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THE SUSTAINABILITY OF STERILIZATION POLICY

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I. INTRODUCTION¹

In a context of free capital mobility the Central Bank (CB) can simultaneously control the exchange rate and the interest rate. This statement is contrary to the so-called open economy trilemma. We argue that the trilemma is false under certain circumstances and therefore it is not valid as a general theorem.

The condition that makes possible the exchange rate control with the simultaneous preservation of monetary autonomy is the existence of an excess supply of foreign currency at the central bank's exchange rate target. In this context, the monetary authority can determine the exchange rate by buying the excess supply in the foreign exchange market; then, the CB can control the interest rate by sterilizing the monetary effects of the foreign exchange intervention, selling either Treasury bills or its own bills in the monetary market. The CB has two instruments to accomplish its two objectives: the intervention in the foreign exchange market to fix the value of the exchange rate and the intervention in the monetary market to control the interest rate.

The excess supply of foreign currency – at the exchange rate that the CB wants to maintain and at the current domestic interest rate – is in fact an excess demand for domestic assets. We can imagine a fully sterilized intervention as an operation carried out in two steps. In the first step, the Central Bank intervention in the foreign exchange market expands the monetary base. The resulting situation would entail an increased monetary base stock, an unchanged stock of interest-bearing domestic financial assets, and a lower domestic interest rate than the initial one.

In the second step, the complete sterilization fully compensates the change in the private portfolio that took place in the first step. The Central Bank absorbs the increase in the monetary base and sells financial assets by exactly the same amount as the initial excess demand for domestic assets (i.e. the excess supply of foreign currency), thus restoring the interest rate to its original level (Bofinger and Wollmerhäuser, 2003).

The context of excess supply of foreign currency at the CB's targeted exchange rate is what makes the trilemma invalid and enables the Central

Bank to determine both the exchange rate and the interest rate. We think that this idea has not been widely recognized because the literature that discusses the monetary autonomy as well as exchange rate regimes and policies rarely deals with conditions of excess supply of foreign currency. On the contrary, most of it focuses on situations of deficits in the balance of payments.

Certainly, the trilemma is generally valid in deficit situations. Under conditions of excess demand in the foreign exchange market, even powerful Central Banks have an intervention capacity that is ultimately limited by the availability of foreign reserves. Consequently, under conditions of excess demand for foreign currency even those central banks are incapable of having an exchange rate target without affecting the interest rate. But there is no symmetry between situations of deficit and surplus in the balance of payments. In one case the trilemma is valid while in the other it is not (Frenkel, 2007).

The sterilized buying intervention is possible at any moment in time. But is it possible to carry out this policy indefinitely? Not in every circumstance. The sustainability of the policy depends on the interest rate earned by the foreign reserves, the domestic interest rate, the exchange rate trend and the evolution of the variables that determine the demand and supply of monetary base. The main conclusion of this paper is that there is a maximum level for the domestic interest rate that allows the sterilization policy to be sustainable. Under conditions of excess supply of foreign currency at the exchange rate target level, the CB can determine the exchange rate and has freedom to establish a domestic interest rate at a level equal or lower than that maximum level. We stated this conclusion in a previous work (Frenkel, 2007). In this paper we present a formal model that supports it.

The paper is organized as follows. Following this introduction, in section 2 we state the problem and define the degree of monetary autonomy. The model is introduced in section 3, in which we also define and derive the sustainability condition. In addition, we show that such condition is equivalent to the CB having non-negative financial results. Section 4 discusses the dynamics of the sustainability condition. In section 5 we

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define and derive the condition for the permanence of the degree of monetary autonomy. Both sections 3 and 5 include numerical examples using figures similar to those observed in Argentina at the end of 2006. In section 6 we present two interesting cases of application of the obtained results. Both cases are illustrated with numerical examples in order to show that the conditions of sustainability and permanence are satisfied in non-extraordinary situations.

II. THE COST OF STERILIZATION AND THE DEGREE OF MONETARY AUTONOMY

At each point in time, the unit cost of sterilization is:

$$s = i - r - e$$

where s is the cost of sterilization, i is the domestic interest rate, r is the international interest rate, $e = dE/E$ ($E = \$ / \text{us}\$$) is the rate of growth of the domestic price of foreign currency. The cost of sterilization s is zero if

$$i = r + e$$

i.e. if the domestic interest rate is equal to the sum of the international interest rate plus the rate of growth of the exchange rate. Or, what is the same thing, if the UIP condition is strictly satisfied (Bofinger and Wollmerhäuser, 2003).

