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and Money Demand"*

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Currency Substitution, Portfolio Diversification and Money Demand

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We extend the Thomas (1985) dynamic optimising model of money demand and currency substitution to the case in which the individual has no access to bonds denominated in foreign currency. We show that in this case the demand for domestic money is influenced by portfolio decisions. Contrary to what defended by the Portfolio Balance Approach to currency substitution, the results obtained in this paper suggest that the significance of an expected exchange rate depreciation term in the demand for domestic money provides a valid test for the presence of currency substitution. The results also suggest that, in countries facing monetary instability and currency substitution, restricting the availability of interest-bearing assets denominated in foreign currency may have a destabilising impact on the money demand.

JEL Classification: E41, F41, G11.

Keywords: Money Demand, Currency Substitution, Dollarisation, Portfolio Choice.

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1. Introduction

During periods of macroeconomic and political uncertainty, many developing countries experienced a partial replacement of the domestic currency by a foreign currency, either as store of value, unit of account or medium of exchange. This phenomenon is known as *currency substitution* (CS). CS results from the existence of substitutability between currencies (though it is not necessarily implied by it) and it may take place both at the domestic level and in the international arena. CS is a matter of concern for policymakers, as it rises the unpredictability of the money demand and reduces the effectiveness of monetary policy, even under flexible exchange rates (see Giovannini and Turtelboom, 1994, for a survey).

This paper explores the implications of imperfect currency substitutability on the properties of the money demand, using a stochastic dynamic optimising model in which the specific role of money is explicitly accounted for. In particular, it is assumed that money reduces the frictional losses from transacting in the goods market. This feature of the model is essential to distinguish the phenomenon of currency substitution from portfolio choice. The paper compares two extreme assumptions concerning capital mobility: the case in which the consumer has unrestricted access to bonds denominated in foreign currency and the case in which the consumer cannot hold such bonds. In both cases, the individual is allowed to hold an interest-bearing asset denominated in domestic currency, implying that domestic money is dominated as store of value. The first case draws on Thomas (1985). This author demonstrated that borrowing and lending opportunities separate the ownership of currencies from portfolio decisions. That is, on one hand, a consumer selects his currency holdings based on transaction services and user costs. On the other hand, she borrows or lends to achieve a desired denomination structure for the overall portfolio that is independent of the currency holdings.

The Thomas' separation result depends critically on the assumption of complete bond markets. As pointed out by Cuddington (1989), such assumption may not be suitable to describe the demand for money in countries where asset markets are illiquid. Our contribution is to extend the Thomas (1985) model to a case in which the consumer has no access to bonds denominated in foreign currency. This is the appropriate set-up to describe the demand for money in economies subject to capital controls or in economies where the openness of capital markets did not reach a significant part of the population.

An obvious implication of banishing interest bearing assets denominated in foreign currency from the individual portfolio is that foreign bank notes get a store of value role, in addition to the eventual means of payment role. The double role that foreign bank notes may have under asset holding constraints and currency substitution is formally described in this paper. We show that in case the domestic and foreign money are substitutes as means of payment, the demand for domestic money will be influenced by portfolio decisions. This is not to say that there will be a portfolio demand for domestic money. Since domestic money is dominated by an interest-bearing asset, its demand will be driven by transactions purposes, only. Means of payment substitutability opens however a channel through which portfolio adjustments involving foreign money balances impact on the liquidity value of the domestic currency.

The money demand properties in this model are, thus, different from those postulated by the Portfolio Balance Model (PBM) of currency substitution (Cuddington, 1983). In light of that theory, money is viewed as a simple asset, that is gross substitute of all other available assets. When foreign currency and foreign bonds are both available, this leads to a demand for domestic money that depends negatively on the expected exchange rate depreciation by two different channels: currency substitution and capital mobility. For this reason, followers of the PBM have argued that currency substitution and capital mobility are statistically indistinguishable.

In contrast to that theory, the model explored in this paper assumes that money provides liquidity services. This allows home and foreign currency to be substitutes for transactions as opposed to store of value substitution. Comparing the results obtained under extreme assumptions concerning asset availability and currency substitutability, we show that only in case the two currencies are substitutes as means of payment will the demand for domestic money depart from the closed economy specification. This suggests that the significance of an expected depreciation term in the demand for domestic money provides a valid test for the presence of Currency Substitution.

