Banks Make Sterilized FX Purchases Expansionary

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Abstract:

In the most recent wave of capital inflows, 2009-2012, many emerging markets have resorted to sterilized FX purchases as a way to mitigate exchange rate appreciation. The literature on the effectiveness of sterilized FX interventions to alter the exchange rate is large and inconclusive, but there is scant mention to expansionary effects of FX sterilized purchases other than the effect of possible exchange-rate depreciation on net exports. Nevertheless, many emerging markets' central banks have complained that the (fully sterilized) capital inflows have fueled large credit expansions, creating credit bubbles and inflation. We show that, indeed, when the banking sector is duly considered, sterilized FX purchases became expansionary, via a credit channel. The mechanism is the following: under massive sterilized FX purchases, the aggregate banking sector balance sheet increases, with the asset side absorbing the bonds used to sterilize the money expansion generated by the sterilized FX purchase. Since interest rate, the return on bonds, does not change, a portfolio balance effect stimulates banks to increase loan supply and lower their augmented bond holdings. Bond sales by the banks, to make cash to increase loans, pressure the interest rate up. To keep the interest rate from rising, the central bank increases money supply. Higher loan supply increases loans and output. In the new equilibrium, the interest rate is kept constant, while the quantity of money and loans increase, as well as output. Recent Brazilian evidence is reviewed, showing that this effect is empirically relevant. Therefore, when duly considering the banking sector, independently of their effect in preventing nominal appreciation, FX sterilized purchases generally boost credit, activity and inflation.

JEL Codes: F3, F4, E4, and E5

Keywords: Banks, Credit, Sterilized Interventions, Capital Flows, Emerging Markets, Brazil, Macroprudential Policies and Inflation Targeting

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1. Introduction

From 2009 to 2012, international financial markets were very liquid. The abundant liquidity, together with the good prospects of many emerging markets, drove massive capital flows 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 was 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[3] and foreign exchange (FX) sterilized purchases, both largely used in Brazil at the time.

In a country with extremely high interest rates, as it was then the case of Brazil, foreign exchange (FX) reserves purchased through sterilized interventions are very expensive, thereby generating high fiscal costs.[4] The theoretical and econometric evidence as to the effectiveness of sterilized purchases of FX in depreciating the home currency is also very mixed.[5] Nevertheless, sterilized interventions have been conducted in Brazil for a considerable period of time, generating a very large volume of foreign reserves (around USD 370 bi, more than 20% of GDP at the exchange rate prevailing in September, 2016).

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 monetary authority decides to fully sterilize the capital inflow. Under an inflation-targeting regime, or any other with an interest-rate rule, 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.

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[3] See Chamon and Garcia (2016) and Jinjarak et al. (2013) for analyses of the Brazilian recent experience with controls on capital inflows.

[4] For Brazil, "... *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).

[5] Dominguez and Frankel (1993), Sarno and Taylor (2001) and Neely (2005) provide classical surveys. Engel (2013) provide a recent evaluation of the econometric results, ending with the following caveat: "*despite many empirical studies, it is not clear yet whether sterilized intervention meets the same criteria that regulators use to decide whether to approve a cancer drug—that is safe and effective*" (p. 39).

Are such sterilized interventions under inflation targeting expansionary?[6] 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, which matches the complaints of emerging markets´ central bankers.

Indeed, policy-makers in developing countries have complained about capital inflows' expansionary effect on credit aggregates. The Brazilian central bank, for example, considered that: "… *the fragility in some mature economies, combined with favorable perspectives for the Brazilian economy, has determined an inflow of foreign resources, part of 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 warned: "*… 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 admonished: "… *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 seem not to be effective in isolating the real economy from capital flows. Signaling models could provide a rationale for sterilized FX purchases being expansionary.

The traditional theoretical literature on sterilized interventions is focused on its effectiveness in affecting the exchange rate, mainly via two effects: the portfolio balance effect and the signaling effect.[7] There is a very large empirical literature on FX Intervention, e.g., Dominguez and Frankel (1993). Sarno and Taylor (2001) survey early literature (mainly advanced economies); evidence not supportive (intervention is small when compared to size of bond markets). Menkhoff (2013) provides a more recent survey covering Emerging Markets,

[6] The question abstracts from possible effects on the exchange rate. If there are any, we are concerned with expansionary effects over and above the ones caused by exchange rate depreciation caused by sterilized FX interventions.