Evidently, the sterilization policy is sustainable if the cost of sterilization is zero or negative. If this was the condition for sustainability, the sterilization policy would be sustainable if

$$i \leq r + e$$

i.e. $r + e$ would be the maximum level of interest rate that would preserve the sustainability of the sterilization policy.² Rates higher than the latter would turn the policy unsustainable.

² It can happen that $i < r + e$ (a) and still have an excess supply in the foreign exchange market. This can take place because capital flows are a function of $i - (r + E(e))$ (b), where $E(e)$ is the exchange rate's expected rate of growth. It can happen that $E(e) < e$ for quite long periods, so that expression (b) is positive, although a posteriori expression (a) is verified. For example, this has been the case of China in recent years, where the domestic interest rate is lower than the

As it follows, we show that the mentioned condition is not necessary for sustainability. We show that the policy can be sustainable with domestic interest rates higher than $r + e$ and we calculate the maximum rate that makes the sustainability of sterilization possible. To do so, we formulate a simple model that takes into account the fact that in addition to interest-bearing assets, the public demands and the CB issues monetary base that does not yield interests.

The previous considerations suggest defining the degree of monetary autonomy as the difference between the maximum domestic interest rate that allows the sustainability of sterilization policy and $r + e$. By calling i_{max} the mentioned maximum rate and g the degree of monetary autonomy, we define:

$$g = i_{max} - (r + e)$$

Given the international interest rate and the rate of growth of the exchange rate, the higher is the domestic interest rate that can be determined without making the sterilization policy unsustainable, the higher is the degree of monetary autonomy.

III. THE SUSTAINABILITY CONDITION

The CB has foreign reserves as its only asset. Likewise, the CB issues two liabilities: monetary base and sterilization bills that yield the domestic interest rate i .

$$P = B + L$$

where P is the CB's total stock of liabilities, B is the monetary base stock and L is the stock of interest-bearing liabilities.

At the current interest rate i and at the exchange rate E there is an excess supply of foreign currency C in the foreign exchange market, which the CB purchases. The increase in CB's total liabilities is:

$$dP = dB + dL = CE + iL \quad (1)$$

sum of the US Federal Reserve's interest rate plus the rate of growth of the exchange rate. See McKinnon and Schnabl, 2006.

where CE is the value in pesos of the flow C , iL is the flow of interests that the CB has to pay over the stock L of interest-bearing liabilities.

We assume $dP > dB$, so that $dL > 0$.

The increase in the demand for monetary base is

$$dB = B \beta (p + y) \quad (2)$$

where p is the rate of inflation, y is the rate of growth of real GDP and β is the demand elasticity of the monetary base to nominal GDP.

R is the CB's stock of foreign reserves and $d(RE)$ is the increment of the value in pesos of those reserves. Foreign reserves yield r , the international interest rate. Hence:

$$\begin{aligned} d(RE) &= R dE + E dR \\ &= R dE + E (C + r R) \\ &= R dE + E C + E r R \end{aligned} \quad (3)$$

The sterilization policy sustainability condition is defined as:

$$dP \leq d(RE)$$

This condition means that the sterilization policy is sustainable if the ratio between the CB's total liabilities and the value of foreign reserves in pesos - $P/(RE)$ - does not increase.

By replacing in the sustainability condition by (1) and (3) we obtain:

$$\begin{aligned} CE + iL &\leq R dE + EC + E r R \\ iL &\leq R dE + E r R \end{aligned} \quad (4)$$

By dividing expression (4) by RE it results:

$$\begin{aligned} iL/RE &\leq e + ry \\ i &\leq (e + r) / (L/RE) \end{aligned} \quad (5)$$

The sterilization policy is sustainable with interest rates that are equal or lower than the second term of expression (5). We call

$$l_R = L/RE$$

the ratio between the CB's stock of interest-bearing liabilities and the value of foreign reserves in domestic currency; then we formulate the sustainability condition as

$$i \leq (e + r) / l_R \quad (6)$$

If $l_R < 1$ domestic interest rates that preserve the sustainability of sterilization policy can be higher than $e + r$. The lower the ratio l_R , the higher the latter can be. As mentioned above, CB operations determine at each point in time both the domestic interest rate and the exchange rate. The sustainability of these operations depends on both domestic and international interest rates, on l_R and also on the exchange rate's trend.

The maximum interest rate that maintains the sustainability of sterilization policy is:

$$i_{max} = (r + e) / l_R$$

Therefore, the degree of monetary autonomy is:

$$g = i_{max} - (r + e) = (r + e) (1 - l_R) / l_R$$

The degree of monetary autonomy i.e. the difference between the maximum sustainable domestic interest rate and $r + e$ is thus expressed as a proportion of $r + e$. The lower l_R , the higher the degree of autonomy.