This result is rather convenient for empirical purposes. A well known limitation in the empirical analysis of currency substitution is that data of foreign bank notes held by the public are not easily available. For this reason, many empirical studies have proxied this variable by the amount of foreign currency deposits (FCD) held in the banking system¹. Such proxy, has been, however, under criticism: on one hand, it is sensitive to swaps between foreign bank notes and FCD, which do not necessarily reflect currency substitution²; on the other hand, in countries with underdeveloped capital markets, interest bearing FCD may have a role more comparable to that of foreign bonds than that of foreign currency. If that is so, a proxy based on FCD will capture the extent of financial dollarisation but not necessarily currency substitution (Sahay and Végh, 1996). If, according to our results, the currency substitution hypothesis can be assessed estimating directly the demand for domestic currency, then these data limitations are circumvented. Another implication of our results is that, in countries facing monetary instability and currency substitution,

¹ In some developing countries, residents' bank deposits denominated in foreign currency were legalised, with the aim to raise credibility on the domestic monetary policy and to stop capital flight. Where this was done, monetary statistics are providing figures on a regular basis. Since these deposits are likely to grow fast in periods of erosion of macroeconomic conditions, thus accompanying the general shift towards foreign monetary assets, they have been used as a proxy for the extent of CS in many empirical studies.

² This problem is likely to occur when the institutional framework of FCD is not stable. For example, in Mexico, Peru and Argentina, FCD declined in periods of rising inflation, either because of changes in their legal status or due to the erosion of the public confidence in their legal status (Rogers, 1992, Kamin and Ericsson, 1993, Savastano, 1996).

restricting the availability of interest-bearing foreign assets may rise the unpredictability of the money demand. This result somehow challenges the view that bank deposits denominated in foreign currency are a source of financial distress and, therefore, should be restricted.

A recent debate on the empirical implications of different institutional set-ups concerning the availability of assets denominated in foreign currency may be seen in Whited (2004) and Alami (2004). However, these authors follow the aggregative tradition of postulating money demand functions that depend on income and opportunity costs, rather than deriving the money demand properties from individual optimisation.

In the last few years, there has been an increasing attention to the role of money as vehicle for transactions. The search-theoretic approach introduced by Kiyotaki and Wright (1989) is probably the more promising line of research. In that model, individuals are matched randomly to trade goods and a swap will occur whenever both individuals find their consumption good or if they decide to accept a good as means of payment. Extensions of the model to dual fiat currency equilibria include Matsuyama et al. (1993), Shi (1995), Trejos and Rich (1995) and Zhou (1997). Despite the significant progress, these models have the inconvenient of treating money as indivisible and of allowing agents to hold only one type of money or one type of good at a time. Given these limitations, an alternative way of getting money into models is postulating some sort of transactions technology (see, for example, Sims, 1994, Woodford, 2000).

Models of currency substitution in which currencies are viewed as providing liquidity services include Agénor and Khan (1996), Ratti and Jeong (1994), Rogers (1990) and Végh (1989). Since these models assume away uncertainty, however, they cannot describe the portfolio role that foreign banknotes may have in high inflation countries. Imrohroglu (1994) solves a stochastic version of the same model, but the author does not explore the implications of exchange rate uncertainty on the properties of the money demand. Sahay and Végh (1996) refer to the Thomas

(1985) model to describe a case of "asymmetric" CS in which individuals have no access to bonds denominated in foreign currency³. However, in their framework, consumers are allowed to hold interest bearing foreign currency deposits, which play in the model the role of the missing bond. Hence, their analysis does not depart from the original Thomas (1985) model. Rojas-Suarez (1992) discusses a more restricted case in which the consumer has no access to other assets than domestic and foreign money. In this case a portfolio demand for domestic money arises. Such framework may be however too restrictive to describe the demand for money, even in developing countries.

The paper focuses on a particular case of "asymmetric" CS, in which a *local* currency is replaced by an *international* currency in a function performed by the former in the domestic economy. This case shall be distinguished from "international CS", which refers to the functions performed by the major currencies in the global economy (for the functions of international currencies, see Krugman, 1984). The model shares with Thomas (1985) and Rojas-Suarez (1992) the fact that only imperfect means of payment substitutability is allowed for. Recent theories have related imperfect substitutability between currencies to the existence of transaction costs, either associated to purchases of foreign currency or to the use of foreign currency as vehicle for transactions (Guidotti and Rodriguez, 1992, Chang, 1994, Uribe, 1997, Sturzenegger, 1997, Engineer, 2000). In contrast to this literature, in this paper imperfect means of payment substitution is postulated. The implications of perfect means of payment substitutability when agents face no binding restrictions on currency holdings are discussed in Kareken and Wallace (1981). Freitas (2004) discusses the implications of perfect means of payment substitutability in the asymmetrical case, in which foreign residents cannot hold domestic money.

³ Ramirez-Rojas (1985) suggested that currency substitution should be classified as "symmetrical" when residents and non-residents simultaneously hold domestic and foreign currency, and as "asymmetrical", when there is no demand for domestic currency by non-residents.

The paper proceeds as follows. In Section 2, we present the basic model. In Section 3, we discuss the money demand properties under imperfect means of payment substitutability and complete bond markets. In Section 4, we examine the implications of means of payment substitutability on the properties of the money demand when the consumer has no access to interest-bearing foreign assets. Section 5 addresses the empirical implications of the results obtained. Section 6 concludes.