[7] 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) were taken.

where evidence is supportive, most likely because, in those countries, FX interventions can be sizable relatively to domestic bond markets. However, the support for the effectiveness of sterilized FX interventions to affect the exchange rate is not strong (Engel (2015)). Recently, general equilibrium models have been developed, mostly in the DSGE tradition: Kumhof (2010), Benes et al. (2015), Devereux and Yetman (2014), Cavallino (2016) and Fanelli (2017). None of these models address the complaints of the policy makers of sterilized interventions generating a credit boom and a GDP expansion. [8]

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 generally 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 buy assets other than public bonds, be they real or financial assets.

The theory section of the paper is quite simple. The next section reviews a simple model *à la* IS-LM with a banking sector that introduces a new asset, credit,[9] and then extends the standard model 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 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 understand 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 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. Since such partial equilibrium models

[8] A recent exception is Blanchard et al. (2015).
[9] Bernanke and Blinder (1988).

are quite well know, we defer the details of the derivation to Appendix 1, and concentrate here in the intuition of the results.

The intuition of the expansionary effect of a sterilized FX purchase is the following. Assume that the banking sector is represented by a representative bank whose balance sheet is displayed in Figure 1.

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)	

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. 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.

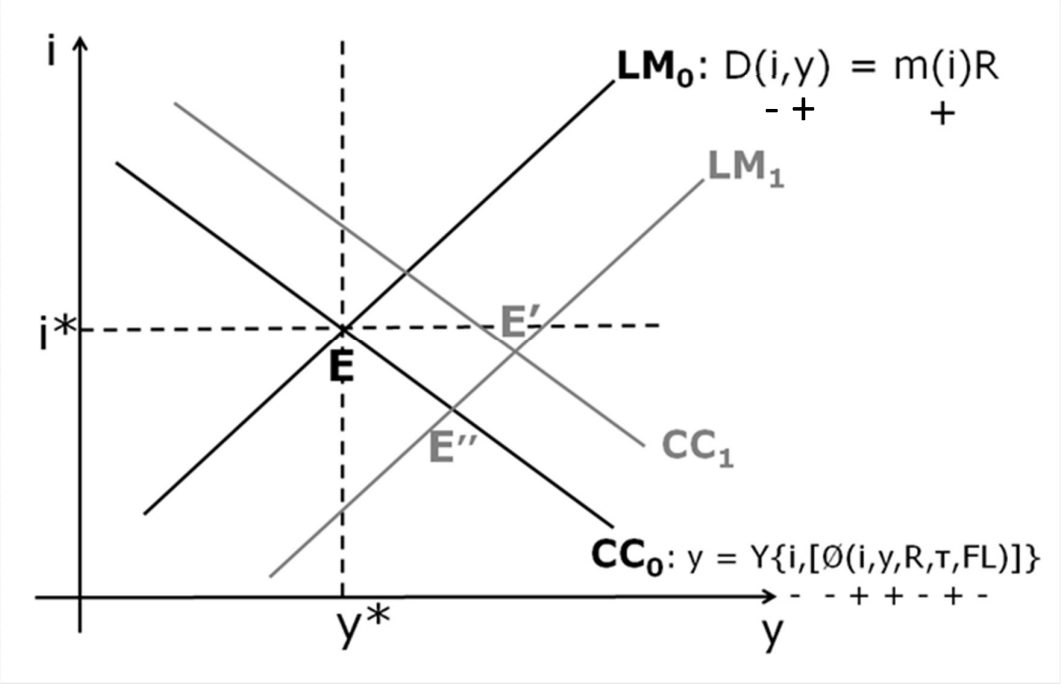
Figure 2: Representative Bank Balance Sheet After the Sterilized FX Purchase

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 ρ 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, ρ, must have fallen. And, with a fall in the loan interest rate, ρ, 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 ρ 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.[10] 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

[10] 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.

