BANCO CENTRAL DE LA REPUBLICA DOMINICANA

XVIII Reunión de técnicos de Bancos Centrales del Continente Americano

A MONETARY APPROACH TO EXCHANGE RATES WITH CURRENCY SUBSTITUTION: THE SMALL, OPEN ECONOMY CASE

Victor A. Canto

Santo Domingo
1–6 noviembre 1981
República Dominicana

A MONETARY APPROACH TO EXCHANGE RATES WITH CURRENCY SUBSTITUTION: THE SMALL, OPEN ECONOMY CASE

Victor A. Canto
September 1981

INTRODUCTION

With the advent of the modern literature on the monetary approach to exchange rate determination, a large amount of effort has been devoted to emphasizing the role of the money markets in the determination of exchange rates. The importance of monetary variables in a regime of floating rates has been analyzed in detail. Bilson (1979) provides an excellent summary of the state of the theory evolving out of the work of Johnson (1972) and Mundell (1968, 1971).

Although an important step forward in our understanding of the foreign exchange market, the monetary approach to floating exchange rate assumes separable demand functions for each national money and as such, it neglects international switching among different monies (i.e., currency substitution). On this issue, see Miles (1978) and Girton and Roper (1981).

This paper develops and estimates a model which accounts for the effects of currency substitution in the determination of exchange rates. Specifically, the model analyzes the case of a small open economy where in addition to the domestic currency, an international currency circulates in the economy. Furthermore, the domestic currency is assumed to circulate only in the small open economy.

The paper is organized as follows. Section 1 presents the basic model and uses it to study the effect of changes in the domestic and international monies on the exchange rate. Some of the implications of the currency substitution model differ from those of the standard monetary model of exchange rate. In particular the following two are worth noting: one being that unanticipated increases in the domestic money will have a less than proportionate effect (smaller than unity) on the exchange rate rather than the unitary effect predicted by the standard model. The second being that if the international currency, say the dollar, is used by residents of other countries for transaction purposes (i.e., there is currency substitution) the U.S. money supply will differ from the world money supply. And in general, one would not expect to find a negative relationship between unanticipated increases in the U.S. money supply even though a negative relationship may exist between unanticipated changes in the world supply of dollars. In contrast, the standard monetary model assumes the absence of currency substitution and thus the equality of the U.S. money supply and the world money of dollars and as a result predicts a negative relationship between unanticipated changes in the U.S. money supply and the exchange rate.

In section II following the methodology developed by Box and Jenkins (1970), the model is estimated using monthly data spanning the period from June 1969 to April 1979. The prediction of the model regarding the sign and the magnitude of the different parameters appears to be sustained by the data. Overall, the theoretical framework is consistent with the sample information.

Although the structure of the model does not facilitate a direct measure of the elasticity of substitution (see Miles 1978), it does avoid one potential source of simultaneous equation bias in the earlier empirical work on the subject. The empirical results reported in this paper are consistent with a high degree of substitutability. This in turn raises some important questions about the ability of the domestic monetary authorities to insulate the economy and to alter the quantity of money (foreign plus domestic) circulating the economy.

The Model

The traditional monetary approach to exchange rates assumes that different monies are nontraded goods. That is, the residents of a given country transact only in domestic currency (see Bilson (1979) and Mussa (1976)). The main feature of the exchange rate model developed in this paper is that it accounts for different degrees of currency substitution. The degree of substitutability allowed ranges from the case where the domestic residents transact only with the domestic currency so that no direct displacement of one money by another occurs even when exchange rates are volatile (i.e., zero substitution across currencies), to the case where there is perfect fungibility in the demand for different monies (i.e., infinite elasticity of substitution across currencies).

We take the case of a small open economy, defined as one whose international price of traded goods is exogenously determined. In addition, we do not allow for the existence of nontraded goods. Thus, in absence of any frictions, international commodity arbitrage will result in the law of one price. That is:

$$p^d = e + p^f \tag{1}$$

Where p^d and p^f denote the log of the domestic and foreign price levels respectively and e the log of the exchange rate between the domestic and foreign monies.