2. The model

Consider an infinitely lived consumer, living in a small open economy. There is only one (non-storable) consumption good, which domestic price is equal to P . The consumer is endowed with a constant flow of the good, denoted by y . The consumer maximises the expected value of a discounted sum of instantaneous utility functions of the form:

$$\mathbb{E} \int_0^{\infty} e^{-\beta t} \frac{c_t^{1-\phi}}{1-\phi} dt, \quad (1)$$

where c_t denotes for real consumption at time t , β is a positive and constant subjective discount rate and $\phi > 0$ is the Arrow-Pratt measure of relative risk aversion.

The individual has unrestricted access to domestic currency (called peso, M) and foreign currency (dollar, F). Bonds denominated in domestic currency (A) and in foreign currency (B) may also be available, depending on the institutional framework under consideration. In this and next sections, we formulate the unrestricted case. Restrictions on bond availability are examined in sections 4 and 5. The individual' real wealth is defined as⁴:

$$w = m + f + a + b, \quad (2)$$

where $m = M/P$, $f = EF/P$, $a = A/P$, $b = EB/P$, P is the domestic price level and E is the price of the dollar in peso-units.

⁴ Such framework may look too restrictive to describe the demand for money in high inflation countries, as it banishes real assets from the individual portfolio. In Appendix 1 we extend the model to the presence of a real asset. This leads to a currency substitution problem that is embedded in the optimal portfolio choice between the safe asset and the risky assets. Such an extension captures the role that indexed bonds may have as a tool against financial dollarisation - as it happened in countries like Brazil and Chile - but the main message concerning the properties of the money demand does not change qualitatively.

Domestic and foreign securities have certain nominal returns, represented by i and j , respectively. Currency holdings earn zero nominal returns. There is uncertainty, however, concerning real returns. The consumer takes the inflation rate as exogenous, because individually she cannot influence the price level. She may, however, perceive the price level and the exchange rate to be correlated. To capture this, it is assumed that the domestic price level and the exchange rate evolve stochastically, according to⁵:

$$\frac{dP}{P} = \pi dt + \sigma dZ, \quad (3)$$

and

$$\frac{dE}{E} = \varepsilon dt + \gamma dX, \quad (4)$$

where dZ and dX are standard Wiener processes with instantaneous correlation equal to r . Denoting by $\rho = \sigma\gamma r$ the covariance between the stochastic processes (3) and (4) and using the Ito's lemma, we obtain the real returns to domestic bonds, domestic money, foreign bonds and foreign money:

$$\frac{da}{a} = (i + \sigma^2 - \pi)dt - \sigma dZ, \quad (5)$$

$$\frac{dm}{m} = (\sigma^2 - \pi)dt - \sigma dZ, \quad (6)$$

$$\frac{db}{b} = (j + \varepsilon + \sigma^2 - \pi - \rho)dt - \sigma dZ + \gamma dX, \quad (7)$$

⁵ With such specification, asset demands will be neutral in respect to the domestic inflation rate. Thomas (1985) deflated domestic assets by the domestic price level and foreign assets by the foreign price level and introduced uncertainty in the foreign inflation rate, instead as on the exchange rate. Although the two approaches are equivalent for the issues being discussed here, the specification above looks more appealing to describe the case of dollarisation, in which a foreign currency can be used along with the domestic currency as vehicle for transactions that take place in the *domestic* economy.

$$\frac{df}{f} = (\varepsilon + \sigma^2 - \pi - \rho)dt - \sigma dZ + \gamma dX. \quad (8)$$

Money is distinguished from bonds in that it provides liquidity services. We assume that money reduces frictional losses from transacting in the good markets⁶. Purchases of the consumption good are subject to a transaction cost, τ , that depends positively on the real consumption level (c) and negatively on the amount of real money balances. To allow for currency substitution, it is assumed that both the domestic currency and the foreign currency serve as a media of change. To keep in shape with simplicity, we will refer to a particular transactions technology, introduced by Végh (1989):

Assumption 1. (The transactions technology): $\tau(\cdot)$ is a non-negative, twice continuously differentiable and convex function of the form:

$$\tau = cv \left[\frac{m}{c}, \frac{f}{c} \right], \quad (9)$$

with $v(\cdot) > 0$, $v_1 < 0$, $v_2 < 0$, $v_{11} > 0$, $v_{22} > 0$, $v_{12} \geq 0$ and $\Delta = v_{11}v_{22} - v_{12}^2 > 0$.

In (9), τ refers to the amount of real resources spent in transacting and a subscript k ($k=1,2$) to the function $v(\cdot)$ denotes partial differentiation with respect to the k argument. Linear homogeneity and the assumption that additional real money balances (either domestic or foreign) bring about diminishing reductions in transaction costs are not necessary for the main propositions to hold, but help, respectively, to simplify the algebra and to assure well behaved money demand functions⁷.

⁶ An alternative specification would assume that money enters in the utility function. The two approaches become functionally equivalent when the utility function is weakly separable, as happens to be the case in most of the currency substitution literature. For a stochastic model with money in utility, currency substitution and complete bond markets, see Smith (1995).