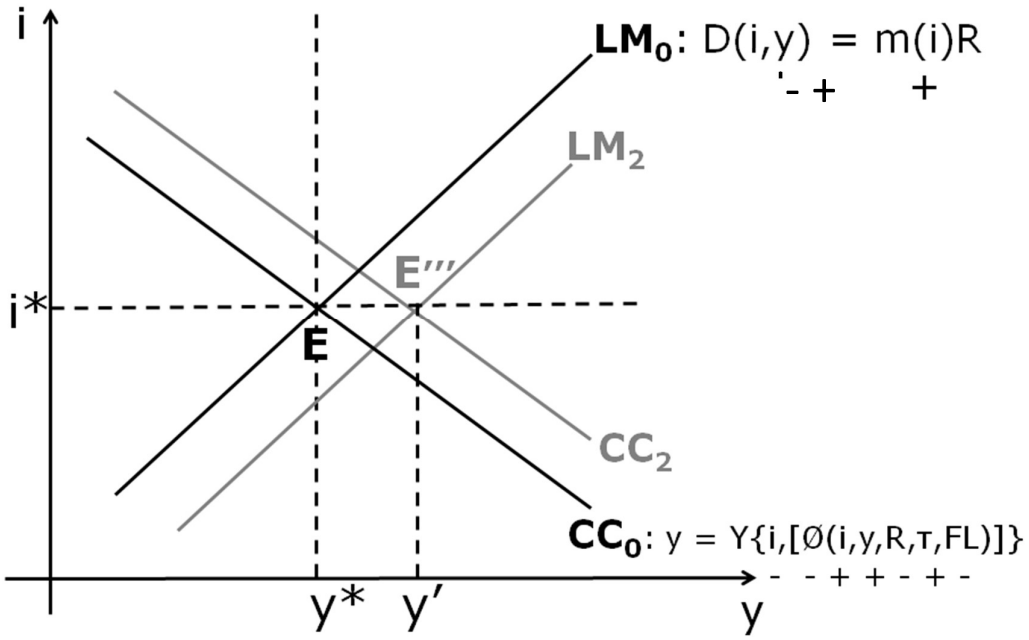
balance sheet looked like the one in Figure 2. As argued before, this cannot qualify as equilibrium with the same rates *i* and ρ that prevailed before the sterilized FX purchase. Therefore, banks will sell bonds to generate funds to make more loans. This portfolio adjustment tends to increase the interest 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. 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 ρ 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 rated, *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**.

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. Of course, whether or not such effects are of practical importance is an empirical issue. In Section 4, 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 3 uses the model to derive another important policy conclusion regarding policy measures to counteract the detrimental effects of capital inflows.

Chart 2



3. 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.[11]

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 fully destined to the direct purchase of domestic government bonds and all 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 2's model. The inflows that enter the country to directly 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 investment vehicule (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

[11] Financial Times (2010).

interest rates (i.e., 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. Since the capital inflows that fund bank credit are attracted by the high ρ, not the high *i*, the effect of a lower *i* would only deter the capital flows not aimed at investing in public bonds if *i* and ρ were complements, which may or may not be the case.

Even in the case where *i* and ρ are complements, the lower interest rate will probably increase the expansionary effects of the inflows that fund bank credit, because it will fuel aggregate demand, through the usual interest rate channel. 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 ρ, but the expansion on *y*, by increasing the demand for loans, mitigate this effect. Even if the elasticities are such that the fall in *i* substantially reduces ρ, thereby mitigating capital inflows, the final result may be worse, in terms of increasing aggregate demand, than what would have happened in the absence of the monetary loosening .

Even if macroprudential measures (increases in τ, the reserve requirement rate) are deemed adequate for deterring credit expansion, the fall in interest rates will increase macroeconomic policy's dependence on them. The high inflation in Turkey following the policy change (10.45% in January, 2012) showed that the strategy of lowering the interest rates in face of massive capital inflows was not a sensible one.

4. FX Sterilized Interventions in Brazil and Money

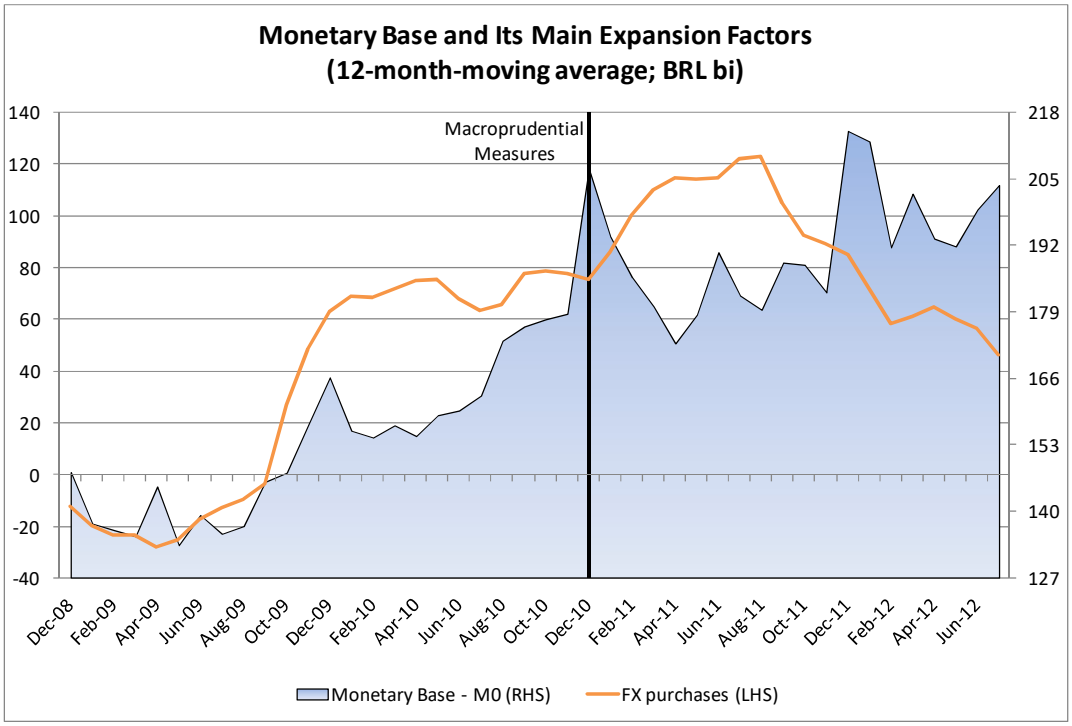
After the great financial crisis of 2007/08, Brazil resumed sterilized FX purchases as early as February, 2009. Since then, foreign reserves have risen from USD 187 bi to USD 350 bi, surpassing 15% of GDP, in October, 2011.[12]