IV. THE CENTRAL BANK'S FINANCIAL (QUASI-FISCAL) RESULT³

The CB's financial result is

$$Cf \approx RE (r + e) - iL$$

The condition of non-negative financial results is

$$Cf \approx RE (r + e) - iL \geq 0 \quad (7)$$

³ This point was suggested by Javier Okseniuk

By dividing by $R E$ we obtain

$$Cf/R E \approx r + e - i l_R \geq 0$$

from where

$$i \leq (e + r) / l_R = i_{max} \quad (8)$$

Expression (8) is the same as the sustainability condition (6) that we derived above. That condition is equivalent to the CB having non-negative financial results.

A numerical example with approximate data on Argentina at the end of 2006

In order to illustrate the presented results, as it follows we calculate the indicators with data approximately similar to those showed by the Argentine economy at the end of 2006.

We assume $r = 4\%$; $e = 3\%$; $i = 10\%$; $l_R = 43\%$. Hence, the maximum interest rate that allows the sustainability is:

$$i_{max} = (r + e) / l_R = 16.3\%$$

i.e. the sterilization policy is sustainable with domestic interest rates that could reach levels up to 16.3%. The current interest rate at that moment was 10%, i.e. lower than the maximum sustainable rate, thus the sterilization policy satisfied the sustainability condition.

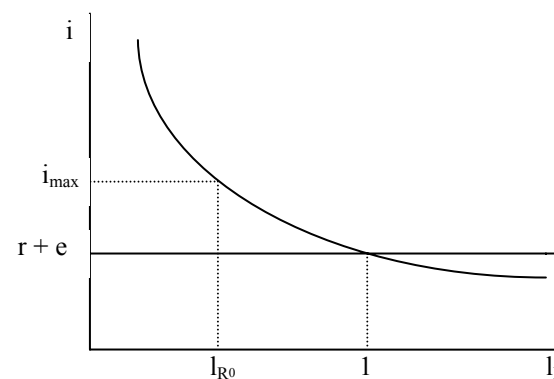
The degree of monetary autonomy with the mentioned parameters is:

$$g = i_{max} - (r + e) = 9.3\%$$

The interest rate could surpass the sum of the international interest rate plus the rate of growth of the exchange rate by 9.3 percentage points without making the sterilization policy unsustainable. With the considered parameters there was a wide margin of monetary autonomy.

V. THE DYNAMICS OF THE SUSTAINABILITY CONDITION

Given r y e , the sustainability condition (6) establishes at each point in time the range of interest rates that preserve the sustainability of sterilization as a function of l_R . The relationship can be seen in the following graph



The curve shows the relationship between i_{max} and l_R . At time 0, the ratio between the CB's interest-bearing liabilities and the value of foreign reserves is l_{R0} and the interest rates that preserve the sustainability are lower than i_{max} . At that moment, the degree of monetary autonomy g is measured by the distance between i_{max} and $r + e$ on the vertical axis.

The ratio l_R varies over time, thus changing the range of sustainable interest rates and the degree of monetary autonomy. As l_R moves along the horizontal axis over time, the curve determines the maximum interest rate, the range of sustainable rates and the degree of monetary autonomy on the vertical axis.

These considerations suggest analyzing the sustainability-condition trend in order to determine whether the maximum interest rate that allows the sterilization policy sustainability tends to increase or decrease as time goes by. Or, what is the same thing, if the evolution of monetary variables and the foreign exchange market tends to increase or reduce the degree of monetary autonomy.

VI. THE PERMANENCE CONDITION

For the mentioned purpose, we define the permanence condition of the degree of monetary autonomy as:

$$d(L/R E) = dl_R \leq 0 \quad (9)$$

If the monetary variables and the foreign exchange market satisfy condition (9) it means that both the maximum sustainable interest rate and the degree of monetary autonomy tend to either remain stable or rise. If condition (9) is not verified, the degree of monetary autonomy tends to decrease. We now proceed to express the permanence condition as a function of variables representing the evolution of the monetary and foreign exchange markets.

