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Currency substitution, portfolio diversification, and money demand

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Abstract. We extend the Thomas (1985) dynamic optimizing model of money demand and currency substitution to the case in which the individual has restricted or no access to foreign currency denominated bonds. In this case currency substitution decisions and asset substitution decisions are not separable. The results obtained 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. Applying this approach to six Latin-American countries, we find evidence of currency substitution in Colombia, Dominican Republic, and Venezuela, but not in Brazil and Chile. JEL classification: E41, F41, G11

Substitution de devises, diversification de portefeuilles, et demande de monnaie. Les auteurs prolongent le modèle d'optimisation dynamique de demande de monnaie et de substitution de devises de Thomas (1985) au cas où l'individu a un accès restreint ou nul aux débetures en devises étrangères. Dans ce cas, les décisions de substitution de devises et de substitution d'actifs ne sont pas séparables. Les résultats obtenus suggèrent que la nature significative d'une variable enregistrant une dépréciation anticipée du taux de change dans l'équation de la demande de monnaie nationale fournit un test valide de la présence de substitution de devises. En appliquant cette approche à six pays d'Amérique latine, on découvre qu'il y a évidence de substitution de devises en Colombie, en République dominicaine, et au Vénézuéla, mais pas au Brésil et au Chili.

1. Introduction

During periods of macroeconomic and political uncertainty, many developing countries experience a partial replacement of the domestic currency by a foreign

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currency either as store of value, unit of account, or means of payment. The latter case is usually referred to as 'currency substitution.' Currency substitution is a demand-driven process that results from *means of payment substitutability* (though it is not necessarily implied by it) and will be distinguished from the broader concept of 'asset substitution' (or 'dollarization'), which refers to the switching from (monetary and non-monetary) assets denominated in domestic currency to (monetary and non-monetary) assets denominated in foreign currency.¹

This paper examines the implications of imperfect means of payment substitutability on the properties of the money demand, using a stochastic dynamic optimizing 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 (CS) from asset substitution (AS). This paper compares two alternative assumptions concerning capital mobility: first the case in which the consumer has unrestricted access to nominally riskless bonds denominated in foreign currency and then the case in which the consumer faces a binding restriction on foreign bond holdings. In both cases, the individual is allowed to hold an interest-bearing asset denominated in domestic currency paying a certain nominal return.

The first case draws on Thomas (1985). This author demonstrated that borrowing and lending opportunities separate CS decisions from AS decisions. Since money bears the same characteristics as (same currency) bonds and earns a lower return, it should not be held in the portfolio for the speculative and risk-diversification reasons that underlie the demand for financial assets in general (Thomas 1985, 354: 'in a model with a complete set of nominally riskless bonds there is no demand for money as a *portfolio asset*'). In this context, domestic and foreign money holdings are selected solely to satisfy transaction needs. The optimal denomination structure of the overall portfolio (AS), in turn, will reflect a balance between expected returns and currency risk. Through borrowing and lending, the individual is able to achieve the optimal level of AS, independently of his choice among monetary assets (CS).

Thomas's separation result depends critically on the assumption that bond markets are complete. As pointed out by Cuddington (1989), such an assumption may not be suitable to describe the demand for money in countries with imperfect capital mobility. The contribution of this paper is to extend the Thomas (1985) model to the case in which the consumer has restricted or 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 openness of capital markets has not reached a significant part of the population.

1 The terminology follows Sahay and Végh (1996). Different meanings for the terms *currency substitution* and *dollarization* are, however, common in the literature. For a survey, see Giovannini and Turtelbomm (1994).

The implication of introducing a binding constraint on foreign bond holdings is that foreign money assumes a store of value role, in addition to its eventual means of payment role. The double role that foreign money balances may have under asset-holding constraints and CS is formally described in this paper. We show that if the domestic and foreign monies are substitutes as means of payment, then the demand for domestic money will be influenced by speculative and risk-hedging decisions. This is not to say that domestic money will be demanded as a 'portfolio asset': since domestic money is dominated by an interest-bearing asset, its demand will be driven by transactions purposes only. Means of payment substitutability, however, opens a channel through which the optimal choice between assets denominated in different currencies impacts the liquidity value of the domestic money. In this context, separation of CS decisions and AS decisions no longer holds.

The money demand properties in this model are, thus, different from those postulated by the Portfolio Balance Approach to Currency Substitution (Cuddington 1983). In the light of that theory, money is viewed as a simple asset, that is, gross substitute of all other available assets. In a context where both foreign money and foreign bonds are available, this leads to a demand for domestic money that depends negatively on the expected exchange rate depreciation by two different channels: substitution vis-à-vis the foreign money (currency substitution) and substitution vis-à-vis the foreign bond (capital flight). For this reason, followers of the Portfolio Balance Approach have argued that the significance of an expected exchange rate depreciation term in the demand for domestic money does not provide a valid test for the presence of CS. In contrast to that theory, the model explored in this paper allows domestic and foreign monies to be substitutes for transactions, while their relevance as store of value depends on the availability of like-denominated bonds. We show that only in the case where the two monies are substitutes as means of payment will the demand for domestic money depart from the closed-economy specification. Moreover, our results give support to the procedure of testing for the presence of CS by assessing the significance of an expected exchange rate depreciation term in the demand for domestic money.

A well-known limitation in the empirical analysis of CS is that data on foreign banknotes held by the public are not easily available. For this reason, many authors have proxied the demand for foreign money by the amount of foreign currency deposits held by residents in the banking system. Other authors have developed methodologies to estimate the amount of foreign money held by the public. They include estimates based on the currency denomination of loans, on postulated money velocities, and on reports of shipments of dollar bank notes from the United States to these countries (see Krueger and Ha 1996 for a survey). Irrespective of the quality of these measures, they all face a fundamental limitation: wherever capital markets are not well developed and there is nominal instability, the demand for foreign money may mostly reflect a store of value motive. Thus, even if an accurate estimate of the demand for foreign money were available, this would tell us nothing of the extent to which foreign money

was replacing domestic money as a vehicle for transactions. If, according to our results, the presence of CS can be assessed estimating a demand function for domestic money, then this limitation is circumvented.