Chart 3 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 3, 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.

[12] It increased further, and is currently around USD 370 bi, almost 25% of the Brazilian GDP.

Chart 3



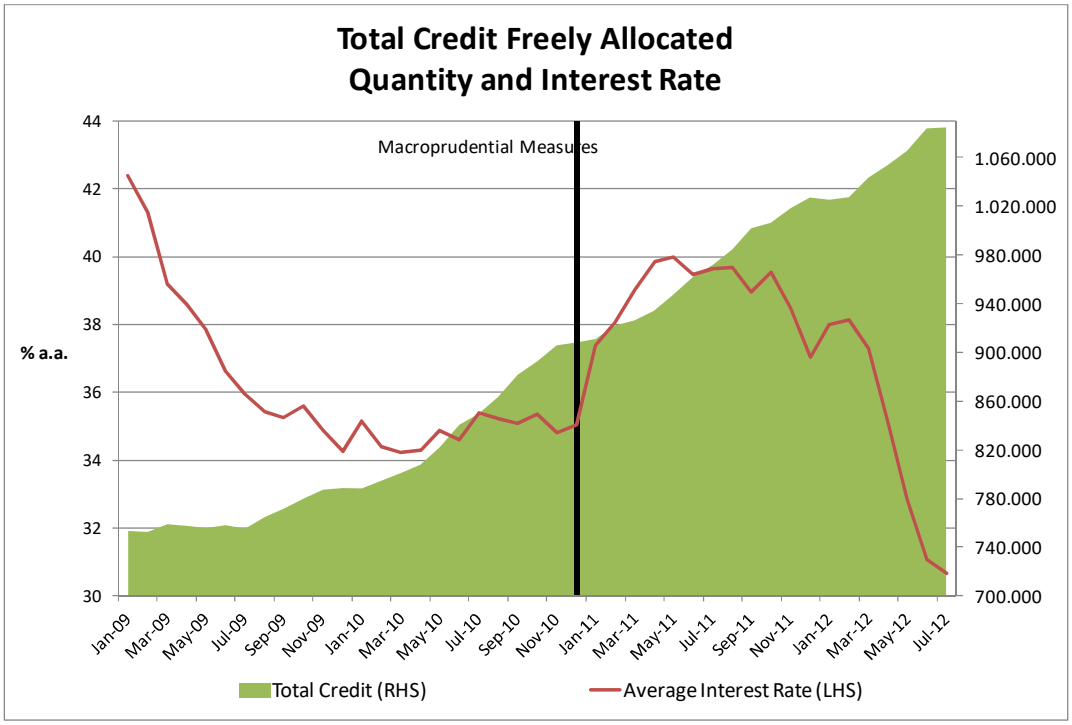
Source: Central Bank of Brazil

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 4 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.

Furthermore, Chart 5 shows that the rate on loans to individuals follows the one-year-interbank rate almost perfectly, with a three-month lag.[13] 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,[14] the month prior to the imposition of macroprudential measures to deter credit growth.[15] 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 ρ in the model. The model asserts that, under massive sterilized FX purchases, the highly unusual negative correlation, as observed in 2010, should be the outcome.

