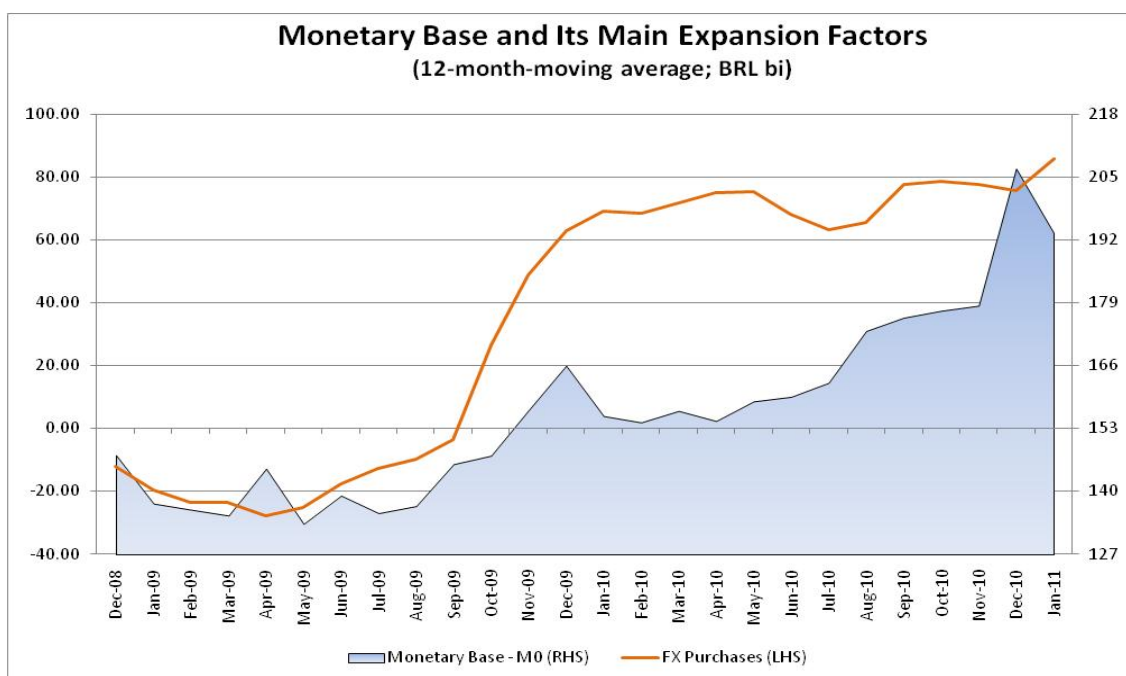
## 5. FX Sterilized Interventions in Brazil and Money

After the peak of the 2008 crisis, Brazil resumed sterilized FX purchases as early as February, 2009. Since then, foreign reserves have risen from USD 187 bi to USD 350 bi, surpassing 15% of GDP in October, 2011.

Chart 5 shows that the monetary base has also expanded rapidly. In 2010, it increased 25%, or BRL 40 bi, compared to an inflation rate of 6%. Real GDP expanded by 7.5%.

As shown in Chart 5, FX purchases (almost BRL 80 bi in 2010) were one of the main factors accounting for such a robust increase in money. Of course other CB operations affected the monetary base, and it is very hard to show causality, but, *prima facie*, it seems plausible that the story told by the previous model explains at least part of what has been happening in Brazil.

