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MONEY DEMAND IN OPEN ECONOMIES: A CURRENCY SUBSTITUTION MODEL FOR VENEZUELA

by

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ABSTRACT

This paper investigates the extent to which domestic money balances in Venezuela are influenced by foreign exchange considerations. To this end, individuals are assumed to choose the levels of foreign and domestic money that minimize the borrowing costs associated with a given level of monetary services. The solution to this optimization problem yields a closed form domestic money demand function. This specification is estimated and the results point to an elasticity of currency substitution in excess of one. Conditioned on these estimates, the paper presents estimates of the out-of-sample exchange-rate risk for the period 1981-1982, prior to the collapse of the fixed exchange rate system in 1983.

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A Currency Substitution Model for Venezuela

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This paper investigates the extent to which domestic money balances in Venezuela are influenced by foreign exchange considerations. To this end, individuals are assumed to choose the levels of foreign and domestic money that minimize the borrowing costs associated with a given level of monetary services. The solution to this optimization problem yields a closed form domestic money demand function. This specification is estimated and the results point to an elasticity of currency substitution in excess of one. Conditioned on these estimates, the paper presents estimates of the out-of-sample exchange-rate risk for the period 1981-1982, prior to the collapse of the fixed exchange rate system in 1983.

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1. Introduction

The purpose of this paper is to examine the extent to which domestic money holdings are influenced by foreign exchange considerations--an influence that has been labeled currency substitution. Intuitively, one would expect such considerations to influence holdings of domestic money because, in a highly integrated world capital market, individuals face a choice not only between holding domestic money and domestic bonds, but also between holding domestic money and foreign money. To the extent that these holdings are interdependent, a change in either foreign interest rates or exchange rate expectations would exert an influence on the composition of optimal money holdings with a corresponding impact on domestic money holdings.

Knowledge of the extent to which foreign exchange considerations affect domestic money holdings is important for the design of both monetary and exchange rate policies. For example, the intended effect of a monetary contraction could be offset if the public has access to foreign money balances. In addition, if the domestic currency is expected to depreciate, then individuals will increase their holdings of foreign money in an attempt to avoid the associated capital losses. A persisting substitution of domestic balances by foreign balances--the so-called dollarization--results in a loss of government seigniorage and could precipitate a balance-of-payments crisis.

Because of the importance attached to currency substitution, it is not surprising that this subject has attracted a good deal of attention in the literature.[1] However, existing studies have not examined the Venezuelan case, which is the focus of attention of this paper. In addition to filling this gap, an analysis of Venezuela's experience might be of interest because her institutional banking structure has not allowed onshore holdings of monetary balances denominated in foreign currency. Previous studies have analyzed the experience of Argentina, Mexico, and Ecuador, where balances of both domestic and foreign currency can be held onshore. Consequently, it is possible to establish if banking regulations are a pre-condition for the existence of currency substitution. As it turns out, they are not. Secondly, this paper might be useful in analysing whether the 1983 exchange-rate collapse in Venezuela had been anticipated by the public at large, or whether it was an entirely unexpected phenomenom.

Besides examining the Venezuelan experience, the present paper also extends the currency substitution literature in another direction. Specifically, most empirical studies of currency substitutability rely on cross-partial elasticities of reduced-form money demand specifications. Unfortunately, such specifications do not always permit identification of the extent to which currency substitution occurs.[2] As a result, it is possible to accept the null hypothesis of no currency substitution when it is false. The present analysis avoids this identification problem by relying on a specification of domestic money holdings derived as the solution to an optimization problem.

In addition to the issue of estimation, the present study might be of relevance to ongoing work on both government seigniorage and crises of balance of payments.[3] As these analyses reveal, central to their conclusions is the existence of a money demand function depending on foreign exchange considerations. Because these functions have not been formally derived, the present analysis might be seen as providing one possible formal justification for their use.

The analysis begins in section 2 with the formulation of a simple, but formal, theoretical model where firms decide the composition of transactions balances that minimizes the borrowing costs associated with a given level of monetary services. The solution to this problem yields a closed form money demand function allowing open economy considerations. Section 2 also points out the advantages of the approach taken in this paper relative to competing empirical models of currency substitution.

Section 3 implements empirically the money demand function derived in section 2 and presents estimates of the elasticity of currency substitution using data for Venezuela. The empirical findings point to the existence of a relatively high elasticity of currency substitution. Section 3 also presents estimates of the exchange-rate risk implied by the currency substitution model developed here. The results suggest that the probability attached to a devaluation of the Venezuelan bolivar experienced a substantial increase by the end of 1982. Finally, section 4 contains our conclusions.

2. An Empirical Model of Currency Substitution

2.1 Optimizing Behavior

The point of departure of this analysis is the empirical observation that the public--that is, firms and individuals--maintains balances of both domestic and foreign currency.[4] Specifically, multinationals and investment corporations maintain balances in more than one currency because, by arbitraging interest rate differentials and fluctuations in currency rates, they reduce the financing cost associated with a given level of output (see Levich 1985). Clearly, the extent to which firms can take advantage of interest rate differentials depends, as indicated by King et. al. (1978), on the degree of integration of world capital markets.

The kind of currency substitution that firms undertake by themselves might be denoted direct currency substitution. For example, oil companies transact in international markets for which they maintain offshore balances of foreign money, the level of which depends on relative financing costs. But firms might also substitute currencies indirectly. For example, a firm whose financing and production decisions are made domestically could be substituting currencies indirectly through domestic financial intermediaries that obtain funds from both domestic and foreign sources.