Capital mobility combined with profit maximizations yields interest rate parity.[1]

$$i_d - i_f = -[e - Ee] \tag{2}$$

where i_d and i_f are defined as one plus the domestic and foreign interest rates and Ee the expected change in the exchange rate. Free trade and capital mobility results in the equalization of factor prices and per capita income across countries (see Mundell (1957) and Samuelson (1965)). Thus,

$$Y^d - N^d = Y^f - N^f \tag{3}$$

where Y^d and Y^f denote the logarithm of the domestic and foreign real income, respectively, and N^d and N^f the logarithm of the domestic and foreign population endowments, respectively.

The theoretical basis for the analysis within the model is the classical demand-for-money theory. The classical model is not reviewed here in detail since good summaries of both theory and empirical evidence are available in the literature (see for example Laidler (1977)). One assumption of the classical demand-for-money theory worth noting, however, is that real activity is viewed largely as exogenous (see Fisher (1911)). Alternatively stated, the classical demand-for-money theory assumes the natural rate hypothesis. Although restrictive, this assumption allows one to focus on the specific effects of monetary policy on the exchange rate.

Throughout the paper, the world supply of a given money is assumed to be noninterest-bearing and to be under the control of the relevant monetary authorities.[2] In addition, it is assumed that the money issued by the monetary authorities of the small country is used only by domestic residents, while in fact the money issued by monetary authorities may be used worldwide. Initially, only two countries are assumed. The rest of the world demand for real balances is expressed as:

$$L^W = aY^W - bi_f \quad (4)$$

where L^W denotes the logarithm demand for real balances, a the income elasticity of demand for real balances, b the interest rate semi-elasticity of demand for real balances.

Residents of the small open economy can transact either in domestic or foreign money. In order to allow for switching among the different monies by the local residents, their allocations of real balances among the two monies is characterized as follows:

$$L_d^d - L^d = \gamma^d - \sigma(1 - \alpha)\,(i_d - i_f) \quad (5)$$

$$L_f^d - L^d = \gamma^f + \sigma\,\alpha(i_d - i_f) \quad (6)$$

where L^d, the log of real balances, is assumed to have the same functional form as L^W. L_d^d and L_f^d denote log of the amount of real balances held in the form of the domestic and foreign money, respectively. γ^d and γ^f are parameters denoting the efficiency of the domestic and foreign money in the production of real balances. σ denotes the elasticity of substitution between domestic and foreign monies, α and $(1 - \alpha)$ the share of domestic and foreign monies in the production of real balances.

The domestic demand for real balances held in the form of each of the two currencies can be expressed as:

$$L_d^d = aY^d + \gamma^d - bi_d + (b - \sigma)(i_d - i_f) \quad (7)$$

$$L_f^d = aY^d + \gamma^f - bi_f - (b - \sigma)(i_d - i_f) \quad (8)$$

Worldwide equilibrium requires the equality of the world demand for the two real monies (equations 4 and 7) with the world money supplies.[3] Substracting one equilibrium condition from the other and substituting equations 1, 2 and 3 yields the following expression for the exchange rate:

$$e = \frac{[a(N^f - N^d) - \gamma^d] + (M^d - M^f) + \sigma Ee}{(1 + \sigma)} \tag{9}$$

where M^d and M^f denote the logarithm the world supply of the domestic and foreign monies, respectively.

Solution to the Market Clearing Exchange Rate Under Imperfect Information

Prior to considering the formation of expectations, it is first necessary to specify the process generating the growth of the different monies M^f and M^d. In what follows it is posited that M^W and M^d are a function of a constant growth rate (assumed to be zero for simplicity), and of random terms m^f and m^d, respectively. Thus,

$$M_t^d - M_{t-1}^d = m^d \tag{10}$$

$$M_t^f - M_{t-1}^f = m^f \tag{11}$$

where m^d and m^f are normally distributed white noise processes with zero mean and constant variances σ_d^2 and σ_f^2, respectively.