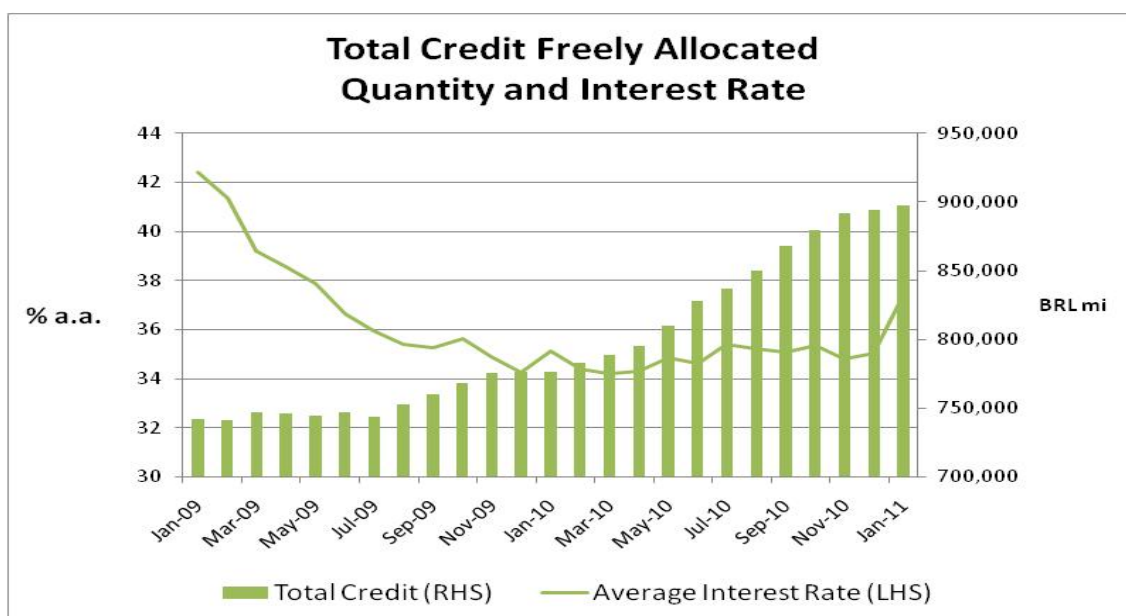
Chart 5



Source: Central Bank of Brazil

Another important piece of evidence that suggests that the story behind this model might be relevant is the behavior of credit markets in Brazil. Chart 6 makes it clear that, albeit very expensive, bank credit has been expanding in Brazil while the average credit interest rate has been declining. This is compatible with a supply of credit expansion larger than the increase in credit demand, precisely what the model presented here predicts would happen with massive sterilized interventions.

Chart 6



Source: Central Bank of Brazil

Furthermore, Chart 7 shows that the rate on loans to individuals follows the one-year-interbank rate almost perfectly, with a three-month lag.<sup>11</sup> This is quite reasonable, since the interbank rate is the best proxy for banks' cost of funding. However, since the beginning of 2010, this positive correlation seems to have broken down: while the interbank rate rose, the loan rate kept following it until November,<sup>12</sup> the month prior to the imposition of macroprudential measures to deter credit growth.