While the role of financial intermediaries is clearly important for currency substitution, an analysis of their influence is outside the scope of the present paper. For our purposes, it is assumed that domestic financial intermediaries are owned by non-financial firms. The latter are assumed to borrow their working capital in domestic and foreign markets at the beginning of the year. At the end of the year, the firm is assumed to pay back both the principal and the associated interest payments. Consequently, the financing cost incurred is

$$(1) \qquad C = (1+i_d)(M_d/P_d) + \left((1+i_f)/(1+E(\Delta e)/e)\right)(M_f/P_f),$$

where

C : portfolio holding costs,

i_d : domestic nominal interest rate,

i_f : foreign nominal interest rate,

M_d : holdings of domestic money by domestic residents,

M_f : holdings of foreign money by domestic residents,

P_d : domestic price level,

P_f : foreign price level, and

e : exchange rate, (domestic currency/foreign currency).

The first term on the right-hand side of equation (1) represents the cost of borrowing domestically; the second term represents the cost of foreign borrowing. Note that the cost of borrowing one unit of foreign money is modeled as the foreign interest rate adjusted by the expected capital gains (or losses) resulting from expected fluctuations in the exchange rate, $E(\Delta e)/e$.

The objective of the firm is to find the mix of money balances that minimizes the borrowing costs of supporting the given level of aggregate monetary services consistent with the firm's profit maximizing output level. As Barnett (1985) has shown, if the firm's transformation function is quasiconvex and if the technology is weakly separable over time, then the intertemporal optimizing behavior of the firm with respect to factor demands, production levels, and net asset holdings, yields an optimal level of monetary services, M*, which is related to the available monetary instruments via a transactions technology U:[5]

$$(2) \qquad M^*/P_d = U(M_d/P_d,\ M_f/P_f).$$

The structure of the transactions technology U(.) determines the extent to which foreign money can substitute domestic money, and its estimation constitutes the focus of attention of this paper. To this end, it is assumed that the transactions technology obeys a CES aggregator function:

$$(3) \qquad M^*/P_d = A\left(\delta(M_d/P_d)^{-\rho} + (1-\delta)(M_f/P_f)^{-\rho}\right)^{-1/\rho},$$

where

δ : distribution parameter, and

ρ : substitution parameter, $\rho \equiv (1-\sigma)/\sigma$, $\sigma > 0$.

The choice of a CES might be justified for two reasons. First, the space of parameter estimates is such that neoclassical properties of optimizing behavior are met globally.[6] Second, alternative hypotheses about the extent of currency substitution can be tested depending on the value of the elasticity of substitution, σ. Specifically, as $\sigma \to 0$, the two currencies become perfect complements to each other; thus the currency mix does not respond to changes in relative financing costs. As $\sigma \to \infty$, the two currencies become perfect substitutes for each other. Consequently, small changes in relative costs induce swift changes in the currency composition. When $\sigma < 1$, the two currencies are said to be complements, whereas if $\sigma > 1$, then the two currencies are said to be substitutes.[7]

Because of the constant-returns-to-scale property common to aggregator functions, and by an appeal to the small country assumption--that is, $P_d = eP_f$, equation (3) can be expressed as

$$M^* = A(\delta M_d^{-\rho} + (1-\delta)(eM_f)^{-\rho})^{-1/\rho} ,$$

which is a convenient characterization of technology.[8]

2.2 Derivation of Optimal Domestic Balances

The optimizing problem faced by the firm can be summarized by the Lagrangean function Λ as

$$(4) \quad \min_{M_d,\, M_f,\, \lambda} \quad \Lambda = (1+i_d)M_d + \left[(1+i_f)/(1+E(\Delta e)/e)\right](eM_f) + $$

$$+ \lambda\{M^* - A(\delta M_d^{-\rho} + (1-\delta)(eM_f)^{-\rho})^{-1/\rho}\}.$$

The first-order conditions associated with this problem are

(5) $\partial\Lambda/\partial M_d = (1+i_d) - \lambda(\partial M^*/\partial M_d) = 0,$

(6) $\partial\Lambda/\partial(eM_f) = \left[(1+i_f)/(1+E(\Delta e)/e)\right] - \lambda\partial M^*/\partial(eM_f) = 0,$ and

(7) $\partial\Lambda/\partial\lambda = M^* - A\left(\delta M_d^{-\rho} + (1-\delta)(eM_f)^{-\rho}\right)^{-1/\rho} = 0.$

Equilibrium requires first that the value of the marginal productivity of each type of money be equal to its borrowing cost and second, that the resulting optimal money balances render a level of monetary services equal to M*.

Division of equation (6) by equation (5) yields

(8) $eM_f/M_d = \left((1-\delta)/\delta\right)^{\sigma} \left((1+i_d)(1+E(\Delta e)/e)/(1+i_f)\right)^{\sigma}$,

which is the optimal mix of money balances. According to equation (8), an increase in domestic interest rates raises the cost of borrowing domestically and thus increases the ratio of foreign to domestic balances. Similarly, if firms expect a depreciation of the domestic currency--that is, $E(\Delta e)/e>0$--then total financing costs can be reduced by increasing holdings of foreign money. Finally, an increase in foreign interest rates raises the cost of foreign borrowing and, as a result, lowers the optimal ratio of foreign to domestic money holdings.