⁷ As shown by Sahay and Végh (1996) and briefly reviewed in Section 3, in the case with complete bond markets, these conditions are sufficient to obtain sensible money demand functions. In Section 4, we show that, when

The fact that foreign currency provides liquidity services does not necessarily imply means of payment substitutability. Suppose, for example, that some fraction of the consumption bundle is purchased using pesos only and that the remaining fraction is purchased using dollars only. In that case, there is no substitutability. Means of payment substitutability occurs when some fraction of the consumption bundle can be purchased with either currency⁸. We might expect that the effect on transaction costs of increasing the holdings of one currency depends critically and negatively on the holdings of the other currency. Formally, this can be stated in the following way:

Definition 1. (*Means of payment substitutability*): the domestic and foreign currency are said to be substitutes as means of payment if the cross derivative v_{12} in equation (9) is strictly positive.

The flow budget constraint depends on the amount of saved wealth allocated to the available assets and on real returns:

$$dw = dm + df + da + db + [y - c - \tau(\cdot)]dt . \quad (10)$$

Using (9) and (5)-(8), the flow budget constraint of the representative consumer becomes:

$$dw = \Phi dt + (w - a - m)\gamma dX - w\sigma dZ , \quad (11)$$

with

$$\Phi = (\sigma^2 - \pi)m + (\varepsilon + \sigma^2 - \pi - \rho)f + (i + \sigma^2 - \pi)a + (j + \varepsilon + \sigma^2 - \pi - \rho)b + y - c[1 + v(\cdot)] .$$

The consumer problem is to maximise (1), subject to the stochastic differential (11). In the following sections this problems is solved under two extreme assumptions concerning the availability of foreign bonds.

domestic agents have no access to bonds denominated in foreign currency, further assumptions are needed to obtain unambiguous interest-rate elasticities.

⁸ Note that this definition is inconsistent with the one used by Stockman (1980) and Svensson (1985). These authors imposed the restriction that each good (domestic and foreign) be bought with only one currency and related currency substitution to the change in money demands resulting from substitutability between goods.

3. The case with complete bond markets (Thomas, 1985)

In this section, we examine the case in which the individual faces no restrictions on asset holdings. As point out by Sahay and Végh (1996), this framework is also appropriate to describe the demand for money in a financially dollarised economy where residents have free access to bank deposits and liabilities denominated in foreign currency.

The Hamilton-Jacobi-Bellman equation of the quasi-stationary problem of maximising (1) subject to (11) is:

$$rV(w) = \max_{c,m,f,a} \left\{ \frac{c^{1-\phi}}{1-\phi} + V'(w)\Phi + \frac{1}{2}V''(w) \left[\gamma^2(w-m-a)^2 + \sigma^2w^2 - 2\sigma w(w-m-a)\rho \right] \right\} \quad (12)$$

where Φ is defined as in (11). Using (2) to eliminate b from Φ and using the first order conditions with respect to a , m and f , respectively, one obtains:

$$\frac{b+f}{w} = \left(\frac{1}{\phi} \right) \left(\frac{j+\varepsilon-i}{\gamma^2} \right) + \left(1 - \frac{1}{\phi} \right) \left(\frac{\rho}{\gamma^2} \right), \quad (13)$$

$$i + v_1 \left(\frac{m}{c}, \frac{f}{c} \right) = 0, \quad (14)$$

$$j + v_2 \left(\frac{m}{c}, \frac{f}{c} \right) = 0. \quad (15)$$

Equation (13) is the well known optimal portfolio rule in a world with two assets (see Branson and Henderson, 1985, for a survey). It states that the optimal share of assets denominated in foreign currency is a weighted average of two terms, the weights depending on the coefficient of relative risk aversion, ϕ . The first term is the speculative component. The second term is the hedging component. The term ρ/γ^2 gives the proportion of assets denominated in dollars that minimises the portfolio's purchasing power risk. According to (13), the consumer is induced to

move away from the minimum risk portfolio by the expected return differential and the extent to which it moves depend on its risk aversion.

Equations (14) and (15) define implicitly the money demand functions. They state that the consumer should hold each currency until the marginal peso (dollar) produces additional transaction services equal in value to its user cost⁹. To investigate the money demand properties, we take differences in (14)-(15):

$$di = -\frac{v_{11}}{c} dm - \frac{v_{12}}{c} df + \left(\frac{mv_{11}}{c^2} + \frac{fv_{12}}{c^2} \right) dc,$$

$$dj = -\frac{v_{21}}{c} dm - \frac{v_{22}}{c} df + \left(\frac{mv_{21}}{c^2} + \frac{fv_{22}}{c^2} \right) dc.$$