<sup>13</sup> The interbank rate follows expectations regarding the interest rate set by the Central Bank, the Selic, equivalent to  $i$  in the model. The loan rate is the equivalent of the  $\rho$  in the model. The model asserts that, under massive sterilized FX purchases, a negative correlation, as observed in 2010, should be the outcome.

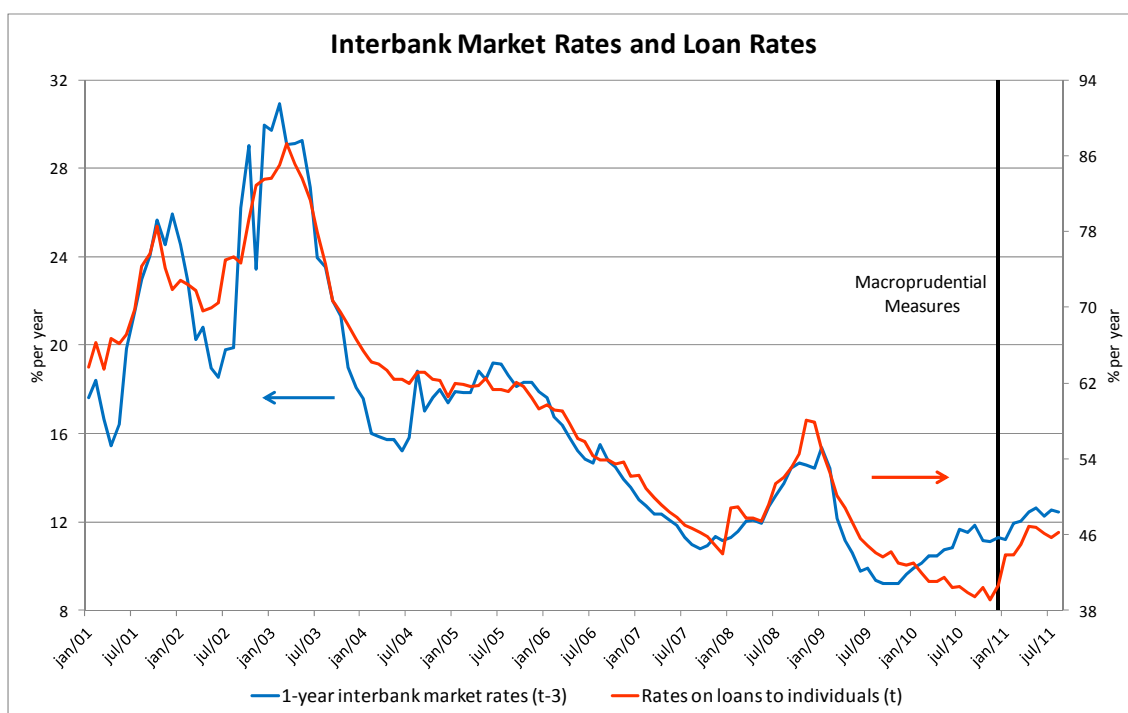
Econometrically, the best result is obtained when the loan rate to individuals is regressed against its marginal cost, the one-year-interbank rate, lagged three-months, together with FX purchases by the CB (12-month average) and a dummy for 2010 interacted with the FX purchases. Table 1 displays the results. FX purchases by the CB become statistically significant only when the 2010 dummy is included in the regression (interacted or not with FX purchases). These econometric results are compatible with the main lessons from the model: the resumption of FX purchases, after recovering from the 2008 crisis, kept the loan rate falling even when the interest rate was rising. That lasted until macroprudential measures were implemented in December, 2010. The Brazilian economy therefore performed as predicted by the model, with the increase in sterilized FX purchases in 2010 causing the loan rate to fall despite the increase in its marginal cost - the one-year-interbank interest rate.