[13] In Chart 5, the interbank rate is leaded three months.
[14] I wish to thank Eduardo Loyo for pointing this out to me.
[15] The effects of macroprudential measures may also be observed on Chart 4, when credit volume stops growing and the average credit interest rate increases.

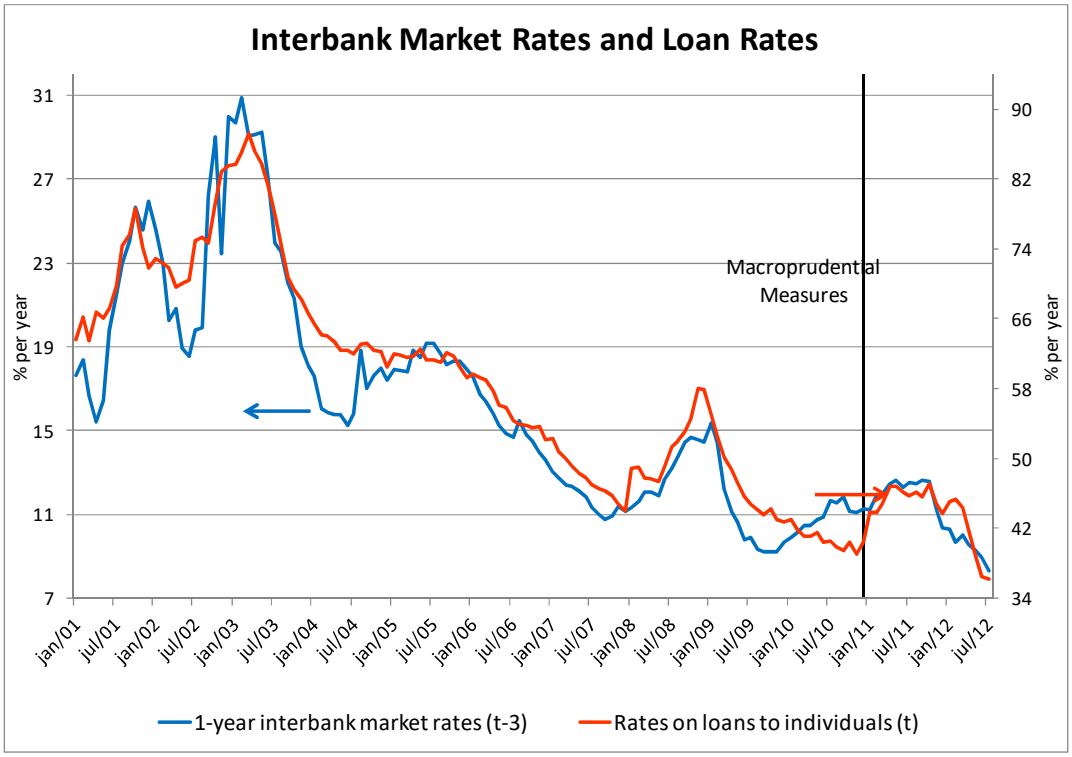
Chart 4



Source: Central Bank of Brazil

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.

Chart 5



Source: Central Bank of Brazil

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 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
ρ	0,499275	Durbin-Watson	0,975744

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 deterministics: C
Long-run covariance estimate (Prewhitening with lags = 1 from HQ
maxlags = 5, Quadratic-Spectral kernel, Andrews bandwidth = 1.1543)