This paper focuses on the particular case of 'asymmetric' CS, in which a *local* currency is replaced by a *foreign* currency as a vehicle for transactions in the domestic economy. This case will be distinguished from 'international CS,' which refers to the competition among international currencies in the global economy (for the functions of international currencies, see Krugman 1984). This model shares with Thomas (1985) the fact that only imperfect means of payment substitutability is allowed for.² The implications of perfect means of payment substitutability are discussed in Kareken and Wallace (1981) for the case in which agents face no binding restrictions on money holdings, and in Lebre de Freitas (2004) for the 'asymmetric' case in which foreign residents cannot hold domestic money. Models postulating imperfect substitutability in the provision of transaction services include Agénor and Khan (1996), Rogers (1990), and Végh (1989). Since these models assume away uncertainty, however, they cannot describe the speculative and risk-hedging considerations that drive the demand for foreign money in high-inflation countries. Imrohorglu (1994) and Smith (1995) extend the analysis to a stochastic framework, but they do not explore the properties of the money demand under asset market restrictions. Sahay and Végh (1996) refer to the Thomas (1985) model to describe a case in which individuals have no access to bonds denominated in foreign currency. However, in their framework, individuals are allowed to hold interest-bearing foreign currency deposits, which play the role of the missing bond in the model. Hence, their analysis does not depart from the original Thomas (1985) model. 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 optimization.

The paper proceeds as follows: The basic model is presented in section 2. The money demand properties under imperfect means of payment substitutability and complete bond markets are discussed in section 3. The case in which the consumer faces a binding constraint on foreign bond holdings is examined in section 4. The empirical implications of the results obtained are addressed in section 5. In section 6, money-demand functions for six Latin-American countries are estimated for a period during which they imposed restrictions on capital flows, and we check whether there is empirical support for currency substitution in each country. The conclusions are presented in section 7.

2 Recent theories have related imperfect means of payment substitutability to the existence of transaction costs on the use of foreign currency. This includes Guidotti and Rodriguez (1992), Chang (1994), Uribe (1997), Sturzenegger (1997), and Engineer (2000).

2. The model

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

$$E \int_0^\infty e^{-\beta t} \frac{c_t^{1-\phi}}{1-\phi} dt, \tag{1}$$

where c_t denotes 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 money (called peso, M), foreign money (dollar, F) and bonds denominated in domestic currency (A). Bonds denominated in foreign currency (B) may or may not be freely available, depending on the institutional framework under consideration. In section 3, we discuss the unrestricted case. The case with restrictions on bond availability is discussed in section 4. The individual's real wealth is defined as³

$$w = m + f + a + b, \tag{2}$$

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.

Domestic and foreign bonds have certain nominal returns, represented by i and j , respectively. Money holdings earn zero nominal returns. There is uncertainty concerning the inflation rate and, hence, on real returns. The consumer takes the inflation rate as given, 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 to⁴

$$\frac{dP}{P} = \pi dt + \sigma dZ \tag{3}$$

$$\frac{dE}{E} = \varepsilon dt + \gamma dX, \tag{4}$$

- 3 Extending the model to the presence of a safe asset leads to a currency substitution problem that is embedded in the optimal portfolio choice between the safe asset and the risky assets (the Merton problem). This extension is available from the authors upon request.
- 4 With such specification, asset demands will be neutral with 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 of in the exchange rate. Although the two specifications are equivalent for the purposes of our discussion, the one followed in this paper looks more useful for describing the case in which foreign money can be used along with domestic money as vehicle for transactions that take place in the domestic economy.

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

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

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

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

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

Money is distinguished from bonds in that it provides liquidity services. We assume that money reduces frictional losses from transacting in the goods markets.⁵ 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 CS, it is assumed that both the domestic money and the foreign money serve as means of payment. For 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

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

they help, respectively, to simplify the algebra and to assure well-behaved money demand functions.⁶

The fact that foreign money 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 this case, there is no substitutability. Means of payment substitutability occurs when some fraction of the consumption bundle can be purchased with money denominated in either currency. In that case, one might expect the effect on transaction costs of increasing the holdings of one money to depend negatively on the holdings of the other money. Formally, this can be stated in the following way:

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

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

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

When (2), (9), and (5)–(8) are used, the flow budget constraint becomes

$$dw = \Phi dt + (b + f)\gamma dX - w\sigma dZ, \tag{11}$$

with

$$\begin{aligned} \Phi = & (\sigma^2 - \pi)m + (\varepsilon + \sigma^2 - \pi - \rho)f + (i + \sigma^2 - \pi)(w - m - f - b) \\ & + (j + \varepsilon + \sigma^2 - \pi - \rho)b + y - c[1 + v(\cdot)]. \end{aligned}$$

The consumer problem is to maximize (1), subject to the stochastic differential (11). To account for restrictions on foreign bond holdings, we formulate the problem, assuming that b is confined to the following control set:

$$\bar{b} - b \geq 0. \tag{12}$$

This constraint will be assumed to be binding or not, depending on the institutional framework under consideration. The Hamilton-Jacobi-Bellman equation of the corresponding quasi-stationary problem is

6 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 bonds denominated in foreign currency are not freely available, further assumptions are needed to obtain unambiguous interest rate elasticities.

$$\beta V(w) = \max_{c,m,f,b \leq \bar{b}} \left\{ \frac{c^{1-\phi}}{1-\phi} + V'(w)\Phi + \frac{1}{2}V''(w) \right. \\ \left. \times [\gamma^2(b+f)^2 + \sigma^2w^2 - 2\sigma w(b+f)\rho] \right\},$$

where Φ is defined as in (11) and $V(w)$ is the optimal value function. The first-order conditions with respect to b, f , and m may be stated in the following way:

$$V'(w)[\varepsilon - i - \rho + j] + V''(w)[\gamma^2(b+f) - w\rho] - \lambda = 0 \quad (13)$$

$$V'(w)[\varepsilon - i - \rho - v_2] + V''(w)[\gamma^2(b+f) - w\rho] = 0 \quad (14)$$

$$i + v_1 \left(\frac{m}{c}, \frac{f}{c} \right) = 0, \quad (15)$$

where $\lambda \geq 0$ is the Lagrangian multiplier associated to the constraint (12). Condition (13) accounts for both interior solutions and a boundary solution for b : according to the Kuhn-Tucker complementary slackness conditions, if the constraint (12) is not binding, then $\lambda = 0$. If, instead, constraint (12) is binding, then $\lambda > 0$, meaning that lessening the constraint would have a positive impact on the optimal value function. These two cases are discussed in the following sections.

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

In this section, we examine the case in which foreign bonds are freely available. In terms of the formulation above, this case is accounted for by postulating a large enough value for \bar{b} so as to ensure that restriction (12) is not binding. Substituting $\lambda = 0$ in (13) and subtracting from (14), one obtains

$$j + v_2 \left(\frac{m}{c}, \frac{f}{c} \right) = 0. \quad (16)$$

Using $\phi = -V''(w)w/V'(w)$ in (13) with $\lambda = 0$ and rearranging, one obtains

$$\frac{b+f}{w} = \left(\frac{1}{\phi} \right) \left(\frac{j + \varepsilon - i}{\gamma^2} \right) + \left(1 - \frac{1}{\phi} \right) \left(\frac{\rho}{\gamma^2} \right). \quad (17)$$

Equation (17) 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 (that is, the optimal level of AS), 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 (bonds plus money) that minimizes the portfolio's purchasing power risk. According to (17), the consumer is induced to move away from the minimum risk portfolio by the expected return differential, and the extent to which she moves depends on her degree of risk aversion.