<sup>11</sup> In Chart 4, the interbank rate is led three months.

<sup>12</sup> I wish to thank Eduardo Loyo for pointing this out to me.

<sup>13</sup> The effects of macroprudential measures may also be observed at the end of Chart 6, when credit volume stops growing and the average credit interest rate increases.

Chart 7



Source: Central Bank of Brazil

**TABLE 1: The Loan Rate and Sterilized Interventions**

Dependent Variable: Loan rate to individuals

Independent Variables: One-Year-Interbank rate, FX Purchases (12-month average) and FX Purchases (12-month average) multiplied by a Dummy for 2010

Sample: 2000:12-2011:08 (T = 129)

Variable	Coefficient	Stand. Error	t-Ratio	P-Value
Constant	30.0487	1.28187	23.44	1.39e-047 ***
One-Year-Interbank Rate (t-3)	1,85388	0,0655097	28,30	3.40e-056 ***
FX Purchases (12-month average)	-0,0392121	0,00620752	-6.317	4.27e-09 ***
FX Purchases (12-month average) multiplied by a Dummy for 2010	-0,0877712	0,0122744	-7,151	6,38e-011 ***

Mean dependent variable	58,14132	S.D. dependent var.	12,53158
Sum squared resid.	1055,908	S.E. of regression	2,906418
R-squared	0,947470	Adjusted R-squared	0,946210
F(3, 125)	751,5366	P-value(F)	9,26e-80
Log-likelihood	-318,6443	Akaike Criterion	645,2885
Schwarz Criterion	656,7278	Hannan-Quinn	649,9365
$\rho$	0,499275	Durbin-Watson	0,975744

In order to duly account for non-stationarity, endogeneity and autocorrelated errors, the econometric analysis was performed using the Phillips-Hansen (1990) procedure. Table 2 displays the results. The FX purchases make the loan rate fall relatively to its long term equilibrium with the interest rate. That effect is even more pronounced in 2010. Note how the coefficients are very similar to the ones in the OLS regression, denoting that the results are quite robust.

**TABLE 2: Cointegration Regression**

Dependent Variable: Loan rate to individuals

Independent Variables: One-Year-Interbank rate, FX Purchases (12-month average) and FX Purchases (12-month average) multiplied by a Dummy for 2010

Sample (adjusted): 14 144

Included observations: 131 after adjustments

Cointegrating equation deterministic: C

Long-run covariance estimate (Prewhitening with lags = 1 from HQ

maxlags = 5, Quadratic-Spectral kernel, Andrews bandwidth = 1.1543)