Equation (8) has been estimated by Ortiz (1983) and Miles (1978). However, the resulting parameter estimates are open to criticism because equation (8) does not represent the solution to the associated first-order conditions, which is given by solving simultaneously equations (7) and (8). From a theoretical standpoint, the main consequence of not using all of the first-order conditions is that the user cost of aggregate money M^*, λ, is left unspecified.[9] From an empirical standpoint, an estimate of σ relying only on equation (8) is inconsistent with the one given by the solution to equations (7) and (8).

These difficulties can be avoided by using all of the first-order conditions. To this end, solve first for eM_f in equation (8) and substitute the result into equation (7) to obtain

$$(9)\quad M^* = A\{\delta M_d^{-\rho} + (1-\delta)([(1-\delta)/\delta]^{\sigma}\,[(1+i_d)(1+E(\Delta e)/e)/(1+i_f)]^{\sigma}\,M_d)^{-\rho}\}^{-1/\rho},$$

which is used to solve for optimal domestic money balances, M_d^* , as

$$(10)\quad M_d^* = \{1+((1-\delta)/\delta)^{\sigma}((1+i_d)(1+E(\Delta e)/e)/(1+i_f))^{\sigma-1}\}^{\sigma/(1-\sigma)}\,\delta^{\sigma/(1-\sigma)}\,(M^*/A).$$

As equation (10) reveals, optimal domestic money balances depend on domestic and foreign interest rates, on the expected rate of depreciation, and on the aggregate level of optimal money services. The comparative statics associated with equation (10) are

$$\partial M_d^*/\partial i_d < 0,\ \partial M_d^*/\partial(E(\Delta e)/e) < 0,\ \partial M_d^*/\partial i_f > 0,\ \text{and}\ \partial M_d^*/\partial M^* > 0.$$

An increase in either the domestic interest rate or the rate at which the exchange rate is expected to depreciate reduces optimal domestic money balances because of the associated increase in the relative cost of borrowing domestically. An increase in either the foreign interest rate or in the given level of monetary services raises optimal domestic money balances.

Of these comparative-static results, the increase of optimal domestic balances in response to higher foreign interest rates is less traditional, and it stands in contrast to the implications of the portfolio-balance model (see Cuddington 1983). The difference between the two approaches lies in the different roles assigned to domestic money balances. In the portfolio-balance model, domestic money is the riskless asset with zero return. Consequently, higher foreign interest rates increase the opportunity cost of holding such balances, which implies a decline in optimal domestic money balances. In the present paper, domestic and foreign money are held because they render the monetary services needed to support a given level of transactions. To the extent that the monetary services of domestic and foreign money are substitutable for each other in the production of monetary services, an increase in the cost of foreign money services leads to an increase in domestic money holdings. Thomas' (1985) theoretical model of currency substitution has the same comparative statics as those presented here.

2.3 Advantages of the Present Formulation

Equation (10) possesses an number of important advantages over competing currency substitution models. First, from an estimation standpoint, it represents the solution to an optimizing problem. Consequently, the estimate of σ is internally consistent with the underlying theory. This consistency would be lost if the estimate of σ were to rely only on equation (8) because no allowance would be made for the restrictions arising from the transaction technology, equation (7). Furthermore, estimation of σ by relying on equation (8) alone--as in Miles (1978) and Ortiz (1983)--faces serious data difficulties, especially for developing countries, because the prevalence of unrecorded capital flights complicates considerably the measurement of M_f.[10] For Venezuela the situation is more complex because, in contrast to the "dollarization" experience of other Latin American countries, monetary balances denominated in foreign currency can be held offshore only. Estimates of σ based on equation (10) avoid reliance on data for M_f.

Second, from a theoretical standpoint, the present formulation distinguishes the cross-partial interest elasticity from the elasticity of currency substitution. The importance of this distinction can be seen by considering the specification of optimal domestic real balances typically found in empirical analyses of currency substitution (see endnote 2):

$$(11)\quad \ln(M_d/P_d) = a_0 - a_1 i_d - a_2(i_f + E(\Delta e)/e)) - a_3 i_a + a_4 \ln(Y/P_d),$$

where i_a represents the return on a third alternative asset. Accordingly, currency substitution is said to exist if the cross-partial interest elasticity a_2 is statistically significant. But as Branson (1972, p.29) has demonstrated, _if_ the underlying transactions technology is characterized by a CES function, then the cross-partial interest elasticity, the direct interest elaticity, a_1, and the elasticity of substitution are related to each other according to the following expression:

$$a_2 = c(\sigma - a_1),$$

where c lies bewteen zero and one. Consequently, to accept the null hypothesis that a_2 equals zero--that is, no currency substitution--is not equivalent to accepting the null hypothesis that σ is equal to zero; on the contrary, it implies that $\sigma = a_1$. The present study avoids this difficulty by relying on a specific structural model. Alternative, and more general, structural models would also avoid the potentially misleading implications associated with reduced-form coefficients.

Finally, the design and implementation of monetary policy benefit not only from knowledge of the existence of currency substitution, but also from knowledge of its magnitude. However, much of the existing literature[11] has been devoted almost exclusively to the issue of statistical significance. Even if cross-partial interest elasticities of 0.001 and 5.0 were equally significant, differences in their magnitudes carry different implications for monetary policy and exchange rate determination which cannot be left unidentified. The present formulation avoids this difficulty by focusing on both the magnitude of σ and its statistical significance.

3. Empirical Implementation

3.1 Econometric Considerations

As it stands, the parameters of equation (10) are not suitable for econometric estimation because first M^* is unobservable and second, both dynamic considerations and stochastic influences have not been recognized.