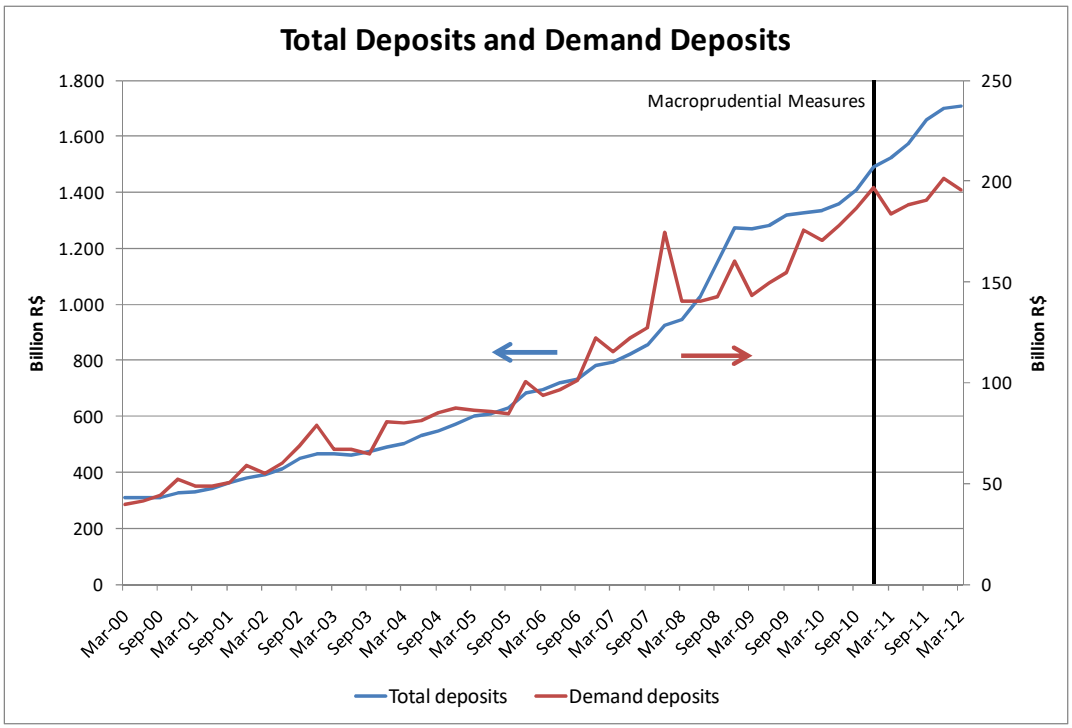
Variable	Coefficient	Stand. Error	t-Ratio	Prob
Constant	28.26229	2.396402	11.79364	0.0000
One-Year-Interbank Rate (t-3)	1.977465	0.122784	16.10528	0.0000
FX Purchases (12-month average)	-0.037931	0.011613	-3.266133	0.0014
FX Purchases (12-month average) multiplied by a Dummy for 2010	-0.105830	0.024147	-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 6 shows the increase of demand deposits and total deposits in Brazilian banks. Chart 7 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. Furthermore, Granger-causation runs from the sterilized FX purchases to loans, but not the other way around.

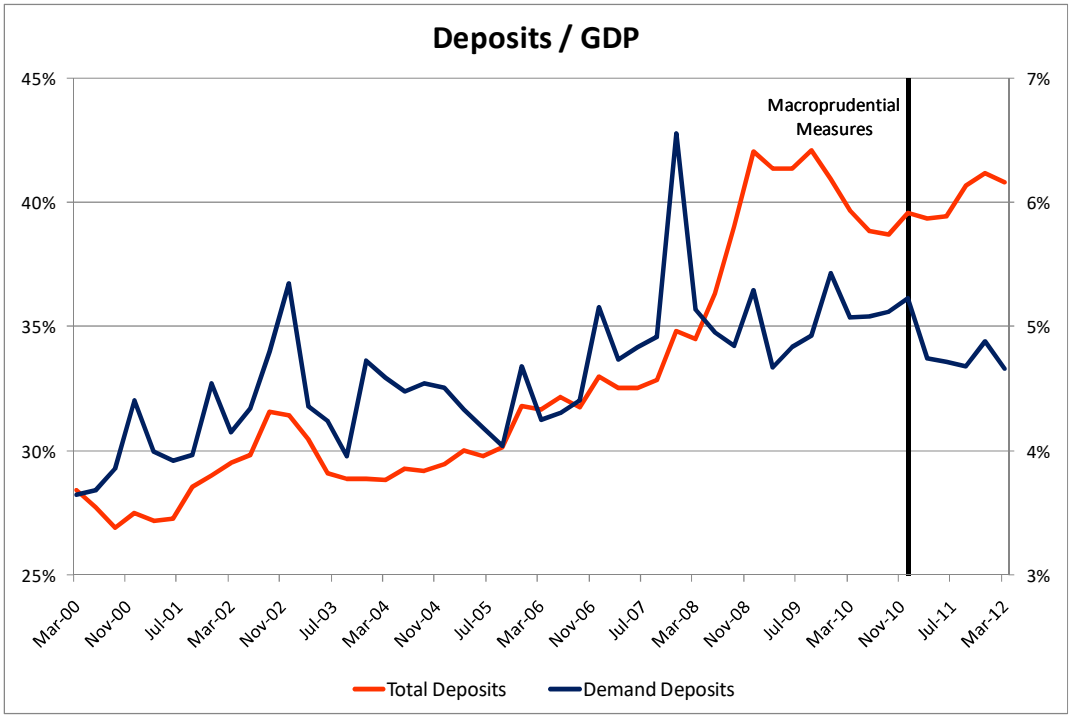
However, when we look at all the liabilities of the banking sector (everything, except capital), we see much higher growth since 2006, as a % of GDP (see Chart 8). Therefore, there is evidence that banks liabilities have been growing, as predicted by the model.