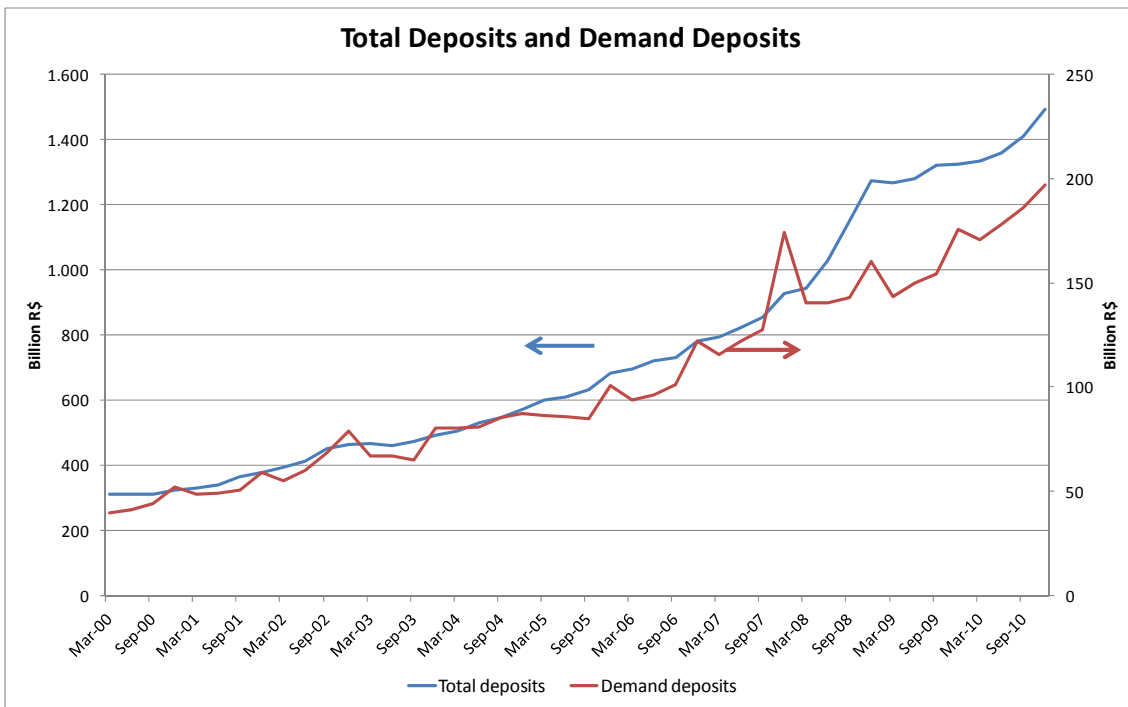
Variable	Coefficient	Stand. Error	t-Ratio	Prob
Constant	28.26229	2.396402	11.79364	0.0000
One-Year-Interbank Rate (t-3)	1.977465	0.122784	16.10528	0.0000
FX Purchases (12-month average)	-0.037931	0.011613	-3.266133	0.0014
FX Purchases (12-month average) multiplied by a Dummy for 2010	-0.105830	0.024147	-4.382788	0.0000

Mean dependent variable	58.31939	S.D. dependent var.	12.51822
Sum squared resid.	1261.924	S.E. of regression	3.152207
R-squared	0.938055	Adjusted R-squared	0.936592
Long-run variance	29.80132	Durbin-Watson	0.851448

The model also predicts that deposits should increase in times of large sterilized FX purchases. Note that Brazilian law forbids deposits in foreign currency in Brazilian financial institutions. Chart 8 shows the increase of demand deposits and total deposits in Brazilian banks. Chart 9 displays the same data in % of GDP. It shows that they increased sharply as a % of GDP, until the crisis, and then stabilized, as a % of GDP.

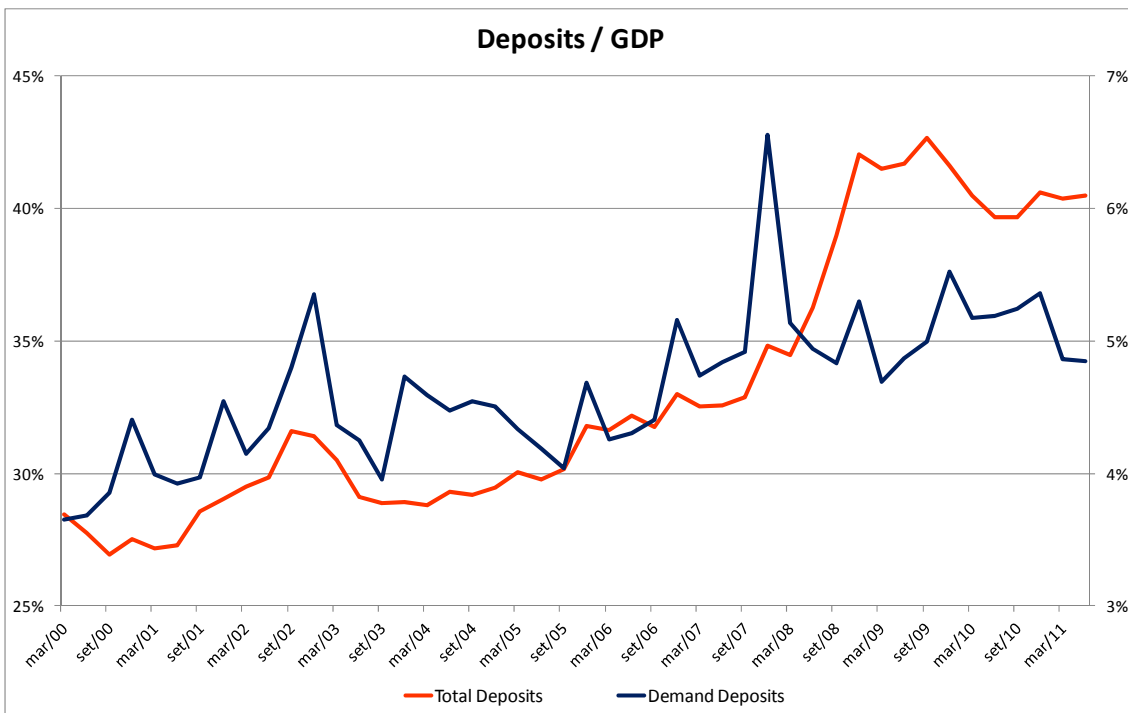
However, when we look at all the liabilities of the banking sector (everything, except capital), we see much higher growth since 2006, as a % of GDP (see Chart 10). Therefore, there is evidence that banks liabilities have been growing, as predicted by the model. However, this phenomenon has been happening since 2006, and was, apparently, not affected by the 2008 crisis.