The level of optimal aggregate monetary services, M^*, is not observable because it depends on σ, which is not known a priori. To circumvent this difficulty, it is assumed that there exists a behavioral relationship between the unobservable M^* and an observable variable. This paper relies on a nonlinear version of the Cambridge equation:[12]

$$M^* = f(Y) = \alpha Y^{1/\mu}, \tag{12}$$

where Y represents nominal income and α represents the liquidity preference. The parameter μ represents the inverse of the income elasticity of aggregate money services M^*. If $\mu = 1$, then equation (12) implies a constant velocity of circulation of domestic money holdings.

Dynamic adjustments are recognized here by adopting the widely used assumption that the difference between the actual demand for domestic money,

M_{dt}, and its desired level, M^*_{dt}, is eliminated with a constant speed of adjustment ψ within the period of observation:[13]

$$(13) \qquad M_{dt} = (M^*_{dt})^{\psi} (M_{d,t-1})^{1-\psi}.$$

Substitution of equation (10) into equation (13), and adding an error term u_t, yields a domestic money demand equation suitable for parameter estimation:

$$(14) \qquad M_{dt} = \{1+((1-\delta)/\delta)^{\sigma}((1+i_d)(E(e_{t+1})/e_t)/(1+i_f))^{\sigma-1}\}^{\psi\sigma/(1-\sigma)}$$

$$\cdot \; K\delta^{\psi\sigma/(1-\sigma)}(Y^{\psi/\mu})(M_{d,t-1})^{1-\psi} + u_t,$$

where $u_t \sim N(0, \sigma_u^2)$, $E(u_t \cdot u_{t-j})=0$ for $j>0$, and $K = (\alpha/A)^{\psi}$.

One of the salient features of this last equation is its intricate nonlinearity in the parameters. As a result, the estimation of these parameters rests on nonlinear least squares; the algorithm employed here is an adaptive quasi-Newton iterative approach developed by Dennis et. al. (1981).[14]

3.2 Exchange-Rate Expectations

Although the theory of exchange rate determination has been the subject of an increasing amount of attention in the literature (see Krueger 1983), the predictive power of existing theoretical exchange-rate models has been challenged recently by Meese and Rogoff (1983). According to their analysis, the exchange rate model with the greatest predictive power is one where the exchange rate this period is expected to prevail in the following period as well:

$$E(e_{t+1}) = e_t,$$

which implies that the exchange rate follows a random walk:

$$e_{t+1} = e_t + v_t, \text{ where } v_t \sim N(0, \sigma_v^2),\ E(v_t \cdot v_{t-j}) = 0 \text{ for } j > 0.$$

The present paper adopts the random walk model of exchange-rate determination on the basis of its superior forecasting power.[15] This choice of expectation model is also motivated by the regression results of Diaz-Alejandro (1984), which reveal that the two most important determinants of the real exchange rate in Venezuela are an intercept and a dummy with a value of 1 for 1983, the year of the collapse of the fixed exchange rate system. Notice that the empirical tests of currency substitution are conditional on the validity of the exchange-rate expectation model adopted here.

The forecasting power of theory-based exchange rate models might improve in the future with the development of alternative theories, more data collection, and more sophisticated estimation techniques. Until then, however, the present analysis rests on what seems now to be strong empirical evidence in favor of the random walk hypothesis for exchange rate behavior.

3.3 Empirical Results

The data used for estimation are annual covering the period 1961-1980. Inclusion of post-1980 data would not allow us to determine whether currency substitution is a general characteristic of the Venezuelan economy or whether it is the result of the events leading to the financial crisis of February 1983.[16] If anything, their inclusion would bias the results in favor of the currency substitution hypothesis.

The results displayed in table 1 reveal that the estimate of the elasticity of currency substitution in Venezuela ranges from a value of 6.0 for M1 to a value of 8.5 for M2. Given the wide range of values that σ can take, the range of elasticity estimates obtained here is relatively narrow. Furthermore, even though these elasticity estimates are less than infinite (perfect substitutability case), they are substantially greater than one, which is the (generally accepted) benchmark value above which currencies are said to be good substitutes for each other.[17] One implication of these empirical findings is that the absence of onshore balances denominated in foreign currency is not a necessary condition for the existence of currency substitution. For Venezuela, currency substitution might be arising from both the relative importance of firms with international transactions and the absence of capital controls.

The parameter μ represents the inverse of the long-run income elasticity of money holdings and its estimated value ranges from 0.76 to 0.96. A test for the null hypothesis of $\mu = 1$ reveals that it is not possible to reject this hypothesis for the monetary aggregates M1 and M3, whereas it is not possible to accept it for the M2 money aggregate. The estimates of μ imply an income elasticity ranging from 1.04 to 1.31 which is similar to estimates obtained by other investigators.[18] The estimate of the (constant) speed of adjustment, ψ, ranges from 0.28 to 0.45 implying that half of the adjustment takes place in a year.

Table 1 contains also several statistical diagnostics aimed at determining the validity of the maintained assumptions for the error term--namely, normality, homoskedasticity, and serial independence. Specifically, the Jarque-Bera statistic for the normality test indicates that it is not possible to reject the hypothesis of a normal distribution for the error process for any of the monetary measures considered here.[19] Secondly, as indicated by the ARCH value, the hypothesis that the error term is homoskedastic cannot be rejected.[20] Finally, the hypothesis of serial independence in the residuals is tested with an F-statistic for the null hypothesis that all the coefficients in an autoregressive form of order 8 are equal to zero. The values for the F-test suggest that the estimated residuals do not exhibit any sign of serial correlation. All in all, the assumptions embodied in the error term are not rejected by the available data.