Equations (15) and (16) implicitly define the money demand functions. They state that the consumer should hold each money until the marginal peso (dollar) produces additional transaction services equal in value to its user cost.⁷ To investigate the properties of money demands, we take differences in (15) and (16):

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

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

Solving for dm and df , and computing the partial derivatives, the following properties are obtained:⁸

$$m = cL^m(i, j), \quad \text{with } L_i^m = -\frac{cv_{22}}{\Delta} < 0 \quad \text{and} \quad L_j^m = \frac{cv_{12}}{\Delta} \geq 0, \quad (18)$$

$$f = cL^f(i, j), \quad \text{with } L_i^f = \frac{cv_{21}}{\Delta} \geq 0 \quad \text{and} \quad L_j^f = -\frac{cv_{11}}{\Delta} < 0. \quad (19)$$

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

$$m = cL^m(i), \quad \text{with } L_i^m = -\frac{c}{v_{11}} < 0 \quad (18a)$$

$$f = cL^f(j), \quad \text{and } L_j^f = -\frac{c}{v_{22}} < 0. \quad (19a)$$

To interpret, we consider two comparative static examples under alternative assumptions concerning the verification of means of payment substitutability:

7 Conditions similar to (15) and (16) were first obtained by Miles (1978), in the context of the *two-step* monetary model of CS. In that approach, CS decisions are postulated to be separate from the choice among non-monetary assets. The proof that separability of CS decisions holds in the dynamic optimizing model with complete bond markets is taken from Thomas (1985).

8 Equations (18) and (19) are not in the reduced form because changes in the interest rates also impact money demands through wealth effects. However, the aim of the exercise is to learn about money velocities so as to obtain testable money demand functions.

EXPERIMENT 1. *A rise in the expected exchange rate depreciation not embedded in the interest rates ($d\varepsilon > 0$, $di = dj = 0$).*

According to (17), this causes an increase in the optimal proportion of assets (money and bonds) denominated in foreign currency (AS), for speculative reasons. Since the user costs of domestic and foreign money remain constant, however, this change does not impact on individual money demands. This result holds regardless of whether the two monies compete in the same commodity domain ($v_{12} > 0$) or not ($v_{12} = 0$).

EXPERIMENT 2. *A rise in expected exchange rate depreciation accompanied by a domestic interest rate rise, so that the expected return differential remains unchanged ($d\varepsilon = di > 0$, $dj = 0$).*

According to equation (17), in this case the optimal proportion of assets denominated in foreign currency (AS) remains unchanged. Since the user cost of the domestic money rises, however, the consumer will optimally reduce her demand for domestic money. The remaining effects depend on whether there is means of payment substitutability or not: in case $v_{12} = 0$, then the adjustment involves only domestic assets. In order to keep the denomination structure of the portfolio (AS) unchanged, the decline in domestic money holdings is built up through purchases of domestic bonds. The demand for domestic money (18a) is the same as in a closed economy.⁹ If instead $v_{12} > 0$, then, as the demand for domestic money declines, the marginal contribution of foreign money to the reduction of transactions costs ($-v_2$) rises. According to (16), this leads to an increase in the demand for foreign money, for transaction purposes. In order to keep the currency composition of the overall portfolio unchanged, the consumer offsets the move by selling dollar-denominated bonds. In this case, there is CS but the level of AS remains unchanged.

These experiments illustrate the Thomas (1985) separation result: on the one hand, the consumer selects his currency holdings, based on each money's transaction services and associated user cost. On the other hand, she borrows or lends to achieve the desired level of AS. An optimal currency hedge is created, and the denomination structure of the individual portfolio is independent of money holdings.

4. The case with a binding constraint on foreign bond holdings

We now assume that constraint (12) is binding. Subtracting (13) from (14) with $\lambda > 0$, one obtains

⁹ In the extreme case in which dollar banknotes provided no transaction services at all (that is, when $v_2 = v_{22} = 0$), condition (16) would not hold in equality and the optimal demand for dollars would be zero. The demand for pesos, however, would still be as described by (18a). Note that, apart from this extreme case, the rise in the domestic interest rate leads to an increase in the *proportion* of money balances that is denominated in foreign currency, even in the absence of CS.

$$j + v_2 \left(\frac{m}{c}, \frac{f}{c} \right) > 0. \tag{16a}$$

When compared with (16), equation (16a) reveals that, in this case, the consumer holds a larger amount of foreign money than if there were no restriction on foreign bond holdings. This captures the substitution of foreign bonds by foreign money as store of value device.¹⁰ In this case, the following proposition holds:

PROPOSITION 1 (FOREIGN MONEY AS A PORTFOLIO ASSET). *If the consumer faces a binding restriction on foreign bond holdings, then the optimal denomination structure of the portfolio is given by*

$$\frac{f + \bar{b}}{w} = \left(1 - \frac{1}{\phi} \right) \left(\frac{\rho}{\gamma^2} \right) + \left(\frac{1}{\phi} \right) \left(\frac{-v_2 + \varepsilon - i}{\gamma^2} \right). \tag{17a}$$

Proof. Substitute the boundary solution $b = \bar{b}$ in (14), use $\phi = -V''(w)w/V'(w)$, and rearrange to obtain equation (17a).

Equation (17a) describes the optimal level of AS. As in (17), the consumer is induced to move away from the minimum risk portfolio by the expected return differential, and the extent to which she moves depends on her degree of risk aversion, ϕ . The novelty here is that the marginal reduction in transaction costs due to foreign money holdings ($v_2 < 0$) replaces j as the relevant return from foreign denominated assets used in the assessment of the expected return differential. Equation (17a) captures the double role that foreign money may have in high-inflation countries where foreign bonds are not freely available: as long as foreign money has a transactions role, this is no longer separable from the store of value role.¹¹

The following implication is straightforward:

COROLLARY 1 (DOMESTIC MONEY DEMAND INFLUENCED BY AS DECISIONS). *Under the conditions of proposition 1, if the domestic money and the foreign money are substitutes as means of payment, then the demand for domestic currency will be influenced by speculative and risk-hedging considerations.*

10 The model may also be solved considering a non-negative restriction on foreign bond holdings, $b \geq 0$ (that is, the individual is not allowed to borrow in foreign currency). When such restriction is binding, the sign of the inequality in (16a) is reversed. This means that the use of foreign money for transaction purposes (and the eventual level of CS) is constrained by the absence of hedging opportunities in the bond market. Although interesting at the theoretical level, this case is at odds with the observation that in high-inflation countries, a large demand for foreign money is primarily held for store of value reasons.