Solving for dm and df , and computing the partial derivatives, the following properties are obtained¹⁰:

$$m = cL^m(i, j), \text{ with } L_i^m = -\frac{cv_{22}}{\Delta} < 0 \text{ and } L_j^m = \frac{cv_{12}}{\Delta} \geq 0, \quad (16)$$

$$f = cL^f(i, j), \text{ with } L_i^f = \frac{cv_{21}}{\Delta} \geq 0 \text{ and } L_j^f = -\frac{cv_{11}}{\Delta} < 0. \quad (17)$$

A particular case occurs when there is no means of payment substitution ($v_{12} = 0$). In that case, the system simplifies to:

$$m = cL^m(i), \quad \text{with } L_i^m = -\frac{c}{v_{11}} < 0 \quad (16a)$$

⁹ Conditions similar to (14) and (15) were first obtained by Miles (1978), in the context of the *two-step* model of liquidity services and currency substitution. In that approach, however, separability between portfolio decisions and currency substitution decisions was postulated. The proof that separability holds in the dynamic optimising model with complete bond markets is from Thomas (1985).

$$f = cL^f(j), \quad \text{with } L_j^f = -\frac{c}{v_{22}} < 0. \quad (17a)$$

To interpret, consider a rise in the expected exchange rate depreciation not imbedded in the interest rates ($d\varepsilon > 0, di = dj = 0$). According to (13), this causes a portfolio adjustment from domestic assets to foreign assets, for speculative reasons. As long as the user costs of holding money remain constant, however, such adjustment does not impact on currency holdings.

Now assume that the rise in expected exchange rate depreciation is accompanied by a rise in the domestic interest rate, so that the expected return differential remains unchanged ($d\varepsilon = di > 0, dj = 0$). From equation (13), we know that the optimal proportion of assets (money and bonds) denominated in each currency remains unchanged. However, since the user cost of the domestic currency rises, the consumer will optimally reduce the amount of domestic money balances. The remaining effects depend on whether the two currencies are substitutes or not as means of payment:

- If the currencies are not substitutes ($v_{12} = 0$), the adjustment involves only domestic assets. In order to keep the currency composition of the portfolio unchanged, the consumer switches from peso-currency to peso-bonds. The domestic money demand function (16a) is the same as in a closed economy¹¹.
- If the two currencies are substitutes as means of payment ($v_{12} > 0$), the fall in peso-currency holdings rises the marginal productivity of dollar bank notes. Thus, the demand for dollar-currency rises for transaction purposes. In order to keep the currency

¹⁰ Equations (16) and (17) are not in the reduced form because changes in the interest rates also impact on money demands through wealth effects. However, the aim of the exercise is to learn about money velocity, so as to obtain testable money demand functions.

¹¹ In the extreme case in which dollar bank notes provided no liquidity services at all (that is $v_2 = v_{22} = 0$), then condition (15) would not hold in equality and the optimal demand for dollars would be zero. The demand for pesos would still be as described by (16a).

composition of the overall portfolio unchanged, the consumer offsets such move buying peso-denominated bonds and selling dollar-denominated bonds.

These examples illustrate the Thomas (1985) separation result: on one hand, a consumer selects her currency holdings, based on each money's transaction services and its associated user cost. On the other hand, she borrows or lends to achieve her desired overall portfolio currency composition. An optimal currency hedge is created and the denomination structure of the individual portfolio is independent of the currency holdings. Changes in the expected exchange rate depreciation not embedded in the nominal interest rates affect the overall portfolio denomination but fail to influence the individual money demands.

4. Currency substitution when foreign bonds are not available

We now assume that individuals cannot hold bonds denominated in foreign currency. In this case, the following proposition holds:

Proposition 1 (non-separation). *If the consumer is constrained to have zero holdings of the foreign bond, then the optimal holdings of foreign bank notes obey to:*

$$\frac{f}{w} = \left(1 - \frac{1}{\phi}\right) \left(\frac{\rho}{\gamma^2}\right) + \left(\frac{1}{\phi}\right) \left(\frac{-v_2 + \varepsilon - i}{\gamma^2}\right) \quad (13a)$$

Proof: Maximise (1) subject to the stochastic differential (11) under the restriction $b=0$. Use equation (2) to eliminate f in the Hamilton-Jacobi-Bellman equation. The first order condition in respect to m leads to equation (14). The first order condition with respect to a simplifies to (13a).

Equation (13a) is similar to (13) with the difference that foreign currency plays the role of the missing bond¹². As in (13), the consumer is induced to move away from the minimum risk portfolio by the expected return differential and the extent to which it moves depend on its degree of risk aversion, ϕ . The novelty here is that, to the extent that foreign money holdings help reducing transaction costs (that is, $v_2 < 0$), this will be accounted for in the assessment of the expected return differential. Equation (13a) captures the double role that foreign bank notes may have in high inflation countries where individuals have no easy access to interest-bearing foreign assets¹³.