3.4 Implications of Currency Substitution: Could The 1983 Exchange-Rate Collapse Have Been Anticipated?

After supporting a fixed exchange rate regime for over twenty years, the monetary authorities in Venezuela closed the foreign exchange market in February of 1983 to prevent a speculative run on international reserves. The purpose of this section is to use the empirical results obtained above to estimate the out-of-sample exchange risk prior to the 1983 collapse.

The exchange-rate risk, θ, is defined here as the difference between the exchange rate expected to prevail next period and the forward rate for that period. Because of the commitment of the monetary authorities during the 1981-82 period to support a fixed exchange rate system, the forward rate in Venezuela would simply be the official exchange rate, e^*. Logarithmic differentiation of the short-run version of equation (8) yields[21]

$$\text{(15)} \qquad \Delta\theta = \Delta(\ln M_{ft} - \ln M_{dt})/(\psi\sigma) + \Delta(\ln(1 + i_f) - \ln(1 + i_d)),$$

where

$$\theta = \left(E(e_{t+1}) - e^*\right)/e^* = E(e_{t+1} - e^*)/e^*.$$

Equation (15) gives the out-of-sample, or "revealed," exchange-rate risk conditioned on the currency substitution model developed here. Note that, according to (15), perfect currency substitutability ($\sigma \to \infty$) is a sufficient and necessary condition for interest rate parity between two currencies. [22]

Table 2 presents data on domestic and foreign money (offshore) balances and on domestic and foreign interest rates. With this information, it is possible to compute a rough estimate of the exchange-rate risk for the years 1981-1982 using the parameter estimates for the M1 money aggregate. For the purposes of this computation, it is assumed that the exchange-rate risk in 1980 is zero, an assumption that is consistent with the analysis of Diaz-Alejandro (1984).[23]

As table 2 reveals, the exchange-rate risk associated with the Venezuelan bolivar increased by 46.4 percent in 1981 and by a further 48.3 percent in 1982, giving a 117.1 percent overall increase. These results suggest that the probability attached to the expected devaluation of the Venezuelan bolivar rose quite substantially after two years.[24] Such expectations might have been triggered by declining nominal oil prices and by a level of international reserves below Venezuela's short-term external obligations. Given the relatively large estimate of the elasticity of currency substitution, acting on the increased probability of a devaluation entailed a depletion of international reserves to the point where the monetary authorities were forced to close the foreign-exchange market in February of 1983. [25]

Provocative as it may be, the preceding analysis is subject to a number of qualifications that might limit its applicability to other circumstances. First, the data available for M_f are based on liabilities of U.S. banks to

Venezuelan residents. Thus no allowance is made for liabilities of non-U.S. foreign banks to Venezuelan residents, liabilities of foreign banks to Venezuelans not registered as residents, and non-financial assets of Venezuelans abroad. To the extent that excluding these components underestimates the increase in foreign money balances, the change in the exchange-rate risk computed here might represent a lower bound to such risk. Secondly, the computations rest on the validity of the model used, on the constancy of the estimated elasticity of currency substitution, and on the exchange rate model assumed for its estimation. With these caveats in mind, the exchange-rate risk estimates obtained in this paper should be seen as tentative.

4. Conclusions

The purpose of this paper has been to determine empirically the extent to which domestic money balances in Venezuela have been influenced by foreign exchange considerations. To this end, individuals are assumed to face a relatively simple optimization problem the solution of which yields the specification of domestic money holdings. This specification is implemented empirically, and the results yield statistically significant estimates of the elasticity of currency substitution estimate ranging between 6 and 8. This empirical evidence lends support to the idea that foreign exchange considerations are important for modeling money demand behavior in Venezuela and, as result, for the design of monetary and exchange rate policies.

Given the elasticity estimates, the currency substitution model is used to estimate changes in the out-of-sample conditional exchange-rate risk for the period prior to 1983. The estimates suggest that the expectation of a devaluation of the Venezuelan bolivar became increasingly more likely towards the end of 1982. Because these estimates are preliminary, further work is needed before their tentative nature can be removed. Specifically, it is important to determine the sensitivity of the elasticity estimates to changes in the underlying assumptions about the transactions technology, the dynamic adjustment, and the model of exchange-rate expectations. Analyses that relax or eliminate these assumptions are certain to enhance our understanding of the importance of currency substitution.

ENDNOTES

1 One of the first papers in the area of money substitutes is Chetty (1969). For more recent theoretical analyses see Canto and Miles (1983), Krueger (1983), Girton and Roper (1981), Cuddington (1983), Calvo and Rodriguez (1977), Boyer (1978), King et. al. (1978), Nickelsburg and Canto (1983), Calvo (1985), and Thomas (1985). For empirical analyses focusing on currency substitutability and the behavior of the exchange rate for the major currencies, see Brillembourg and Schadler (1979), Britain (1981), Miles (1981), and Melvin (1985). For the role played by currency substitution in the international transmission of inflation see McKinnon (1982), Goldstein and Haynes (1984), and Darby and Stockman (1983). For the literature focusing on developing countries, see Tanzi and Blejer (1982), Nickelsburg (1984), Nickelsburg and Canto (1983), Ortiz (1983), and Blejer (1978).

2 See the analyses of Ortiz (1983), Cuddington (1983), Nickelsburg (1984), Nickelsburg and Canto (1984), Tanzi and Blejer (1982), Blejer (1978); Canto and Miles (1983) and Miles (1978) are exceptions in this regard.