11 If the consumer also had no access to domestic bonds, one would obtain an optimal portfolio rule similar to (17a), 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).

The intuition underlying corollary 1 is simple: if the amount of foreign money holdings affects the liquidity value of the domestic money, then any change in the demand for foreign money for store of value reasons will impact on the demand for domestic money, even if the latter is dominated by an interest-bearing asset.

To illustrate, we solve the system (17a)–(15) for m and f , using the transactions technology (9). Proceeding as before, we obtain the following properties:

$$m = cL^m(i, \varepsilon, \gamma), \quad \text{with } L_i^m = \frac{w(v_{22} - v_{12}) + c\phi\gamma^2}{\Omega} > < 0 \quad (18b)$$

$$L_\varepsilon^m = \frac{wv_{12}}{\Omega} \leq 0, \quad \text{and } L_\gamma^m = -\frac{2(w - a - m)\gamma\phi v_{12}}{\Omega} \geq 0$$

$$f = cL^f(i, \varepsilon, \gamma), \quad \text{with } L_i^f = \frac{w(v_{11} - v_{21})}{\Omega} > < 0, \quad (19b)$$

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

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, (18a). The demand for foreign money becomes such that $L_i^f = -L_\varepsilon^f < 0$.

To interpret, consider the following comparative static examples under alternative assumptions concerning the verification of means of payment substitutability.

EXPERIMENT 1. *A rise in the expected exchange rate depreciation not embedded in the domestic interest rate ($d\varepsilon > 0, di = 0$).*

From (17a), this induces a move from domestic bonds to foreign money balances for speculative reasons. As long as foreign money provides transaction services ($v_2 < 0$), the consumer will face a decline in transaction costs. The remaining effects depend on whether there is means of payment substitutability: if $v_{12} = 0$, then these developments do not impact the demand for domestic money. In this case, the higher demand for foreign money reflects AS but not CS. If, however, $v_{12} > 0$, then the increased holdings of foreign money negatively impact the marginal contribution of domestic money to the reduction of transactions costs. Thus, the demand for domestic money declines, since it is replaced by foreign money in transactions. This second case illustrates how a pure speculative movement, raising the demand for foreign money, is transmitted, through CS, to the demand for domestic money.

EXPERIMENT 2. *A rise in expected exchange rate depreciation embedded in the domestic interest rate ($d\varepsilon = di > 0$).*

From (17a), the optimal proportion of assets denominated in each currency does not change for pure speculative reasons. However, from (15), the rise in the user cost of the domestic money leads agents to reduce its demand. This, in turn, may or may not impact the level of AS: in case $v_{12} = 0$, the decline in the demand for domestic money is built through purchases of domestic bonds only (just as it is in a closed economy). In this case, the demand for foreign money remains unchanged, as will the level of AS. If, however, $v_{12} > 0$, then the decline in domestic money holdings positively impacts the marginal productivity of foreign money to the reduction of transactions costs so that its demand rises for transaction purposes. This is a pure CS effect that, notwithstanding, goes along with the level of AS.

It is important to observe that the signs of the partial derivatives with respect to the domestic interest rate in (18b) and (19b) are uncertain. To understand this, consider a third experiment, in which the domestic interest rate rises alone:

EXPERIMENT 3. *A rise in the domestic interest rate not accompanied by the expected exchange rate depreciation ($di > 0, d\epsilon = 0$).*

From (17a), this induces a move from foreign money balances to domestic bonds for speculative reasons. On the other hand, from (15), the rise in the user cost of the domestic money leads agents to reduce its demand. Then, if $v_{12} = 0$, there are no transmission effects from one money market to the other. In this case, both the decline in the demand for domestic money and the move out of foreign money balances are built through purchases of domestic bonds only (note that, when $v_{12} = 0$, L_i^m and L_i^f are unequivocally negative). If $v_{12} > 0$, then the fall in the demand for money in each denomination positively impacts the marginal productivity of the other money, inducing offsetting CS effects, through which both money demands rise. To obtain negative elasticities ($L_i^m < 0$ and $L_i^f < 0$), it is sufficient to assume that own effects dominate CS effects (that is, $v_{kk} > v_{12}$, where $k = 1, 2$). Other results, however, are consistent with $\Delta > 0$ in equation (9). For example, when $v_{22} > v_{12} > v_{11}$, one would obtain $L_i^m > 0$ and $L_i^f < 0$.

5. Implications for empirical work

In the empirical literature on CS, some authors have investigated the presence of CS by evaluating the statistical significance of a term capturing the expected exchange rate depreciation in the demand for domestic money (Fasano-Filho 1987; Kamin and Ericsson 2003). Such a procedure was criticized by Cuddington (1983) in the context of the Portfolio Balance Approach to CS. This approach treats money as a simple asset, without specifying any particular feature, so as to make it distinguishable from the other assets. Postulating gross substitutability between money and all other assets, this leads 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 following functional form has been proposed:

$$\log\left(\frac{M}{P}\right) = \alpha_0 + \alpha_1 \log y + \alpha_2 i + \alpha_3 (j + \varepsilon) + \alpha_4 \varepsilon, \quad (20)$$

where $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_3 < 0$, and $\alpha_4 < 0$. The term α_3 captures substitutability between the domestic money and the foreign bond, and the term α_4 captures substitutability between the domestic money and the foreign money. Since the demand for domestic money depends negatively on the expected exchange rate depreciation, both through substitutability vis-à-vis the foreign money and substitutability vis-à-vis the foreign bond, followers of the PBM have claimed that CS and capital mobility are statistically indistinguishable. Moreover, in the light of that approach, it has been argued that the specification of a CS motive in the money demand does not constitute a qualitative difference relative to a specification where either CS is ruled out or foreign monetary and non-monetary assets are implicitly lumped together (Cuddington 1983).

The Portfolio Balance Approach has two main shortcomings. First, as noted by Branson and Henderson (1985), gross substitutability is not always consistent with individual optimization. Second, the model does not explain why money is held when dominated by interest-bearing assets. A closer scrutiny of the properties of the money demand in the light of firmer microeconomic foundations was made by Thomas (1985) for the case with complete bond markets. As was shown in section 3, in this case there is no demand for money as a 'portfolio asset.' From equations (18) and (18a), a possible specification to test for the presence of CS in this context is to investigate the sign and the significance of β_3 in

$$\log\left(\frac{M}{P}\right) = \beta_0 + \beta_1 \log y + \beta_2 i + \beta_3 j, \quad (21)$$

where $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 > 0$.