To model the functioning of the economy under imperfect information, it is a convenient abstraction to think that economic activity in the economy occurs in a continuum of physically and informationally separated market locations. It is assumed that information flows instantaneously across the agents within any location, but it is propagated to the rest of the economy with a one period lag.[4] In this set up, unexploited profits opportunities will not exist when there is only one price for each location. But prices may differ across locations.

The spot exchange rate is viewed here as resulting from the optimizing behavior of the household under imperfect information. The formation of expectations is assumed to be rational in the sense of Muth (1961). Given current available information, participants in each market use the structure of the economy, which is known to every one, to form the operational forecast of the exchange rate. Furthermore, actions based on these forecasts generate the assumed structure. We assume that in any location, z, at time t, agents demand and supply of foreign exchange, results in the following exchange rate:

$$e_t(z) = \frac{K + (M^d - M^f) + \sigma E[e|I_t(z)] - (\varepsilon^d(z) - \varepsilon^f(z)}{(1 + \sigma)} \qquad (12)$$

where K denotes a parameter describing the effect changes in the relative demand for the two monies in the exchange rate.

$\varepsilon^d(z)$ and $\varepsilon^f(z)$ denote stochastic components specific to market z. These shocks are assumed to be generated by a white noise process with zero mean and constant variances $\sigma\varepsilon_d^2$ and $\sigma\varepsilon_f^2$ respectively. E is the expectation operator and $I_t(z)$ the information set.

The equilibrium values of exchange rates can be shown to be[5]

$$e_t(z) = K + M_{t-1}^d - M_{t-1}^f + [m_t^d + m_t^f + \varepsilon_t^d(z) + \varepsilon_t^f(z)][\frac{1 + (\theta_t - \theta_2)}{1+\sigma} \sigma] \qquad (13)$$

In turn, an aggregate spot price index, e_t, can be calculated as a (geometric, unweighted) average of the spot price where the relative distrubance terms $\varepsilon_t^d(z)$ and $\varepsilon_t^f(z)$, are averaged out in determining e_t.

$$e_t = M_{t-1}^d - M_{t-1}^f + [m_t^d - m_t^f] \left[\frac{1 + (\theta_1 - \theta_2)\sigma}{1+\sigma}\right] + K \quad (14)$$

One result for e_t in equation 15 is that M_{t-1}^d and M_{t-1}^f, which are contained in the information set, $I_t(z)$, have a proportional effect on the exchange rate, that is, the same result as the standard monetary approach to exchange rate. The exchange rate, however, is also affected by concurrent events which the market has not anticipated. But, since market particpants do not have separate observation of $e_t(z)$ nor of the aggregate index e_t, they cannot separate the impact of an increase in the money supplies (m_t^d, m_t^f) from the impact of other excess demand shifts ($\varepsilon_t^d(z)$, $\varepsilon_t^f(z)$). Unanticipated effects will lead to currency switching (i.e., currency substitution). Hence, (m_t^d, $\varepsilon_t^f(z)$) and (m_t^f, $\varepsilon_t^d(z)$) enter with an equal magnitude and opposite sign coefficient in equation 15. This coefficient equals unity under the following two conditions: First, when the only source of exchange rate uncertainty is due to the domestic monetary policy ($\theta_1 = 1$); the other, when there is no substitution between the two currencies ($\sigma = o$). That is on whether domestic residents hold only the domestic currency. Thus if both monies contribute to the exchange rate variance, it follows that, $1 < \theta_i < 0$, in which case only if there is no substitution across currencies ($\sigma = 0$) will the coefficient for the innovation in the money supply be unity. Alternatively stated, a coefficient different than unity can be interpreted as evidence favoring the currency substitution model over the standard monetary approach to the exchange rate.

A World of More Than Two Countries

The theoretical analysis in the previous pages is now extended to the case where more than two countries exist. A large economy is assumed to exist, say, the U.S. and its residents, is assumed to transact only in U.S. dollars. For the rest of the world it is assumed that residents of each country, if they choose to, can transact in the local currency as well as the U.S. dollar. Furthermore, each of the countries is assumed to be small relative to the world and U.S. economies.