Chart 6



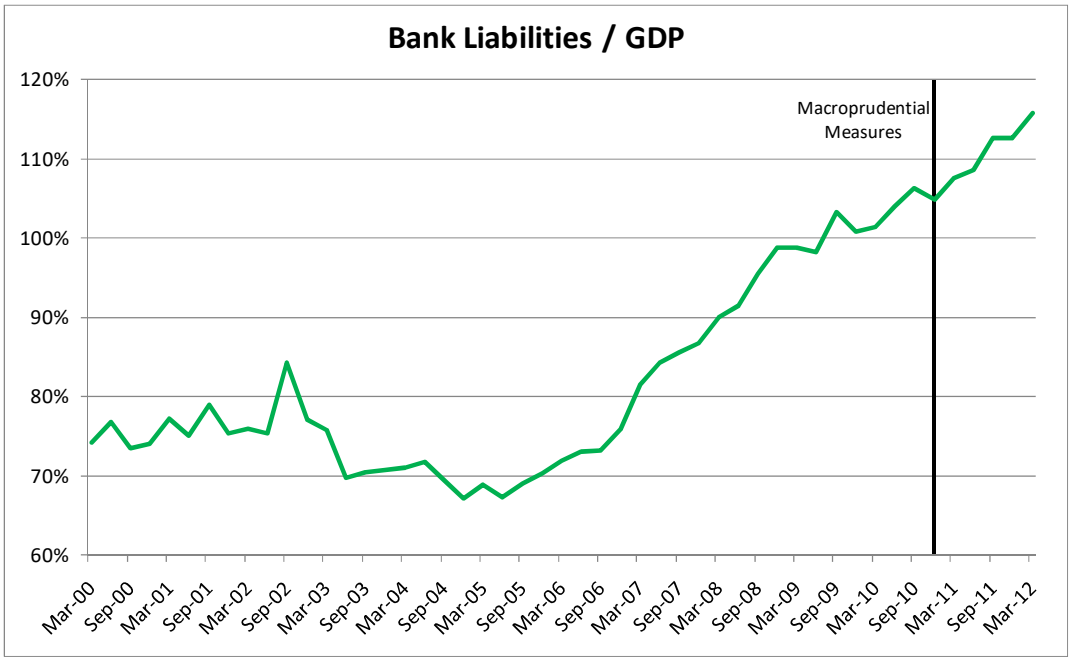
Source: Central Bank of Brazil

Chart 7



Source: Central Bank of Brazil

Chart 8



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 were controls on capital inflows.[16] An additional policy action was the decision taken in 2010 to let the Brazilian Central Bank return to derivatives markets, trading purchasing currency forwards (called dollar swaps in Brazil). The purchase of a dollar swap by the Central Bank is equivalent to a sterilized intervention,[17] 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, insofar as intervening via derivatives does not entail the same changes in banks portfolios as plain sterilized interventions do.

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 resorted to sterilized FX purchases to mitigate exchange rate appreciation and large credit expansions caused by massive capital inflows. 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[18] 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, via a credit channel, distinct from possible effects on the exchange-rate.

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,

[16] For an appraisal of the effectiveness of capital controls in Brazil to prevent currency appreciation, see Chamon and Garcia (2016).
[17] Obstfeld and Rogoff (1996), pp. 597-9.
[18] Bernanke and Blinder (1988).

becomes more powerful. An increase in bank reserves will lead to a larger output expansion than in the usual IS-LM model.

We use this model to argue that sterilized interventions under inflation targeting is expansionary. When, for example, a foreign loan is taken out by the banking sector bank, its liabilities increase. The sterilized FX purchase by the CB is aimed at making the banking sector hold all the increase in liabilities in the form of government bonds, at the same interest rate. However, with increased liabilities funding only more bonds at the same interest rate, the banks want to rebalance their portfolios, selling bonds in order to make more 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.[19] The external funding provided by capital inflows constitutes one important way through which this leverage may occur. We show here that sterilized interventions do not contain the expansionary effects of the leverage increase caused by capital inflows.

On the other hand, the expansionary effect of sterilized interventions has other transmission channels apart from the one described in the model, via the banking sector. The main idea is that capital flows will increase aggregate 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.[20]

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 funds it with its export proceeds, because, for example, the returns are higher than those obtained by investing these export revenues in governments 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. Capital flows directly targeted to purchase government bonds represent an external source of demand for government bonds, thereby creating a downward pressure on interest rates (therefore increasing government bond prices). If the CB did not act to keep interest rates constant, these capital inflows could lead to an increase in aggregate demand, but it could not create the expansionary effect through the expansion of bank liabilities.