The Thomas model will 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 substitution among major currencies (Bergstrand and Bundt 1990; Mizen and Pentecost 1994; Lebre de Freitas 2006). 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, playing the role of the missing bond. The Thomas model is less suitable, however, to describe the phenomenon of CS in countries where consumers have no free access to interest-bearing foreign assets. As pointed out by Cuddington (1989), in that case one expects the demand for foreign money to have a store of value role in addition to the eventual means of payment role.

The results obtained in section 4 give support to the Cuddington (1989, 269) claim that, when foreign bonds are not freely available, the demand for foreign

money should reflect 'a portfolio component.' They also imply that, in case the two monies are substitutes as means of payment, the demand for domestic money will be influenced by AS decisions. However, our findings do not give support to an empirical test based on equation (20). Alternatively, equation (18b) suggests that a valid test for the presence of CS in countries with imperfect capital mobility is to access the sign and the significance of δ_3 and δ_4 in

$$\log\left(\frac{M}{P}\right) = \delta_0 + \delta_1 \log y + \delta_2 i + \delta_3 \varepsilon + \delta_4 \gamma, \quad (22)$$

where $\delta_1 > 0$, $\delta_2 > 0$, $\delta_3 < 0$, and $\delta_4 > 0$. Note that a similar exercise based on the demand for foreign money (19b) does not necessarily reveal the presence of CS.

It may be argued that, under uncovered interest rate parity, the choice of the particular model to be estimated is less relevant. Nevertheless, this does not change the main result of this paper: irrespective of the degree of capital mobility, only in case of CS will the demand for domestic money depart from the closed-economy specification (18a). Thus, the CS hypothesis may be investigated without ambiguity regarding the identification of the relevant effect.

6. Empirical application

In this section, an empirical test based on the theoretical model presented above is implemented for six Latin-American countries that experimented with restrictions on capital flows for long periods of time. The focus on Latin America is motivated by extensive background work reporting the presence of CS in the region (see, for example, Calvo and Végh 1992; Guidotti and Rodriguez 19).¹²

The departure point for the construction of the sample is the data on 'unofficial dollarization,' collected by Feige et al. (2003). These authors computed a 'Currency Substitution Index,' defined as the proportion of monetary assets outside banks that is denominated in foreign currency. The estimates are based on reported shipments of monetary assets denominated in U.S. dollars from the United States to different destinations. The authors also computed an 'Asset Substitution Index,' given by the ratio of residents' bank deposits denominated in foreign currency to total bank deposits. Figure 1 shows the corresponding figures for 1997–8 for 13 Latin-American countries.

It should be noted that none of these measures corresponds to our definitions of CS and AS. On the one hand, as long as foreign money may be held for store of value reasons, the first measure does not necessarily indicate the extent to which it is replacing domestic money as a vehicle for transactions. On the other hand,

12 Although several African countries have experimented with capital/exchange controls and CS, data limitations are more serious in that region.

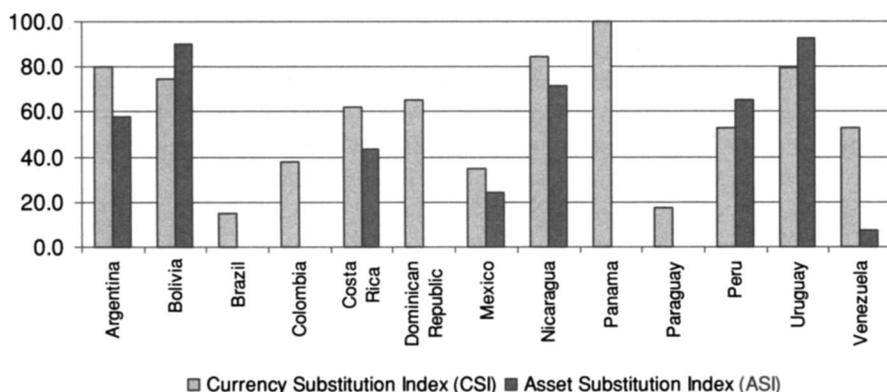


FIGURE 1 Unofficial dollarization in Latin America

NOTES: The data were kindly shared by Edgar Feige. The indexes are defined as follows:

$$\text{CSI} = \text{FCC}/(\text{FCC} + \text{LCC})$$

FCC = Foreign currency (cash) in circulation outside banks

LCC = Local currency (cash) in circulation outside banks

$$\text{ASI} = \text{FCD}/(\text{LCD} + \text{LTD} + \text{FCD})$$

FCD = Foreign currency deposits held with domestic banks

LCD = local checkable deposits

LTD = local time and savings deposits

SOURCE: Feige et al. (2003, figure 2.2)

the proposed index of AS does not measure the proportion of assets that are denominated in foreign currency. Still, the latter may be suggestive of the extent to which foreign banknotes are dominated by interest-bearing assets. Since our aim is to test for CS in a context where foreign banknotes have a significant store of value role, our sample is restricted to those countries in figure 1 with a zero or very low 'Asset Substitution Index,' These are Brazil, Colombia, the Dominican Republic, Paraguay, and Venezuela (Panama is not included because it is officially dollarized). To this group we add Chile, because this country had high inflation rates in the 1970s and 1980s, applied capital controls for a long period of time, and had relatively low financial dollarization.¹³

In order to restrict the analysis to periods with high restrictions on capital flows, we use Quinn's (1997) 0 to 4 measure of capital controls' intensity and also the IMF *Annual Report on Exchange Arrangements and Exchange Restrictions (AREAR)*, which are reported in table 1 for the six countries under study. According to the table, with the exception of Venezuela, all countries in this sample had capital controls in place for around 30 years. When quarterly data are used, this allows for a very reasonable number of observations. Because of data availability, the sample period starts in 1970, except for Chile, for which

13 Levy-Yeyati's (2006) data on financial dollarization cover Chile from 1976 to 2001. On average, during this period foreign currency deposits in Chile were below 10% of total deposits.