If each of the non-U.S. countries is small as assumed, one can neglect the effect of changes in the relative price of each currency vis-à-vis the U.S. dollar in the determination of worldwide demand for U.S. dollars. Thus, world wide equilibrium may still be adequately represented by equation 4. Thus, in turn, the previous section analysis of the exchange rate determination is still applicable.[6] However, it must be noted that the variable M^f in equation 12 denotes the world money supply of dollars--not the U.S. money supply. The difference between M^f and USM1 is due to the net importation of dollars by the rest of the world. The argument here is analogous to the fixed-exchange-rate monetary approach to the balance of payments, the one difference being that the local monies are no longer substitutes in supplies (i.e., the currencies are no longer convertible). However, even though the currencies are nonconvertible, they are substitutes in demand and people use them in local transactions. Thus, rather than being registered as an official settlements balance, the importation of money is now recorded as a private capital flow.

This analysis suggests that in the case of rational expectations in the fixed-exchange-rate monetary approach to the balance of payments, unanticipated changes in the quantity of money circulating the U.S. economy will mirror the stochastic shock specific to the U.S. economy ε(US). Therefore unanticipated changes in the U.S. money supply will have no effect on the exchange rate between the small open economy money and the U.S. dollar. Alternatively stated, it is the unanticipated change in the world supply of dollars, and not the unanticipated changes in the U.S. money supply, which will influence the exchange rate. In contrast, the standard monetary approach to exchange rate assumes that local residents hold only the local currency, in which case the world supply of the currency equals the domestic supply, and as a result, predicts a negative relationship between the exchange rate and the U.S. money supply. As a result, the relationship between the small open economy exchange and the U.S. money supply can be used to descriminate between the currency substitution hypothesis and the zero substitution hypothesis implicit in the monetary approach to exchange rates.

Empirical Investigation: The Case of The Dominican Republic

Officially, since the creation of its central bank in 1948, the Dominican Republic has maintained a one-to-one parity with the U.S. dollar. However, since the 1960s, the Dominican monetary authorities have pursued a dual exchange rate system whereby the Central Bank provides foreign exchange at the official parity rate to activities deemed important to the economic development plans of the country. Importation of all other goods and services (as well as private capital flows) are allowed as long as importers provide their own foreign exchange.[7] Largely, as a result of this policy, the Dominican Republic has simultaneously experienced fluctuations in the black market exchange rate, as well as in the balance of payments. The dual exchange rate policy has resulted in a weakening of the economy balance of payments adjustment mechanism to excessive domestic creation[8] while simultaneously strengthening the role of the black market as an equilibriating mechanism to excessive domestic credit creation.

The Dominican authorities have not attempted to directly regulate the black market, nor have they altered the official rate. In this regard, the Dominican experience has been different from that of a crawling peg or managed float experienced by many countries during the last decade.[9] Even though in principle illegal, the black market has been allowed to operate freely in order to alleviate the pressures on the Central Bank. Furthermore, the market has been officially renamed the "parallel market" in order to eliminate the connotation implicit in the old name.[10]

There are several institutional features of the parallel market worth noting. First, since there are no "official" exchange rate locations, the market has produced its own conveniently located houses of exchanges. Secondly, since there are no restrictions to entry, individual transactors can be found in major tourist spots, outside hotels, banks and other centrally located places. Third, the exchange price is subject to negotiation and as a result, the price may differ not only across locations but also across transactions in a given location. Finally, largely as a result of the foreign exchange parallel market, the central bank has been able to collect daily information from the major foreign exchange dealers on the average transaction price.[11] The institutional feature of the Dominican Republic money and capital markets that deserves attention is the lack of well-developed futures and domestic capital markets. The lack of a well-organized future and bond[12] market eliminates the availability of forward exchange rate data.