Chart 8



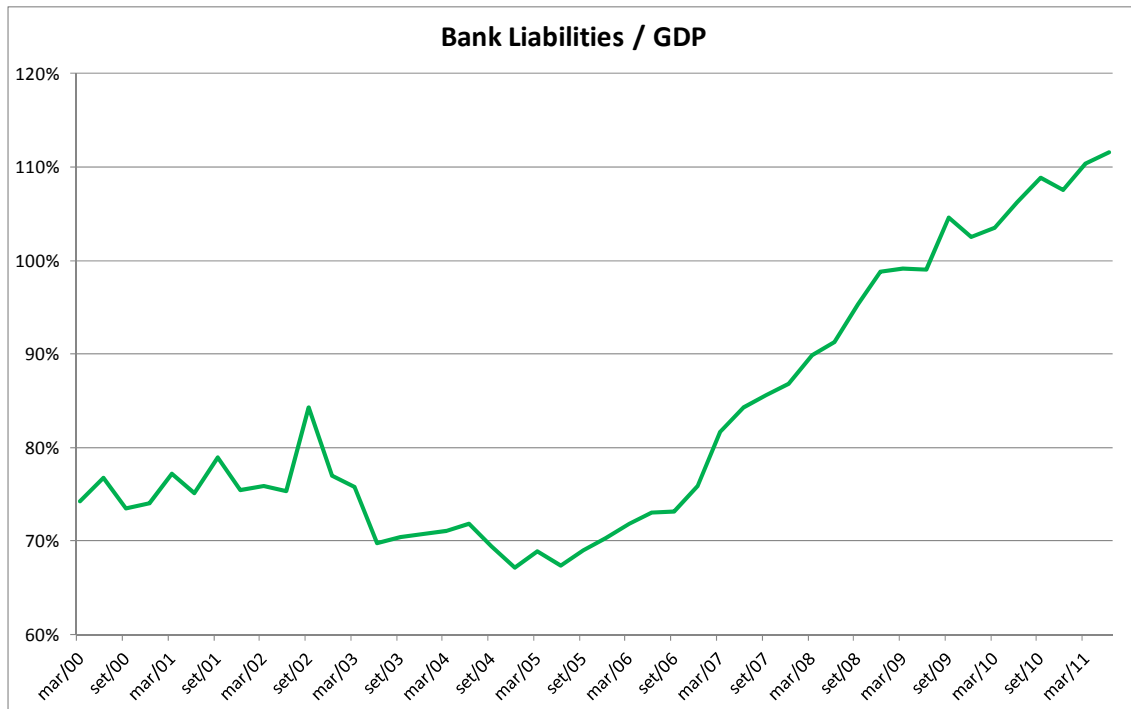
Source: Central Bank of Brazil

Chart 9



Source: Central Bank of Brazil

Chart 10



Source: Central Bank of Brazil

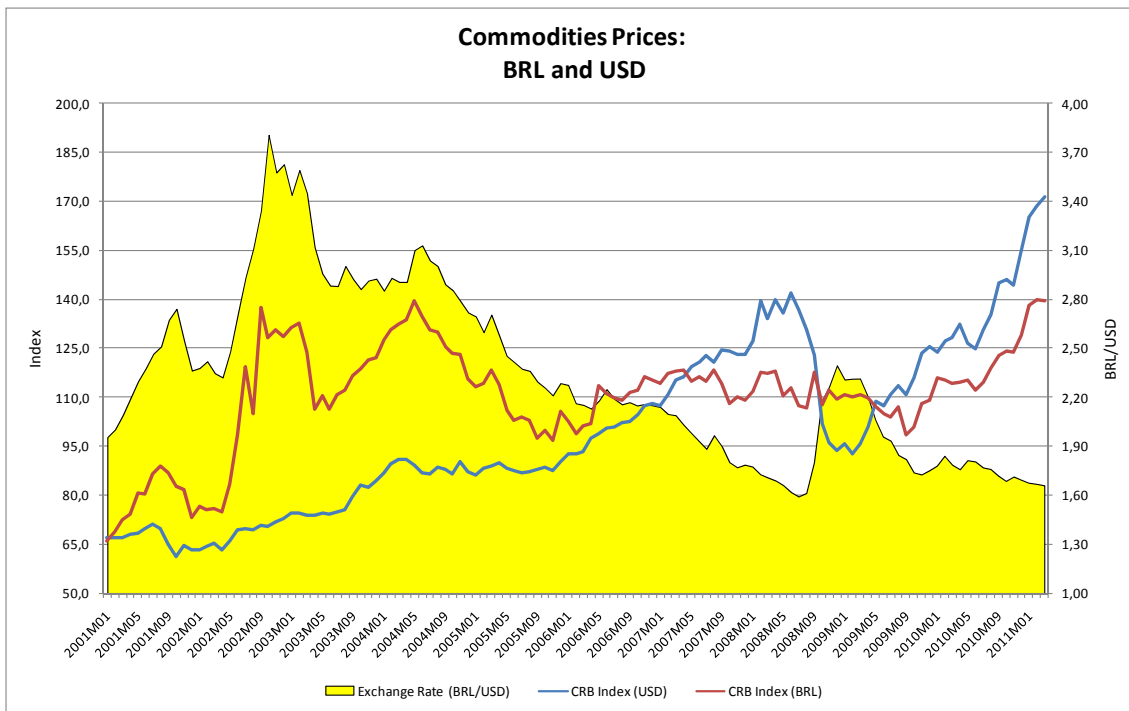
As mentioned before, several policy measures, besides sterilized interventions, were taken to deal with what were perceived to be excessive capital inflows. Another set of policy measures have targeted a subset of capital inflows. Since March 2011, short-term credit (up to two years) obtained by Brazilian banks abroad has been taxed to deter further capital inflows. These measures aim to deter the FX flows that prompt sterilized interventions.

An additional policy action was the decision taken in 2010 to let the Brazilian Central Bank return to derivatives markets, trading with currency swaps. The purchase of a currency swap by the Central Bank is equivalent to a sterilized intervention,<sup>14</sup> in the sense of interventions that keep money constant. As the previous results show, what are generally referred to as sterilized interventions under inflation targeting are not equivalent to the textbook definition. Therefore, the two forms of intervention may produce different results in terms of their effectiveness in altering the exchange rate.

Since 2010, something seems to have changed in the behavior of the BRL/USD exchange rate. Although there has been a historical correlation between terms of trade and the exchange rate, improvements in the terms of trade since mid-2010 have not been accompanied by a corresponding appreciation of the BRL, thereby transmitting the commodities' positive price (in USD) shock to domestic inflation. Chart 11 shows this phenomenon.