TABLE 1
Restrictions to capital movements in the sample countries

Country name	Quinn (1997) scale of 0–4 (0 = totally restricted, 4 = totally free)		Dummy variable based on IMF AREAR, line E.2 (0 = not restricted; 1 = restricted)	
	Year	Value	Period	Value
Brazil	1973	1.5	–	0
	1982	1.5	1966–98	1
	1988	1.5		
	1997	2.0		
Chile	1973	1.5	–	0
	1982	1.5	1966–98	1
	1988	1.5		
	1997	2.0		
Colombia	1973	1.5	–	0
	1982	1.5	1966–95	1
	1988	1.5		
	1997	3.5		
Dominican Republic	1973	1.5	–	0
	1982	1.0	1966–95	1
	1988	2.0		
	1997	2.5		
Paraguay	1973	2.5	–	0
	1982	1.5	1966–95	1
	1988	1.5		
	1997	4.0		
Venezuela	1973	3.5	1966–83	0
	1982	3.0	1984–98	1
	1988	2.0		
	1997	3.0		

SOURCES: The data on Quinn's (1997) classification and on the IMF dummy were kindly shared by Dennis Quinn.

interest rate data are available only after 1977, and for Venezuela, which applied capital/exchange controls only after 1984.¹⁴

The model to be estimated does not impose a priori the functional form (22). Instead, it is general enough to account also for models (20) and (21). With this procedure we allow the data to select the appropriate model. In order to account for eventual non-stationarity of real money¹⁵ and of independent variables, we

14 In the case of Venezuela, the dummy variable based on the IMF AREAR is equal to one from 1984 to 1998, which means high restrictions on capital flows. Quinn (1997), in turn, assigns a grade of 3 in 1997, which means very few restrictions. Taking into account the two sources, we decided to restrict the period with capital/exchange controls in this country to 1984–96.

15 Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests indicate that $\log(M/P)$ is stationary in Brazil, Chile, and the Dominican Republic and has a unit root in Paraguay and Venezuela. Results for Colombia are mixed, since a PP test rejects the null hypothesis of a unit root, but the ADF test does not, and the KPSS rejects the null hypothesis of stationarity. Unit root tests are available from the authors upon request.

employ the Stock and Watson (1993) Dynamic OLS methodology, according to which one regresses the dependent variable with the contemporaneous levels of the explanatory variables, leads and lags of their first differences, and a constant. Since real money is not seasonally adjusted, we also include quarterly dummy variables. Finally, the first lag of real money is included to account for autocorrelation. The equation to be estimated is the following:¹⁶

$$\begin{aligned} \log\left(\frac{M}{P}\right)_t = & a_0 + a_1 \log Y_t + a_2 i_t + a_3 j_t + a_4 \varepsilon_{t+1} + a_5 \gamma_t + \sum_{s=1}^3 \phi_s q_s \\ & + a_6 \log\left(\frac{M}{P}\right)_{t-1} + \sum_{i=-3}^3 \alpha_i \Delta \log Y_{t-i} + \sum_{i=-3}^3 \beta_i \Delta i_{t-i} \\ & + \sum_{i=-3}^3 \delta_i \Delta j_{t-i} + \sum_{i=-3}^3 \phi_i \Delta \varepsilon_{t+1-i} + \sum_{i=-3}^3 \varphi_i \Delta \gamma_{t-i} + v_t \end{aligned} \quad (23)$$

where M/P is real money (Money, IMF-IFS, line 34, divided by the CPI, IMF-IFS, line 64), Y is real GDP (nominal GDP, IMF-IFS, line 98B, divided by the CPI, IMF-IFS, line 64), i is the domestic interest rate (IMF-IFS, line 60B, 60L or 60 – according to availability), j is the U.S. Treasury Bill rate (IMF-IFS, line 60c), ε is the one-quarter ahead expected exchange rate depreciation (for which we use three alternative proxies, as explained below), γ is the standard deviation of the exchange rate (IMF-IFS, line RF) computed over the last one to three years, depending on which maximizes the Schwartz Bayesian Information Criterion (SBIC), q_i are the quarterly dummy variables, and u is the error term.¹⁷ Although we start with a model that includes all leads and lags of the explanatory variables up to order 3, the SBIC is used to obtain a more parsimonious model.

Three alternative proxies for the one-quarter ahead expected exchange rate depreciation are tested: the inflation differential relative to the United States (based on the relative version of the Purchasing Power Parity), the current quarter depreciation rate ('myopic' expectations), and a forecast based on information available at the time expectations were formed (rational expectations). The last

16 The constant term was excluded from estimations in the cases of the Dominican Republic and Venezuela, as it was never statistically significant when included.

17 Whenever quarterly data on GDP were not available, we estimated them from annual data using the frequency conversion option 'cubic match last' of Eviews 5.0. The money market rate (line 60B) is available with a reasonable number of observations only for Brazil and Paraguay. The time deposits rate (line 60L) was used instead in the cases of Chile and Dominican Republic. In Colombia and Venezuela, we used the discount rate (line 60). Since interest rate data start in 1991 in the case of the Dominican Republic and in 1990 in the case of Paraguay, the previous values of these countries' interest rate series were proxied by the four-quarter change in the CPI (IMF-IFS, line 64X). Since Brazil faced two hyperinflations during the sample period, it has much greater variance of prices, interest rates, and exchange rates than the other five countries. For that reason, in the estimations for Brazil, the interest rate and the expected depreciation rate are used in logs, and the exchange rate volatility is proxied by the coefficient of variation of the exchange rate (instead of the standard deviation).

case is estimated using two-stage least squares (2SLS), with the choice of the instruments for the expected exchange rate depreciation driven by the results of the first-stage estimations.¹⁸

Table 2 shows the estimation results for each one of the six countries selected, using the three alternative proxies for the expected exchange rate depreciation. In general, the coefficients on GDP and on the domestic interest rate are statistically significant and have the conventional signs. As expected in a sample restricted to periods with capital controls, the U.S. Treasury Bill rate is seldom statistically significant. The only exception is Paraguay, for which it has the wrong sign.

As far as the verification of the CS hypothesis is concerned, the results point to two distinct cases: first, in Brazil and Chile no other variable apart from those appearing in a standard (closed economy) specification of the money demand was found to be statistically significant. According to our theoretical model, this is suggestive of absence of CS. Second, in Colombia, the Dominican Republic, and Venezuela, both the expected depreciation term and the volatility term are, in general, statistically significant and have the respective signs according to model (22) (in the case of the Dominican Republic, results for the 2SLS are less conclusive, probably because of misspecification of the forecasting model). This is suggestive of the presence of CS. The case of Paraguay reveals some ambiguity, because the exchange rate depreciation is statistically significant in one equation, but no other result points to CS (also note that the estimated coefficient for the Treasury Bill rate has the wrong sign).¹⁹

The findings for Brazil and Chile are consistent with the general assertion that these two countries have been an exception in the context of Latin America: despite the several episodes of high inflation in these two countries, it appears that they did not translate into a significant replacement of their respective monies by the U.S. dollar as a vehicle for transactions (see, for example, Savastano 1996, 225). For the remaining countries, one would like to confront the results with an effective measure of the extent to which foreign money has been used as means of payment. To the best of our knowledge, however, no such measure exists.