From (9) we make

$$d(L/R E) = [dL R E - L d(R E)] / (R E)^2 \leq 0 \quad (10)$$

By taking into account that $dL = dP - dB$ and by replacing (1), (2) y (3) into (10), after some simplifications we obtain:

$$C E + iL - B \beta (p + y) - L (C/R + r + e) \leq 0$$

It is convenient to regroup the terms so as to leave on the left side of the expression only those terms that include C , i.e. the flow of foreign currency purchases by the CB:

$$C/(L/E) - C/R \leq r + e - i + (B/L) \beta (p + y)$$

By taking into account that $l_R = (L/E)/R$ and by regrouping the terms we obtain:

$$C/R \leq [l_R / (1 - l_R)] \{ (B/L) \beta (p + y) - [i - (r + e)] \} \quad (11)$$

Given the interest rate and the exchange rate trend, both determined by the CB, the latter has no control over the excess supply of foreign currency in the foreign exchange market. The permanence of the degree of autonomy is verified if the mentioned variables satisfy condition (11). In this expression the permanence condition is formulated as a restriction on the flow of foreign currency purchased by the CB, as a proportion of the foreign reserves stock. In order that the sustainability condition remains stable or

the degree of autonomy increases, the ratio C/R must not be higher than the right member of (11). A greater flow of purchases imply that the degree of autonomy tends to decrease.

The right side of expression (11) includes all the variables concerning the monetary structure and the dynamics of the economy. The restriction depends positively on l_R , on the ratio between the monetary base and the stock of interest-bearing liabilities and on the rate of growth of the demand for monetary base. Hence, the greater the mentioned variables are, the larger may be the purchases of the CB in the foreign exchange market without affecting the permanence of the sustainability condition. On the other hand, the restriction depends negatively on the difference between the current domestic interest rate and $r + e$.

[Another numerical example with approximate data on Argentina at the end of 2006](#)

We assume at the end of 2006: $B/L = 1.75$, the elasticity $\beta = 1$, $i = 10\%$, $r = 4\%$, $e = 3\%$, $l_R = 43\%$, the stock of foreign reserves $R = \text{us\$ } 31$ billions, and the projected rate of growth of nominal GDP for 2007 $(p + y) = 19\%$.

The term $[l_R / (1 - l_R)] = 0.75$

With these data, the following permanence condition results from expression (11):

$$C/R \leq 22.7\%$$

The permanence of the degree of monetary autonomy that prevailed at the end of 2006 required that the flow of purchases of dollars was not greater than 22.7% of foreign reserves, i.e. about us\$ 7 billions annually. A greater flow of purchases tends to reduce the maximum sustainable rate and the degree of monetary autonomy.

In fact, for 2007 it was projected a flow of foreign-currency purchases that was higher than the volume that would allow the permanence of the degree of monetary autonomy, but this is not too worrisome because the resulting increase in l_R , given the other parameters, has a relatively small effect on the maximum sustainable interest rate and the degree of monetary autonomy. In effect, dl_R can be directly computed from equation (10) and the values of the parameters put forward. If we assume, for example, $C/R = 40\%$, it results that l_R increases 10 percentage points in one year (from 43% to 53%) and given the other parameters, the maximum sustainable rate decreases 0.7% (from 16.3% to 15.6%).

On the other hand, it is worth stressing the sensitivity of both the maximum sustainable rate and the degree of monetary autonomy to the exchange rate trend. For example, with $l_R = 43\%$, for each percentage point that the exchange rate increases (decreases), the maximum sustainable interest rate increases (decreases) $1\% / 0.43 = 2.33\%$. If the rate of growth of e is zero instead of 3% annually, the maximum interest rate falls 7 percentage points, from 16.3% to 9.3%.

VII. TWO INTERESTING CASES

As it follows we consider two interesting cases of application of the sustainability and permanence conditions that we derived above, which illustrate the degree of monetary autonomy in different circumstances.

In both cases the exchange rate policy keeps the real exchange rate constant. Hence, in both cases:

$$e = p - p^*$$

where p^* is the international inflation rate.

Case 1

In case 1 the domestic inflation rate equals the international inflation rate, $p = p^*$, so that $e = 0$. By substituting in (6), the sustainability condition in this case is:

$$i \leq r / l_R = i_{max}$$

If $l_R < 1$, there exists some degree of monetary autonomy despite the fact that the rate of variation of the exchange rate is zero.

The permanence condition in this case is:

$$C/R \leq [l_R / (1 - l_R)] [(B/L) \beta (p + y) - (i - r)] \quad (12)$$

The CB can buy foreign currency and preserve the degree of monetary autonomy as long as the flow of purchases satisfies condition (12) and the expression is positive. This is:

$$(B/L) \beta (p + y) > (i - r)$$

The condition states that the increase in the demand for monetary base – which is a function of the rate of inflation and the rate of growth- in proportion to the stock of interest-bearing liabilities must be higher than the difference between the domestic and the international interest rates.