3 For Balance-of-payments-crisis models see Krugman (1979) and Obstfeld (1984). For analyses of government seigniorage, see Fischer (1982), and Khan and Ramirez-Rojas (1984).

4 For Venezuela, these balances can be held offshore only. For data on US$ balances of Venezuelan residents, see the Federal Reserve Bulletin. Data on liabilities of German banks to Venezuelan residents are published by the Deutsche Bundesbank (Balance of Payments Statistics, table 7d); only recent information is available. Data on liabilities to Venezuelan residents from other countries are scant.

5 The model developed here is analogous to Thomas' (1985) model, except that he determines the level of output (consumption C in his model) endogenously, whereas it is exogenously given in this paper. This separability assumption is needed for consistent aggregation; see Barnett (1980, 1985). Clearly, the empirical validity of the separability assumption should be tested in future research.

6 The space of parameter estimates of well-known flexible functional forms, such as the translog (Simos 1981) or the generalized Leontieff, do not satisfy globally the restrictions imposed by neoclassical optimizing behavior. Note, however, that the CES is not the only functional form satisfying these neoclassical properties. I have benefitted from comments by William Barnett and James Boughton on this regard.

7 Bordo and Choudhri (1982), and Boughton (1981) criticize the validity of the CES function for Canada and for the U.S., respectively. Bordo and

Choudhri assume that the ratio of domestic to foreign balances can be expressed as a function of real income and interest rates. They find that the coefficient on income is significant which would invalidate the CES as a functional form for Canada. However, these tests rest on the validity of postulated demand functions and on the assumed normality of the regression residuals. These demand functions correspond to the solution of an unspecified optimization problem which need not be consistent with the CES formulation. Furthermore, they do not test for normality in the residuals; if these fail to be normal, then their statistical inferences would not be valid. Boughton derives asset demand functions from an objective function which includes the CES as special case; his empirical results indicate that half of the cases examined support the CES functional form. (He also tests for normality of the errors.) Because the financial market in Venezuela is significantly "less mature" than the financial markets in the U.S. and Canada, it might be possible (as Boughton has indicated to me) that the CES might provide a useful first approximation to the transaction technology in Venezuela. It is certainly possible for the transactions technology to be typified by some other functional form, and the sensitivity of our results to alternative transaction technologies ought to be the subject of further investigation.

8 One way to test for the existence of purchasing power parity, suggested by Genberg (1978), is to regress the logarithm of the real exchange rate, eP_f/P_d, on a time trend. If the coefficient on this variable is significant, then it is not possible to accept the null hypothesis of PPP. Using annual data for Venezuela for the period 1961-1980, I obtain the following results (t-statistics in parentheses):

$$\ln(e_t P_{ft}/P_{dt}) = \underset{(53.7)}{5.960} + \underset{(0.4)}{0.003}\text{TIME}; \quad \bar{R}^2 = -0.12, \ DW=2.14, \ SER=0.103, \ rho=0.578,$$

where e=bolivars/\$US; P_f= Venezuela's import price; and P_d= Venezuela's GDP deflator. This evidence, while consistent with PPP for the period 1961-1980, is far from being a substitute for a more serious study of whether PPP holds in Venezuela. As evidenced in the papers of the Symposium on Purchasing Power Parity (Journal of International Economics, May 1978), this task is beyond the scope of this paper. Unfortunately, the papers contained in that symposium do not examine the Venezuelan experience.

9 Specifically, $\lambda = 1$ is an admissible value which implies, by duality, that $\sigma = 1$. Thus the value of σ is being assumed rather than being estimated. I am grateful to Eric Bond for bringing this point to my attention.

10 See Khan and Ul-Haque (1985) who offer a model of capital flight and discuss problems associated with its measurement.

11 For example, see Blejer (1978), Cuddington (1983), Nickelsburg (1984), and Ortiz (1983).

12 While this is clearly an ad-hoc procedure, it is at least consistent with the idea that a given level of output requires a certain amount of monetary services. Note that this adhocness is not needed in general. Specifically, one could measure M* as a divisia index of domestic and foreign balances; such an index is a second order approximation to any functional form (see Barnett 1980). However, this approach requires data on balances denominated in foreign currency which, in the Venezuelan case, are difficult to obtain.

13 Besides not being the solution to an intertemporal problem, one clear limitation of this assumption is that the speed of adjustment is the same for all explanatory variables. See Corbo (1982) for a dynamic adjustment based on a disequilibrium hypothesis.

14 The algorithm minimizes the sum of squared residuals iteratively. The parameter vector at the kth iteration $\underset{\sim}{b}_k$ is

$$\underset{\sim}{b}_k - \underset{\sim}{b}_{k-1} = -t_k(H_k)^{-1}g_k = -t_k(J_k'J_k + S(\underset{\sim}{b}_k))^{-1}g_k,$$

where t_k is the step length, H_k is the Hessian, g_k is the gradient, J_k is the Jacobian, and S(.) is a function of the residuals. The Gauss-Newton algorithm ignores this last term, whereas the Newton algorithm computes it at each iteration and it is extremly slow and expensive. The method used here computes S(.) iteratively according to

$$S_{k+1}\Delta\underset{\sim}{b}_k = J_{k+1}'(\underset{\sim}{u}(\underset{\sim}{b}_{k+1}) - \underset{\sim}{u}(\underset{\sim}{b}_k)), \text{ where } \underset{\sim}{u}' = (u_1, \ldots, u_T).$$

For further details, see Dennis et. al. (1981). This algorithm is available in the computer software known as TROLL.