Comparing the estimation results with the data displayed in figure 1, we observe that the countries with a higher 'Currency Substitution Index' are those

18 The results for the first-stage estimations are shown in appendix table A1. We followed a general to specific approach, in which, besides the explanatory variables of the base model, we include in the list of instruments the current and lagged depreciation rates, the current and lagged inflation differentials, the current and lagged growth rates of monetary expansion, and the current and lagged percentage differences between official and parallel exchange rates (data on the latter are taken from Rheinart and Rogoff 2004). The variables that were not statistically significant were sequentially excluded until we reached a parsimonious model that maximized the SBIC.

19 In order to control for an eventual Cagan effect in the money demand, the four-quarter change in the CPI (the homologous inflation rate) was included in the model. This inclusion did not change the results for the remaining explanatory variables or our conclusions regarding the existence of Currency Substitution in the six countries under analysis.

TABLE 2
Dynamic OLS results of money demand estimations

Log (M1/P)	Brazil			Chile			Colombia		
	Inflation differential	Current depreciation	2SLS	Inflation differential	Current depreciation	2SLS	Inflation differential	Current depreciation	2SLS
Constant	0.741 (2.16)**	0.851 (2.48)**	0.829 (1.69)*	-3.106 (-4.05)***	-3.524 (-4.00)***	-2.880 (-3.80)***	-0.437 (-0.84)	-0.721 (-1.56)	-0.764 (-1.61)
Log (real GDP)	0.093 (2.18)**	0.066 (2.30)**	0.101 (1.90)*	0.473 (4.91)***	0.539 (5.27)***	0.448 (4.64)***	0.240 (4.13)***	0.379 (6.11)***	0.377 (5.92)***
Domestic interest rate	-0.083 (-4.41)***	-0.054 (-3.09)***	-0.087 (-1.91)*	-0.002 (-2.58)**	-0.002 (-3.27)***	-0.003 (-3.42)***	-0.001 (-1.04)	-0.0007 (-0.43)	-0.0005 (-0.32)
U.S. Treasury Bill rate	-0.004 (-1.46)	-0.002 (-0.98)	-0.006 (-1.52)	0.006 (1.60)	0.007 (1.25)	0.004 (0.86)	-0.002 (-0.84)	0.001 (0.79)	0.002 (0.93)
Expected depreciation	0.024 (1.57)	0.004 (0.38)	0.032 (1.01)	-0.0008 (-0.78)	-0.0004 (-0.87)	0.0003 (0.49)	-0.001 (-2.03)**	-0.001 (-3.35)***	-0.001 (-3.02)***
Exchange rate volatility	0.039 (0.43)	0.055 (0.63)	0.017 (0.10)	-0.0004 (-0.45)	-0.002 (-1.48)	-0.001 (-0.86)	0.001 (2.00)**	0.002 (2.73)***	0.002 (2.43)**
1 st quarter	-0.269 (-9.74)***	-0.263 (-9.11)***	-0.264 (-8.32)***	-0.124 (-4.70)***	-0.142 (-5.16)***	-0.127 (-5.20)***	-0.120 (-7.27)***	-0.099 (-6.56)***	-0.100 (-6.44)***
2 nd quarter	-0.142 (-5.22)***	-0.135 (-4.99)***	-0.141 (-5.18)***	-0.173 (-7.30)***	-0.164 (-5.56)***	-0.174 (-7.87)***	-0.080 (-5.71)***	-0.086 (-8.29)***	-0.086 (-7.65)***
3 rd quarter	-0.176 (-7.84)***	-0.178 (-9.12)***	-0.181 (-7.59)***	-0.170 (-7.65)***	-0.188 (-7.85)***	-0.175 (-7.42)***	-0.113 (-9.16)***	-0.108 (-8.96)***	-0.103 (-7.82)***
Log (M1/P) (-1)	0.818 (14.30)***	0.824 (14.57)***	0.793 (9.73)***	0.476 (5.14)***	0.393 (4.58)***	0.495 (4.67)***	0.524 (6.36)***	0.212 (2.03)**	0.227 (2.15)**
No. of observations	116	116	108	87	85	87	104	104	104
Sample period	1970-2000	1970-2000	1970-2000	1977-98	1977-98	1977-98	1970-95	1970-95	1970-1995
Adjusted R ²	0.91	0.91	0.90	0.97	0.97	0.97	0.92	0.94	0.93

Continued

TABLE 2 (Continued)

	Dominican Republic			Paraguay			Venezuela		
	Inflation differential	Current depreciation	2SLS	Inflation differential	Current depreciation	2SLS	Inflation differential	Current depreciation	2SLS
Constant									
Log (real GDP)	0.074 (3.37)***	0.066 (3.82)***	0.085 (3.60)***	-2.593 (-3.08)***	-3.347 (-3.76)***	-3.375 (-3.69)***	0.082 (3.12)***	0.045 (1.76)*	0.047 (1.69)*
Domestic interest rate	-0.0002 (-0.32)	-0.001 (-2.88)***	-0.003 (-6.10)***	0.0002 (0.31)	-0.001 (-2.03)**	-0.001 (-2.00)**	-0.002 (-1.93)*	-0.001 (-1.18)	-0.001 (-1.24)
U.S. Treasury Bill rate	-0.001 (-1.04)	-0.001 (-0.07)	-0.004 (-1.38)	-0.004 (-1.77)*	-0.007 (-2.45)**	-0.007 (-2.44)**	0.002 (0.24)	0.004 (0.45)	-0.003 (-0.41)
Expected depreciation	-0.001 (-4.40)***	-0.000001 (-4.53)***	0.0001 (1.08)	-0.001 (-4.83)***	0.000003 (0.35)	0.0001 (0.36)	-0.002 (-3.87)***	-0.0003 (-2.46)**	-0.0003 (-2.19)**
Exchange rate volatility	0.074 (3.67)***	0.044 (3.43)***	0.106 (4.79)***	0.0000002 (0.02)	-0.000007 (-0.63)	-0.000006 (-0.51)	0.001 (5.05)***	0.001 (1.90)*	0.001 (1.77)*
1 st quarter	-0.205 (-14.3)***	-0.178 (-12.4)***	-0.099 (-3.90)***	-0.059 (-3.56)***	-0.074 (-4.10)***	-0.073 (-4.09)***	-0.132 (-3.34)***	-0.113 (-2.58)**	-0.113 (-2.65)**
2 nd quarter	-0.127 (-7.89)***	-0.090 (-6.04)***	-0.017 (-0.64)	-0.019 (-1.20)	-0.007 (-0.41)	-0.003 (-0.19)	-0.071 (-1.84)*	-0.072 (-1.72)*	-0.072 (-1.57)
3 rd quarter	-0.146 (-9.65)***	-0.130 (-8.39)***	-0.059 (-2.26)**	-0.088 (-5.62)***	-0.085 (-5.08)***	-0.082 (-4.62)***	-0.094 (-2.24)**	-0.115 (-2.82)***	-0.118 (-3.18)***
Log (M1/P) (-1)	0.853 (16.13)**	0.868 (21.35)***	0.817 (14.76)***	0.817 (7.47)***	0.610 (6.09)***	0.605 (5.72)***	0.842 (13.64)***	0.911 (15.19)***	0.907 (14.68)***
No. of observations	92	95	95	104	104	104	52	52	52
Sample period	1970-95	1970-95	1970-95	1970-95	1970-95	1970-95	1984-96	1984-96	1984-96
Adjusted R ²	0.96	0.96	0.55	0.97	0.97	0.97	0.96	0.95	0.95

NOTES

OLS estimations using heteroscedasticity-consistent standard errors and covariance.