This condition is not extraordinary at all. In order to illustrate the point we assign arbitrary –though plausible- values to the parameters so as to simplify the calculations. Let the following condition hold:

$$l_R = 0.5; (B/L) = 1 \text{ y } \beta = 1.$$

With the mentioned value for l_R , the maximum sustainable rate is twice as high as the international rate. With these parameters the permanence condition is:

$$C/R \leq p + y - (i - r)$$

Or, put in another way:

$$i - r \leq p + y - C/R$$

Let us assume, for example, $p = p^* = 3\%$; the inflation rate; $y = 6\%$ the rate of growth and $r = 5\%$ the international interest rate. With these data, the degree of monetary autonomy does not fall, for example, when i is not more than two percentage points higher than r , and the annual purchases of the CB do not represent more than 7% of foreign reserves. In this example the maximum sustainable rate is $i_{max} = 10\%$; greater purchases than the ones mentioned gradually reduce the latter rate although in the short run they do not make the sterilization policy unsustainable.

Case 2

In case 2 the economy exhibits an inflation rate that is higher than the international rate, $p > p^*$, so that $e = p - p^* > 0$. In this case the CB implements an *inflation targeting* policy by applying a truncated Taylor rule (without taking output into account):

$$i = \gamma p \quad (13)$$

where $\gamma > 1$ is the parameter of the monetary rule. We want to determine the maximum sustainable value for this policy parameter.

By substituting the exchange rate in expression (6), the sustainability condition of the sterilization policy becomes:

$$i \leq (r + p - p^*) / l_R = i_{max}$$

By substituting (13) into this expression we obtain:

$$\gamma p \leq (r + p - p^*) / l_R$$

from where:

$$\gamma \leq [1 + (r - p^*) / p] / l_R \quad (14)$$

The right side of expression (14) is the maximum value of the policy rule parameter that preserves the sustainability of sterilization policy. The term between brackets is 1 plus the ratio between the international real interest rate and the domestic inflation rate. If $l_R < 1$, values of γ quite higher than 1 become clearly sustainable.

By substituting the rate of variation of the exchange rate, the permanence condition turns out to be:

$$C/R \leq [l_R / (1 - l_R)] \{ (B/L) \beta (p + y) - [i - (r + p - p^*)] \}$$

and by replacing by the policy rule (13) and grouping:

$$C/R \leq [l_R / (1 - l_R)] \{ (B/L) \beta (p + y) - [(\gamma - 1) p - (r - p^*)] \} \quad (15)$$

The permanence of the sustainability condition is verified as long as the purchases of foreign currency satisfy condition (15) and the expression is positive. This is:

$$(B/L) \beta (p + y) > (\gamma - 1) p - (r - p^*)$$

The condition says that the increase in the demand for monetary base, in proportion to the stock of interest-bearing liabilities, must be higher than the difference between the domestic real interest rate $(\gamma - 1) p$ and the international real interest rate.

As we did in the previous case, we assign arbitrary –though plausible– values to the parameters so as to illustrate the results in a simple manner. Let the following condition hold:

$$l_R = 0.5; (B/L) = 1 \text{ y } \beta = 1.$$

The permanence condition (15) then becomes:

$$C/R \leq (p + y) - [(\gamma - 1) p - (r - p^*)]$$

Let us assume, for example, that the international inflation rate is $p^* = 3\%$, the international interest rate is $r = 5\%$, the domestic inflation rate is $p = 10\%$; the rate of growth is $y = 6\%$; and the policy parameter is $\gamma = 1.5$ (hence, the domestic interest rate $i = 15\%$).

With these data, the maximum sustainable level for the parameter γ is 2.4 and the permanence of the sustainability condition is verified if the annual purchases of foreign currency do not represent more than 13% of foreign reserves. As can be seen, there is a wide degree of monetary autonomy and its permanence is verified in conditions that are not at all extraordinary.

It seems interesting to consider a numerical example with a lower rate of growth (which implies a lower rate of growth of the demand for monetary base) and a tighter disinflationary policy (which implies a higher sterilization financial cost), similar to those observed in Brazil in recent years. We assume that the rate of growth is $y = 3\%$ and the policy parameter is $\gamma = 2$. In this numerical example the sterilization policy is also sustainable. However, the permanence of the degree of autonomy is verified as long as the annual purchases by the CB are not higher than 5% of the foreign reserves stock. It must be stressed again that higher purchases do not mean that the sterilization policy becomes quickly unsustainable, but rather that the degree of autonomy gradually decreases. If the flow of purchases by the CB is higher than the mentioned one, once the expansion of interest-bearing liabilities annuls the difference between the maximum sustainable value of the parameter and the parameter applied, the CB must choose between maintaining the policy rule, which becomes unsustainable, and preserving the real exchange rate. In this example, the sustainability problem comes from the fact that the rate of growth is very low and the interest rate is very high.

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