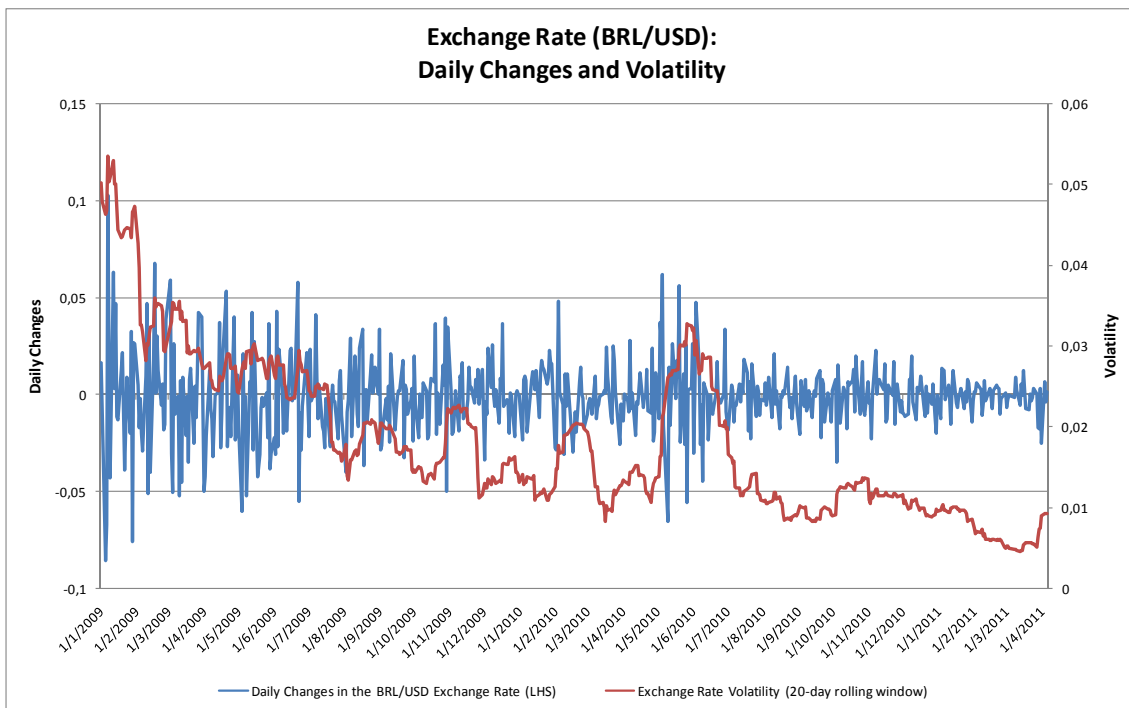
<sup>14</sup> Obstfeld and Rogoff (1996), pp. 597-9.

Chart 11



In addition, the volatility of the BRL/USD rate has fallen markedly, as shown in Chart 12. These are evidences that government interventions may be affecting the exchange rate, mitigating the appreciation that would occur under free floating.

Chart 12





As previously noted, the theoretical and econometric evidences regarding the effectiveness of sterilized interventions in altering the exchange rate are mixed. However, this paper argues that the kind of sterilized intervention conducted in Brazil does not correspond to the canonic definition of sterilized intervention. The sterilization of the increase in money caused by FX purchases is only partial, because the expansionary effect on output increases money demand, thereby requiring less monetary contraction to return the interest rate to its previous level. In a nutshell, Brazil has not been fully sterilizing its FX purchases, in the “monetarist” sense of the expression. Therefore, it does not come as a surprise that FX purchases may have been more efficient in mitigating nominal exchange rate appreciation.

In sum, this section has presented empirical evidence showing that many phenomena observed in the Brazilian economy are compatible with the model’s predictions. Massive sterilized interventions have not been neutral; they increased banks’ liabilities and the supply of credit, making credit cheaper and more abundant, even when the Central Bank of Brazil was raising interest rates. This, in turn, expanded aggregate demand, making it harder to keep inflation at bay. The next section will summarize this paper’s main conclusions and policy prescriptions.

## 6. Concluding Remarks

Many countries have been increasingly resorting to sterilized FX purchases to mitigate exchange rate appreciation. Sterilized FX interventions are defined as FX purchases (sales) by the CB followed by open market operations that offset their monetary impact.

Under inflation targeting, or any monetary policy regime with an interest rate rule, sterilized FX interventions usually refer to FX operations followed by open market operations that restore the interest rate to its target. Restoring the interest rate to its previous level may not be equivalent to restoring the monetary base to its previous level.

We adapt a simple model<sup>15</sup> with a banking sector and richer asset structure than just the money and bonds present in the classical IS-LM model in order to argue that, in general, FX sterilized interventions under inflation targeting are expansionary.

When bank credit is explicitly introduced into the IS-LM model, increases in the monetary base (bank reserves) affect not only the LM curve, but also the new IS curve, termed CC, for “commodities and credit”. This effect is caused by bank loans, which become cheaper and more abundant when bank deposits rise because of the increase in bank reserves. Therefore, when credit is incorporated into the model, monetary policy, by affecting banks’ behavior, becomes more powerful. An increase in bank reserves will lead to a larger output expansion than in the usual IS-LM model. However, the fall in interest rates associated with monetary expansions will be smaller, or may not happen. In fact, if more bank reserves lead to a large fall in interest rates on banks’ loans, it is theoretically possible that an increase in money may end up raising interest rates.

We use this model to argue that sterilized interventions under inflation targeting is expansionary. When a foreign loan is taken out by a bank, its liabilities increase. The sterilized FX purchase by the CB is aimed at making the bank hold all the increase in liabilities in the form of government bonds. However, with increased liabilities, the bank wants to diversify its holdings, and channel part of the new funds into loans. This pressure to reallocate the bank’s portfolio—when the assets (bonds and loans) are imperfect substitutes, and given that the previous interest rate has been restored after the sterilized FX purchase—increases loan supply, lowers the loan rate, thereby expanding aggregate demand.