T-statistics are in parentheses.

Significance level at which the null hypothesis is rejected: ***, 1%, **, %, and *, 10%. Breusch-Godfrey Serial Correlation LM tests always reject serial correlation of the residuals.

The proxy used for the expected depreciation rate is indicated in the column title.

The coefficients on the lags and leads of the first differences of real GDP, domestic interest rate, U.S. Treasury Bill rate, expected depreciation, and exchange rate volatility are not shown in order to economize on space.

for which evidence of CS was found. Obviously, this does not validate the procedure of assessing the extent of CS by estimating the stock of foreign money balances held by the public. But it is consistent with the view that CS is more likely when a considerable demand for foreign money as store of value already exists (this pattern is suggested, for example, in Calvo and Végh 1992). In the light of that interpretation, in Brazil and Chile, where indexed bonds denominated in domestic currency became popular, the demand for foreign money as store of value never reached a level critical enough to induce its acceptability as means of payment.²⁰

7. Conclusions

This paper extends the Thomas (1985) dynamic optimizing model of money demand and currency substitution to the case in which the individual faces a binding restriction on foreign bond holdings. In this case, foreign banknotes may have a store of value role in addition to the eventual means of payment role. We show that means of payment substitutability acts as a channel through which risk-hedging and speculative decisions involving the demand for foreign money impact the demand for domestic money. Moreover, we show that only in case of currency substitution will the demand for domestic money depart from the closed economy specification. The results contradict Cuddington's (1983, 1989) 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 CS. This implication is convenient for empirical purposes: if the CS hypothesis can be assessed by estimating a demand function for domestic money, the problem of disentangling whether foreign money is merely held for store of value purposes or is indeed replacing domestic money as a vehicle for transactions is circumvented.

Applying the test to six Latin American countries that imposed restrictions on capital flows for long periods of time, we found evidence of CS in Colombia, the Dominican Republic, and Venezuela, ambiguous evidence in Paraguay, and no evidence at all in Brazil and Chile. Comparing with existing estimates for the amount of foreign money holdings in these countries, we find consistency with the view that CS is more likely to occur when a considerable demand for foreign money for store of value reasons already exists.

20 Uribe (1997) and Sturzenegger (1997) stress the role of network externalities in the use of money in shaping the relationship between the *aggregate* demand for foreign money and its acceptability as means of payment. In terms of our model, network externalities would be accounted for in a general equilibrium set-up by making the transactions technology (9) depend on the aggregate stocks of domestic and foreign monies. To the extent that the size of the network cannot be influenced by individual decisions, however, the latter would be invariant in respect to that specification.

Appendix

TABLE A1
First-stage results of the 2SLS estimations

Depreciation (+1)	Brazil	Chile	Colombia	Dominican Republic	Paraguay	Venezuela
Constant	-3.991 (-1.70)*	-235.55 (-0.71)	-47.813 (-0.64)	142.585 (0.81)	193.486 (0.44)	-15241.08 (-1.54)
Log (real GDP)	0.158 (0.34)	48.290 (1.01)	3.077 (0.46)	-57.491 (-1.82)*	-24.634 (-0.45)	1322.368 (1.60)
National interest rate	0.403 (1.91)*	-0.373 (-0.60)	0.076 (0.30)	-0.326 (-1.42)	0.750 (1.12)	1.640 (0.88)
U.S. Treasury Bill rate	0.058 (2.66)***	-0.526 (-0.30)	0.437 (1.45)	0.716 (0.62)	-0.474 (-0.32)	51.822 (1.27)
Exchange rate volatility	0.639 (0.80)	-0.675 (-1.01)	-0.100 (-1.08)	1.308 (0.26)	-0.103 (-1.60)	-1.127 (-2.61)**
1 st quarter	-0.366 (-2.22)**	5.334 (0.57)	0.082 (0.05)	25.657 (1.96)*	-7.355 (-0.42)	-27.527 (-0.51)
2 nd quarter	-0.199 (-1.00)	24.688 (2.42)	-0.543 (-0.24)	23.726 (2.28)**	-25.134 (-1.99)**	-119.642 (-2.14)**
3 rd quarter	-0.117 (-0.75)	6.796 (0.75)	1.874 (1.12)	25.315 (2.50)**	-19.070 (-1.98)*	-51.603 (-1.24)
Log (M1/P) (-1)	0.445 (1.34)	-74.869 (-1.33)	2.159 (0.11)	103.363 (2.35)**	40.568 (0.77)	58.638 (0.45)
Depreciation		0.388 (2.72)***	0.930 (6.78)***	-0.004 (-3.91)***	0.503 (3.81)***	0.752 (2.42)**
Depreciation (-1)		-0.235 (-1.37)	-0.168 (-1.24)		-0.240 (-2.73)***	
Inflation differential	0.492 (3.35)***			0.331 (2.62)**		-2.160 (-1.45)
Inflation differential (-1)			0.076 (2.34)**			
% difference between official and Parallel Growth of M1	0.003 (1.66)*		0.164 (3.07)***	0.178 (1.87)*		0.876 (1.92)*
No. of observations	108	87	104	95	104	52
Sample Period	1970-2000	1977-1998	1970-1995	1970-1995	1970-1995	1984-1996
Adjusted R ²	0.88	0.46	0.73	0.32	0.20	0.23

NOTES

OLS estimations using heteroscedasticity-consistent standard errors and covariance.

T-statistics are in parentheses.

Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%.

Breusch-Godfrey Serial Correlation LM tests always reject serial correlation of the residuals.

The coefficients on the lags and leads of the first differences of real GDP, domestic interest rate, U.S. Treasury Bill rate, expected depreciation, and exchange rate volatility are not shown in order to economize on space.

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