The following implication is straightforward:

***Corollary 1** (domestic money influenced by portfolio decisions). In the conditions of Proposition 1, if the domestic currency and the foreign currency are substitutes as means of payment, then the demand for domestic currency will be influenced by portfolio decisions.*

The intuition underlying Corollary 1 is quite simple: if the amount of dollar-currency holdings affects the moneyness of the peso-currency, then any variable influencing the demand for dollar-currency will influence the demand for peso-currency, even if the later is dominated as store of value.

To illustrate, we solve the system (13a)-(14) for m and f , using the transactions technology (9). Proceeding as before, the following properties are obtained:

$$m = cL^m(i, \varepsilon, \gamma),$$

¹² Note that nothing in this model prevents the individual from being short of foreign currency. For f to become negative, one needs either a low coefficient of relative risk aversion or a negative return differential. Our aim, however, is to discuss the case of high inflation countries, where the optimal demand for foreign currency is positive.

¹³ If the consumer had no access to any type of interest-bearing assets, one would obtain an optimal portfolio rule equivalent to (13a), except that i would be replaced by $-v_1$ in the interest differential. Currency substitution in a world without bonds was first discussed in the context of the monetary model by Calvo and Rodríguez (1977) and is analysed in the context of the liquidity services model by Rojas-Suarez (1992).

$$\text{with } L_i^m = \frac{w(v_{22} - v_{12}) + c\phi\gamma^2}{\Omega}, L_\varepsilon^m = \frac{wv_{12}}{\Omega} \leq 0 \text{ and } L_\gamma^m = -\frac{2f\gamma\phi v_{12}}{\Omega} \geq 0, \quad (16b)$$

$$f = cL^f(i, \varepsilon, \gamma),$$

$$\text{with } L_i^f = \frac{w(v_{11} - v_{21})}{\Omega}, L_\varepsilon^f = \frac{-wv_{11}}{\Omega} > 0 \text{ and } L_\gamma^f = \frac{2f\gamma\phi v_{11}}{\Omega} < 0, \quad (17b)$$

where $\Omega = -\Delta w/c - v_{11}\phi\gamma^2 < 0$.

In the particular case in which the two currencies are not substitutes as means of payment ($v_{12} = 0$) the demand for domestic money simplifies to the closed economy specification, (16a). The demand for foreign money becomes such that $L_i^f = -L_\varepsilon^f < 0$.

Interpreting, consider first a rise in the expected exchange rate depreciation not imbedded in the domestic interest rate ($d\varepsilon > 0, di = 0$). From (13a), this induces a portfolio shift from peso-bonds to dollar-currency. In the same manner, a decline in the exchange rate volatility ($d\gamma < 0$) induces agents to move away from peso bonds to buy dollar-currency. When the moneyness of the peso does not depend on the amount of dollar holdings, these developments do not impact on the domestic money demand. In the presence of means of payment substitutability, however, the demand for peso-currency will fall in response.

When the rise in the expected exchange rate depreciation is embedded in the domestic interest rate ($di = d\varepsilon > 0$), the demand for dollar-currency does not change for portfolio reasons. However, the rise in the user cost of the peso-currency leads agents to reduce the demand for domestic money. If the two currencies are substitutes, this will induce a rise in the demand for dollars as vehicle for

consumption. This is a pure currency substitution effect: the demand for pesos declines and the demand for dollars rises¹⁴.

It is important to observe that the signs of the partial derivatives with respect to the domestic interest rate in (16b) and (17b) are uncertain. To understand this, assume that the domestic interest rate raises alone ($di > 0$, $d\varepsilon = 0$). If there was no currency substitutability, this would lead to a decline in the demand for peso-currency (as in a closed economy) accompanied by a portfolio shift from dollar currency to peso-bonds (with $v_{12} = 0$, L_i^m and L_i^f are unequivocally negative). If the currencies are substitutes as means of payment, however, less money holdings in one currency denomination lead to a rise in the liquidity value of the other currency. To obtain negative elasticities ($L_i^m < 0$ and $L_i^f < 0$), it is sufficient to assume that own effects dominate over currency substitution effects (that is $v_{kk} > v_{12}$, with $k=1,2$). Other results are however consistent with $\Delta > 0$, in equation (9). For example, with $v_{22} > v_{12} > v_{11}$, one would obtain $L_i^m > 0$ and $L_i^f < 0$.

5. Implications for empirical work

In the earlier empirical literature on currency substitution (Miles, 1978, Ramirez-Rojas, 1985), the currency substitution hypothesis was tested evaluating the significance of a term capturing the expected exchange rate depreciation in the demand for domestic money. This procedure - which has also been adopted in recent estimates for the euro-area money demand (see Artis, 1996, for a survey) - was criticised by Cuddington (1983), in the context of the Portfolio Balance Model (PBM) of currency substitution.