15 The empirical evidence of Meese and Rogoff need not apply to the Venezuelan case. However, the random-walk hypothesis for exchange rate expectations might be applicable for Venezuela during the period under consideration because of both the commitment of her monetary authorities to support the fixed exchange rate system and the large international reserves. The Venezuelan exchange rate remained fixed at 4.292 bolivars/US$ for the period 1976-1982. For the earlier period, it was also fixed at a slightly different value (see data appendix).

16 For further evidence on the anomalies associated with the post-1980 period, see Sachs' comments to Diaz-Alejandro (1984), especially pp. 395-396. Sachs argues that the years 1981-1982 were very atypical.

17 The empirical results for the portfolio balance model, equation (11), for the period 1961-80 are (t-statistics in parentheses):

$$\ln M_{dt} = \underset{(2.7)}{0.592} + \underset{(6.6)}{1.084} \ln Y_t - \underset{(-2.6)}{5.343}\, i_d - \underset{(-1.0)}{0.199}\, (i_f + E(\Delta e)/e) + \underset{(0.6)}{0.123} \ln P_{dt}$$

$$-\underset{(-2.7)}{0.690}\, \Delta \ln P_{dt} + \underset{(1.7)}{0.234} \ln M_{d,t-1} \;;\; \bar{R}^2 = 0.99 \;\; DW=1.49 \;\; SSE=0.046 \;\; JB=0.19 \;\; ARCH\text{-}t=0.25 \;\; AR(8)=0.19;$$

the monetary aggregate is M1; Y is nominal GDP; other definitions are found in table 1 and in footnote 8. Note that commodity inventories are treated as an alternative asset, which could justify inclusion of the inflation rate. Also, the coefficient for the price level is $(1 - a_4)$, which is very close to zero. This finding implies that the income elasticity is not different from one, as can be tested directly using the above estimates.

On the basis of this evidence, one would conclude that foreign exchange considerations do not influence domestic money holdings in Venezuela. However, using Branson's result--that is, $a_2 = c(a_1 - \sigma)$, one finds that $\sigma = 6.975$ $(=5.343/(1-0.234))$ with $Var(\sigma)=4.22$, which suggests that foreign exchange considerations do influence domestic money holdings.

18 For example, Ortiz (1983) obtains an income elasticity ranging between 1.4 and 1.5; the income elasticity estimates of Blejer (1978) are also in the neighborhood of one.

19 Testing for the hypothesis that the errors behave according to the normal distribution relies on the Jarque-Bera statistic (Jarque and Bera 1980), JB:

$$JB = T(\mu_3^2/(6\mu_2^3) + (1/24)(\mu_4/(\mu_2^2 - 3)^2) \sim \chi^2(2),$$

where $T \equiv$ sample size, and $\mu_j = \sum_{t=1}^{T} \hat{u}_t^j/T$; the first term of the JB statistic represents the skewness and the second represents departures of the estimated kurtosis from the kurtosis associated with the normal distribution; both measures are derived for the empirical distribution of the residuals, $\hat{u}$.

20 The test for homoskedasticity rests on the work of Engle (1982) on autoregressive conditional heteroskedasticity (ARCH) disturbances. Specifically, the model used to test for homoskedasticity is

$$E(\hat{u}_t^2 | \hat{u}_{t-1}) = \gamma_0 + \gamma_1 \hat{u}_{t-1}^2;$$

the null hypothesis of homoskedastic errors cannot be rejected if $\gamma_1=0$, which is tested with a t-statistic.

21 The short-run version of equation (8) is

$$\Delta \ln(eM_f/M_d) = \psi\sigma\, \Delta \ln((1 + i_d)(1 + E(\Delta e)/e)/(1 + i_f)).$$

Note that use of this equation does not involve any inconsistency if the parameter estimates are obtained using <u>all</u> the first-order conditions.

22 Note that, for assets that are perfect substitutes for each other, the portfolio-balance model yields this interest parity condition. The reason why these two alternative models yield the same result is because the cost minimization problem is the dual to the wealth maximization problem.

23 Diaz-Alejandro (1984), relying on time-series evidence, points out that in retrospec, Venezuela did not required drastic policy adjustments in 1980. Furthermore, he argues that the 1979-80 oil price shocks were perceived as permanent improvements in the terms of trade. On these accounts, it seems reasonable to assume that exchange-rate risk in Venezuela is zero in 1980. Finally, note that the estimated residuals of the money demand equations of table 1 show no sign of serial correlation.

24 The growth rates for M2 during 1981 and 1982 are 20.2 and 3.6 percent, respectively; the ex-post exchange-rate risk of the bolivar with M2 data is 43 percent. The growth rates for M3 during 1981 and 1982 are 15.8 and 3.2 percent, respectively; the ex-post exchange-rate risk associated with M3 data is 81.5 percent.

25 Note that U.S. liabilities to Venezuelan residents, valued at the official exchange rate, are very close to the value of M1 holdings.