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.

[19] Adrian and Shin (2009).
[20] Blanchard et al. (2015) refer to those flows as non-bond inflows.

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—not fully sterilized in the sense of keeping money constant—become expansionary.[21] 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 experience during the aftermath of the great financial crisis 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 mechanism behind the model may be important to explain what happened in Brazil is the joint behavior of the consumer loan rate and the banks´marginal cost for loans, i.e., the one-year-interbank interest rate. They showed a remarkably high correlation, as expected, 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 unusual negative correlation is precisely what the model says would happen under massive sterilized FX purchases. Formal econometric investigation confirms the graphic intuition.

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 finance), it is <u>not</u> 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, combining 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. Therefore, the dependence on the so-called macroprudential measures to keep inflation at bay would be even higher. The increase in inflation in Turkey corroborates the idea. Only a model that differentiates the loan rate from the interest rate on government bonds, as the one in this paper, can be useful to derive policy implications for these strategies, very much in fashion among emerging markets, until recently, when capital flows turned back.

[21] 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.

When and if capital resumes its flow toward emerging markets, inflation targeting countries that conduct sterilized interventions to mitigate the appreciation of the exchange rate in face of massive capital inflows will have another reason for concern. Sterilized FX interventions may be effective in preventing nominal exchange rate appreciation, but they create a collateral expansionary effect via a credit channel, thereby increasing inflation and potentially threatening financial sector stability.

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Appendix 1 – The Adapted BB Model

1.1 The original 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")*" [22]. 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 ρ 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"[23]:

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

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 (τ.*D*) plus excess reserves (*E*). Therefore, from the bank's balance sheet:

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

The portfolio shares of bonds (β), loans (λ) and excess reserves (ε), β+λ+ε=1, are determined according to returns (zero for excess reserves):

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

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

$$E = \varepsilon(\underset{-}{i})D(1-\tau) \qquad (5)$$

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* x *i* space. Money supply (*D*, the model equivalent of M1) is given by the amount of reserves (*R*, the model

[22] Bernanke and Blinder (1988), p. 435.
[23] *Ibid*..

equivalent to M0), under the control of the central bank, multiplied by the money multiplier (*m*):

$$m(\underset{+}{i}) = 1/[\varepsilon(i)(1-\tau)+\tau] \qquad (6)$$

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* x *i* plane:

$$D(\underset{-}{i},\underset{+}{y}) = m(\underset{+}{i})R \qquad (7)$$

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):

$$L(\underset{-}{\rho},\underset{+}{i},\underset{+}{y}) = \lambda(\underset{+}{\rho},\underset{-}{i})D(1-\tau) \qquad (8)$$

Given loan demand, *L*(*ρ*,*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, *ρ*, also enters:

$$y = Y(\underset{-}{i},\underset{-}{\rho}) \qquad (9)$$

The key novelty of the BB model is precisely that *ρ* affects the IS curve. Since, by the equilibrium in the loan market (equation (8)), *ρ* 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* x *i* plane, although a tridimensional *y* x *i* x ρ representation would probably be more instructive. To represent the model in the *y* x *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 *ρ* as a function of the other variables: *i*, *y*, *R* and τ:

$$\rho = \emptyset(\underset{+}{i},\underset{+}{y},\underset{-}{R},\underset{+}{\tau}) \qquad (10)$$

In (10), the derivative of *ρ* 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 *ρ*. 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 ρ a negative function of i.

Substituting the ρ, 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.

$$y = Y\{\underset{-}{i}, [\underset{- \; - \; + \; + \; - \; +}{\emptyset(i, y, R, \tau)}]\} \qquad (11)$$

The CC curve is also downward sloping in the y x 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.

1.2 Introducing 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, 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. However, 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^*).[24]

[24] "*Most central banks no longer target monetary aggregates, so instead, sterilized intervention can be thought of as foreign exchange market activity by the central bank that does not change its target interest rate*" (Engel, 2013).

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.

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

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

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

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

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

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

$$\rho = \emptyset(\underset{+}{i}, \underset{+}{y}, \underset{-}{R}, \underset{+}{\tau}, \underset{-}{FL}) \qquad (10')$$

$$y = Y\{\underset{-}{i}, [\emptyset(\underset{-}{i}, \underset{+}{y}, \underset{+}{R}, \underset{-}{\tau}, \underset{+}{FL})]\} \qquad (11')$$