¹⁴ Note that, since the marginal contribution of dollar-holdings to the reduction of transaction costs ($-v_2$) is decreasing, the expected return differential in (13a) changes, giving rise to a second round of effects, via portfolio

The PBM postulates gross substitutability between money and all other assets, leading to money demand functions that depend positively on income and wealth and negatively on the return of each alternative asset. When the available assets are domestic money, foreign money, domestic bonds and foreign bonds, the proposed functional form is (the sign above each argument refers to the respective partial derivative):

$$\frac{M}{P} = m \left(\overset{-}{i}, \overset{-}{j}, \overset{-}{\varepsilon}, \overset{+}{\varepsilon}, \overset{+}{y}, \overset{+}{w} \right) \quad (18)$$

The second argument of function (18) captures substitutability between the domestic currency and the foreign bond and the third argument captures substitutability between the domestic currency and the foreign currency. Since the demand for domestic currency depends negatively on the expected exchange rate depreciation both through substitutability vis-à-vis the foreign currency and substitutability vis-à-vis the foreign bond, followers of the PBM have claimed that currency substitution and capital mobility are statistically indistinguishable. Moreover, in light of that approach, it has been argued that CS does not constitute a qualitative difference relative to capital flight (Cuddington, 1983). Empirical exercises based on the PBM include Cuddington (1983), Rogers (1992), Mizen and Pentecost (1994), Akçay et. al (1997).

The PBM has two main shortcomings. First, as noted by Branson and Henderson (1985), gross substitutability is not always consistent with individual optimisation. Second, the model does not explain why money is held, despite being dominated by interest-bearing assets. A closer scrutiny of the properties of the money demand in light of firmer microeconomic foundations was made by Thomas (1985), for the case with complete bond markets. As shown in Section 3, in this

adjustment, that partially offsets the initial currency substitution effect.

case, there is no portfolio demand for money. From equations (14) and (14a), a possible test for the CS hypothesis in such framework is to investigate the significance of the foreign interest rate, j , in:

$$\frac{M}{P} = m\left(\overset{-}{i}, \overset{+}{j}, \overset{+}{y}\right). \quad (19)$$

The Thomas' model shall be seen as the centrepiece to test the CS hypothesis in countries with developed financial markets. Not surprisingly, this model has been used to test the presence of currency substitutability among major currencies (Joines, 1985, Bergstrand and Bundt, 1990, Mizen and Pentecost, 1994). Sahay and Végh (1996) used the same model to discuss the case of high inflation countries where bank deposits denominated in foreign currency are available. The Thomas model is less suitable, however, to describe the phenomenon of CS in countries where consumers have no access to interest-bearing foreign assets. As pointed out by Cuddington (1989), in that case, one expects the demand for foreign currency to have both a means of payment and a store of value role.

The results obtained in Section 4 give support to the Cuddington (1989) claim that, in the absence of foreign bonds, there will be a portfolio demand for foreign currency. They also suggest that, in case the two currencies are substitutes as means of payment, the demand for domestic currency will be influenced by portfolio considerations. However, our findings do not give support to an empirical test based on the PBM (18). In alternative, equations (16a) and (16b) suggest that a valid test for the presence of currency substitution in countries in which foreign bank notes play a store of value role is:

$$\frac{M}{P} = m\left(\overset{-}{i}, \overset{-}{\varepsilon}, \overset{+}{\gamma}, \overset{+}{y}\right). \quad (20)$$

This corresponds to the traditional test (Ramirez-Rojas, 1985), except for the inclusion of a term capturing exchange rate volatility.

Of course, equations (19) and (20) are based on extreme assumptions. In (19), individuals are allowed to borrow or lend any amount of foreign money, at a given interest rate. In (20), individuals are not allowed to hold bonds denominated in foreign currency. One may think, however, in economies composed by individuals of the two types. If a positive fraction of the population has access to bonds denominated in foreign currency while another positive fraction has not, probably a functional form combining elements of (19) and (20) would provide a suitable specification to start with when testing for CS in developing countries.

It may be argued that, under uncovered interest rate parity, the choice of the particular model to be estimated is less relevant. This does not change, however, the main message of the paper: irrespectively of the degree of capital mobility, only in the presence of means of payment substitutability will the demand for domestic money depart from the closed economy specification (16a). Thus, the CS hypothesis may be investigated, without ambiguity concerning the identification of the relevant effect.

6. Conclusions

The paper extends the Thomas (1985) dynamic optimising model of money demand and currency substitution to the case in which foreign bank notes are the only available asset denominated in foreign currency. In this case, foreign bank notes have a portfolio role in addition to the eventual means of payment role. We show that means of payment substitutability acts as a channel through which portfolio decisions influence the demand for domestic money, even if the later is dominated as store of value. Moreover, we show that only in case of currency substitutability will the demand for domestic money be influenced by open economy variables. This result contradicts the Cuddington (1983, 1989) very influential claim that the significance of an expected depreciation term in the demand for domestic money does not provide a valid test for the presence of currency substitution.