Table 1
Parameter Estimates For Conditional Money Demand
Alternative Definitions of Aggregate Money
Venezuela: 1961-1980
(Numbers in parentheses are t-statistics)

		M1	M2	M3
Elasticity of Currency Substitution:	σ	6.038	8.521	7.409
		(2.1)	(3.9)	(7.4)
(Inverse of) Income Elasticity:	μ	0.956	0.763	0.871
		(5.4)	(15.4)	(7.5)
Speed of Adjustment:	ψ	0.279	0.446	0.297
		(1.7)	(3.9)	(2.5)
	K	1.109	1.095	1.132
		(20.1)	(29.5)	(27.0)
$\bar{R}^2$		0.99	0.99	0.99
D.W.		1.56	1.83	1.27
Durbin's h		0.668	0.442	1.926
Normality test[a]: Jarque-Bera (JB~$\chi^2(2)$)		0.902	0.723	0.360
Heteroskedasticity test[b]: Arch-t		0.080	-0.21	-0.39
Serial Correlation AR(8)[c]: F(8,4)		0.380	0.470	0.430

Data Sources: M_d = M1, M2, and M3 in nominal terms: Banco Central de Venezuela. i_d = interest rate charged by commercial banks in Caracas: Banco Central de Venezuela. i_f = U.S. Treasury bill rate: IMF. e = exchange rate (bolivar/US dollar): Banco Central de Venezuela. Y = nominal GDP: Banco Central de Venezuela.

a. Significance level at which the normality hypothesis is rejected.
b. t-statistic; if it exceeds a value of 2, the homoskedasticity hypothesis is rejected.
c. Significance level at which the serial independence hypothesis is rejected.

Table 2
Out-of-Sample Conditional Exchange-Rate Risk
Venezuela: 1981-1982

		1980	1981	1982
Balances of Foreign Money[a]				
M_f (mill. $US)		3476	6342	11667
$\Delta M_f/M_f$	(%)		82.5	84.0
Balances of Domestic Money[b]				
M_d (mill. bolívares)		49915	53482	49013
$\Delta M_d/M_d$	(%)		7.2	-8.4
Domestic Interest Rates[c]				
i_d	(%)	12.9	13.7	16.9
Δi_d	(%)		0.8	3.2
Foreign Interest Rates[d]				
i_f	(%)	11.6	14.1	10.7
Δi_f	(%)		2.5	-3.4
Exchange-Rate Risk[e]				
$\Delta\theta$	(%)	0	46.4	48.3
Official Exchange Rate				
e* (bolivars/US$)		4.30	4.30	4.30

a. Liabilities of U.S. banks to Venezuelan private residents.
b. M1 monetary aggregate.
c. Interest rate charged on loans by commercial banks in Venezuela.
d. U.S. Treasury bill rate.
e. The exchange-rate risk is computed using the following approximation to equation (15):

$$\Delta\theta = (\Delta M_f/M_f - \Delta M_d/M_d)/(\psi\sigma) - \Delta(i_d - i_f), \text{ where } \sigma = 6.038,\ \psi = 0.279.$$

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DATA APPENDIX

M1L - Logarithm of money supply, M1, 1975=1; Venezuela.

60	-1.914560	-1.887500	-1.925360	-1.860340	-1.734410	-1.644560	-1.620460	-1.514760
68	-1.419010	-1.330360	-1.289880	-1.108420	-0.982554	-0.778841	-0.432851	-0.000000
76	0.117652	0.348806	0.539280	0.604041	0.732767			

M2L - Logarithm of money supply, M2, 1975=1; Venezuela.

60	-1.997750	-2.052180	-2.036720	-1.877930	-1.720520	-1.651550	-1.653060	-1.524530
68	-1.433650	-1.325170	-1.244910	-1.089490	-0.888293	-0.704302	-0.417571	-0.000000
76	0.215658	0.442856	0.567951	0.657593	0.916956			

M3L - Logarithm of money supply, M3, 1975=1; Venezuela.

60	-2.156740	-2.211180	-2.183400	-2.011350	-1.843210	-1.769570	-1.760260	-1.621900
68	-1.514400	-1.395080	-1.296450	-1.106860	-0.883940	-0.690209	-0.410505	-0.000000
76	0.233988	0.460660	0.580575	0.648890	0.846281			

PRICE_PGDP75 - GDP deflator, 1975=1; Venezuela.

60	0.497068	0.498270	0.499247	0.508934	0.513904	0.515614	0.524301	0.531888
68	0.548037	0.541396	0.560969	0.597704	0.622997	0.698218	1.007530	1.000000
76	1.055350	1.137980	1.208690	1.476560	1.827360			

INTEREST_R - Interest rate charged by commercial banks; Venezuela.

60	8.100000	8.300000	8.200000	9.100000	8.400000	8.300000	8.600000	8.700000
68	9.000000	9.600000	10.300000	10.100000	10.100000	10.100000	10.100000	10.100000
76	10.000000	9.800000	10.100000	11.600000	12.900000			

INTEREST_RUS - U.S. 90-day Treasury Bill.

60	2.940000	2.380000	2.780000	3.160000	3.550000	3.950000	4.880000	4.330000
68	5.350000	6.690000	6.440000	4.340000	4.070000	7.030000	7.870000	5.820000
76	4.990000	5.270000	7.220000	10.040000	11.620000			

EXR_AV - Exchange rate, bolivars/$US; Venezuela

60	3.349500	3.350000	3.349750	3.349500	4.501250	4.499750	4.498500	4.500000
68	4.500000	4.499250	4.498250	4.500750	4.400500	4.304750	4.284500	4.285000
76	4.289750	4.292000	4.292000	4.292000	4.292000			

GDPNL - Logarithm of nominal GDP, 1975=1; Venezuela.

60	-1.527730	-1.477220	-1.387990	-1.301400	-1.199590	-1.137580	-1.096250	-1.044470
68	-0.966837	-0.935325	-0.815867	-0.722662	-0.649151	-0.476042	-0.050013	-0.000000
76	0.134587	0.276030	0.365563	0.573623	0.770011			