The model in this paper relies on a portfolio balance effect generated inside the bank. Recent research on the behavior of financial institutions has shown that they tend to over leverage in good times.<sup>16</sup> The external funding provided by capital inflows constitutes one important way through which this leverage may occur. As explained by the model, such an effect occurs despite sterilization.

On the other hand, the expansionary effect of sterilized interventions has other transmission channels apart from the one described in the model, which, in this case, is constituted by the banking sector. The main idea is that capital flows will increase aggregate

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<sup>15</sup> Bernanke and Blinder (1988).

<sup>16</sup> Adrian and Shin (2009).

demand when the CB keeps the interest rate constant at its level before the capital flows and the sterilized FX purchases. This is true for banks that fund their domestic loans by borrowing from abroad, but is also valid for FDI or corporate securities issued abroad to fund investment projects.

It is also true for trade flows that allow firms that export to fund their investment projects. For example, if an exporter decides to undertake an investment project, and fund it with its export proceeds, because, for example, the returns are higher than those obtained by investing these export revenues in government bonds, at prevailing interest rates (that will be kept constant with the sterilized intervention), there will be an expansionary effect despite the sterilization. This expansionary effect is akin to the effect displayed in the model in Section 3.

However, the expansionary effect does not hold for capital flows directly targeted to purchase government bonds (e.g., carry-trade), for they would not increase aggregate demand.

The part of the intuition that explains why money expands when the interest rate is kept constant is the following. Capital flows not directly targeted to government bonds raise aggregate demand, thereby also increasing money demand, at the prevailing interest rate. Therefore, money supply has to increase, in equilibrium. In the model, an increase in the monetary base is what leads, in the first place, to an increase in loans. Therefore, sterilized interventions under inflation targeting—in reality not fully sterilized—become expansionary.<sup>17</sup> At the new equilibrium there will be higher aggregate demand, a higher quantity of money, lower loan rate and higher quantity of loans at the same interest rate. The timing to arrive at the new equilibrium has to do with how fast banks reallocate their portfolios after the sterilized intervention, not with the few minutes the CB takes to perform a sterilized FX purchase..

Brazil's recent experience was reviewed to argue that the expansionary effect of sterilized interventions may be significant. The monetary base expanded 25% in 2010, while GDP grew 7.5%. Credit also increased substantially, with most loans becoming cheaper. Besides timid increases in interest rates, at the end of 2010, the government has resorted to macroprudential measures, such as increases in reserve requirements. All these evidences are compatible with the expansionary effect of sterilized interventions under inflation targeting.

One empirical evidence that the mechanisms behind the model may be important to explain what happened in Brazil, is the behavior of the one-year-interbank interest rate and the loan rate. They showed a remarkably high correlation until the end of 2009, a time when both rates were falling. Since then, the interest rate has gone up, anticipating the increases signaled by the Central Bank of Brazil, that were later actually implemented. However, the loan rate kept falling. This is precisely what the model says would happen under massive sterilized FX purchases. Econometric investigation confirms the intuition.

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<sup>17</sup> The model shows that even if the CB would were to fully sterilize, a smaller expansionary effect would occur. This is because, with larger liabilities, banks will offer more and cheaper credit, thereby expanding the CC curve.

The main policy implication of this paper is that when a country receives large inflows of FX that are not aimed at purchasing government bonds (including trade revenues), it is not sufficient, in order to fully sterilize FX purchases, for the CB to restore the previous interest rate level. If the FX flows affect aggregate demand, e.g. via bank credit, sterilized interventions under inflation targeting will be expansionary.

Another policy implication is that policy strategies like the one adopted in late 2010 by Turkey, that combine lower interest rates with the so-called macroprudential measures are inconsistent. The capital inflows that would be deterred by the fall in interest rates, those aimed at purchasing government bonds, are not the ones that make FX sterilized purchases expansionary. On the contrary, lower interest rates would expand aggregate demand and loan demand, keeping the loan rate high enough to keep attracting more foreign funds. Therefore, the reliance on so-called macroprudential measures to keep inflation at bay would be even higher.

Inflation targeting countries that conduct sterilized interventions to mitigate the appreciation of the exchange rate in face of massive capital inflows may have another reason for concern. Even if those sterilized interventions are effective in preventing nominal exchange rate appreciation, they may represent a positive shock to aggregate demand, thereby increasing inflation with all its detrimental effects, among them, the appreciation of the real exchange rate.

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