This result is rather convenient for empirical purposes. A well known limitation in the empirical analysis of currency substitution is that of measurability. Since data on foreign bank notes circulating in an economy are not easily available, many empirical studies have proxied the extent of currency substitution by the ratio of foreign currency deposits held in the banking system (FCD) to domestic money. This proxy has been criticised, however, on the grounds that FCD are mostly held for store of value reasons instead as for transaction purposes. Hence, a proxy based on this variable may capture the extent of financial dollarisation but not necessarily currency substitution. If, according to our results, the currency substitution hypothesis can be assessed estimating directly the demand for domestic currency, then these data limitations are circumvented.

The model also gives some insights on the implication of introducing (removing) capital controls in an economy facing monetary instability and currency substitution. As shown in the paper, if individuals have access to bonds denominated in foreign currency, money velocities will

respond to changes in the domestic and foreign interest rates, only. If, in alternative, foreign bonds and liabilities are not available, the money demands will respond to variables influencing portfolio decisions, namely the expected exchange rate depreciation, the inflation rate and respective volatilities. Since in countries facing nominal instability these variables are likely to be less stable than the foreign interest rate, the implication is that restricting the availability of interest bearing foreign assets may actually rise the unpredictability of the money demand. This result is at odds with the evidence is that financially dollarised economies tend to exhibit higher monetary instability than economies where assets and liabilities denominated in foreign currency are not allowed (Levy-Yeyati, 2004).

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Appendix 1 - Extension to the presence of a real asset

In this appendix we extend the model to the case in which the individual has access to an indexed bond, s , with a certain real return, r :

$$\frac{ds}{s} = rdt, \quad (\text{a1})$$

The real returns on a , m , b and f are given by (5), (6), (7) and (8), respectively. The individual maximises his lifetime expected utility function (1) subject to a flow budget constraint that may or may not account for holdings of foreign bonds.

Case 1: Foreign bonds available:

In this case, the individual real wealth is given by:

$$w = m + f + a + b + s \quad (\text{a2})$$

Re-formulating the flow budget constraint (10) and maximising, we obtain equations (14), (15), and:

$$\frac{s}{w} = 1 - \frac{[i + \sigma^2 - \pi - r]\gamma^2 + [j + \varepsilon - i - \rho]\rho}{\phi[\sigma^2\gamma^2 - \rho^2]} \quad (\text{a3})$$

$$\frac{b + f}{w} = \left(\frac{1}{\phi}\right)\left(\frac{j + \varepsilon - i - \rho}{\gamma^2}\right) + \left(1 - \frac{s}{w}\right)\left(\frac{\rho}{\gamma^2}\right) \quad (\text{a4})$$

Equations (14) and (15) state the separation between currency substitution and portfolio decisions. With the transactions technology (9), the money demand functions are as described by (16) and (17).

Equation (a3) gives the optimal demand for the safe asset as a function of the real return differential vis-a-vis the domestic bond, adjusted for the eventual non-independence between the

real returns of the domestic and the foreign bond (when $\rho=0$, this simplifies to the well known Merton formula). Equation (a4) differs from (13) in that the optimal proportion of assets denominated in foreign currency is now deduced by the weight of the safe asset in the individual portfolio (imposing $s=0$ in a4 one obtains equation 13). This equation captures the role that indexed bonds may have as a tool against financial dollarisation, as happened to be the case in countries like Brazil and Chile.

Case 2: No foreign bonds available

In this case, the individual real wealth is given by:

$$w = m + f + a + s \tag{a5}$$

The first order conditions of the corresponding maximisation problem lead to equation (14) and:

$$\frac{s}{w} = 1 - \frac{\rho[-v_2 + \varepsilon - i - \rho] + [i + \sigma^2 - \pi - r]\gamma^2}{\phi[\sigma^2\gamma^2 - \rho^2]} \tag{a6}$$

$$\frac{f}{w} = \left(\frac{1}{\phi}\right)\left(\frac{-v_2 + \varepsilon - i - \rho}{\gamma^2}\right) + \left(1 - \frac{s}{w}\right)\left(\frac{\rho}{\gamma^2}\right) \tag{a7}$$

The difference in respect to the model of section 4 is that the optimal proportion of assets denominated in foreign currency is now deduced by the weight of the safe asset in the individual portfolio (equation 13a is a particular case of (a7), with $s=0$). As before, in case the domestic and foreign currency compete in the same commodity domain ($v_{12} > 0$), the demand for domestic

money will be influenced portfolio decisions. The demand for domestic money will differ from (20) in that both the inflation rate and the inflation volatility enter as additional parameters¹⁵.

¹⁵ A different case occurs when there is no exchange rate uncertainty ($\rho=\gamma=0$). In that case, the foreign currency (f) has a role similar to that of interest-bearing time deposits denominated in domestic currency. Since in that case, both m and f are dominated by the domestic bond, their demands will be exclusively determined by the respective transaction services and opportunity costs (i and $i-\varepsilon$). The inflation rate and inflation volatility will influence the choice between the risky bond and the safe asset, but will not impact on money demands.

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