Interestingly, many of the instituional features of the Dominican Republic resemble closely the ones assumed in the theoretical model, such as: the informationally separated markets (i.e., the index z), the lack of a forward foreign exchange and the unweighted market index for the exchange rate.

Some Caveats on the Empirical Implementation of the Theoretical Model

The exogeneity of the Dominican Republic and its effect on exchange rate remains an important issue. While not the only definition of causality, in what follows the cross-correlation between the prewhitened residuals, of estimated ARIMA models for the money supply and exchange late reported in Table 3 are utilized to examine the causal relationship between the Dominican money supply and the exchange rate. Haugh (1972) has shown that the asymptotic distribution of cross-correlations of the true innovations of the respective series. In particular the sample cross-correlation are asymptotically normal and independent across lags with mean zero and variance $(N-|K|)^{-1}$ for lag K and N observation. In the data the cross correlation between the DRM1 residuals and the e residuals are fairly small for the proceeding month and approximately two standard deviation for the subsequent month. Durbin (1970) has shown that the sample cross-correlations of ARIMA residuals at negative lags no longer have the same destribution as would cross-correlation of true ARIMA innovations, essentially because of dependence between the ARIMA parameter estimates and the cross-correlation estimates. The implication, as pointed out by Pierce (1977), Haugh and Pierce (1977) and Sims (1977) is that the standard error for the negative lag cross-corrleation may be less than $(N-|K|)^{-\frac{1}{2}}$. One must therefore be cautious about accepting the hypothesis of one way causation from DRM1 to e when the alternative is two way causation on the basis of ARIMA cross-correlation alone. However, given the basic premise that predictive power, if present, is likely to be strongest at low lags, and that over the sample period e is much more predictable from DRM1 than DRM1 from e there seems to be a strong case for rejecting the hypothesis of no relation to causality running at least from DRM1 to e. Furthermore, the magnitude of the Box-Pierce statistics adjusted for downward bias, S^*, is below its expected value for the twelve leads under the null hypothesis of no auto correlation with a P-value of .442.

The empirical implementation of the model implicitly assumes that relative purchasing power and factor price equalization hold, as well as the same income elasticity of demand for real balances across countries. The validity of these assumptions were not investigated empirically due to the lack of reliable monthly data.

Finally, the derivation of the equilibrium value of the exchange rate (equation 14) assumes a very simple money supply process for the Dominican Republic. To the extent that the actual money process differs from the one assumed in the text, the anticipated component of the exchange rate equation has to be modified accordingly. However, the coefficient of the unanticipated component remains unchanged. It is this coefficient for which most of the empirical analysis focuses.

Estimation Procedures

In order to develop some time series estimates of the effects of the different monies in the exchange rate, the model developed above is restated in econometric form. A model that describes such dynamic response is sometimes called a transfer function model. Following Bax and Jenkins (1970), the transfer function noise model may be written as:

$$e_t = \nu(L)\, m_t^d + \nu_2(L)\, m_t^f + \frac{\theta_u(L)}{\phi_u(L)}\, \nu_t \qquad (15)$$

where $\nu_i(L)$, $\phi_u(L)$, $\theta_u(L)$ are finite polynomials in the lag operator, where it is assumed that the input variables have been differenced to induce stationarit,y and where ν_t is assumed to be a white noise process. The weights, ν_{io} . . . ν_{i2} are called the impulse response functions associated with input "i" and describe the deviation in the exchange rate e_t, e_{t+1}, e_{t+2}, resulting from a one unit deviation in the input m_i at time t. The summation

$$\sum_{J=0}^{\infty}{}_i\ \nu_{iJ} = g_i \qquad (16)$$

is called the steady state gain associated with input i and denotes the change in the equilibrium level of the exchange rate resulting from a one unit change in the level at which the output variable is fixed.

When there is a single input, m_t, Box and Jenkins suggest estimating impulse response weights in the following manner: find a linear filter $\phi_1(L)\ \theta_1^{-1}(L)$ such that

$$\alpha_{it} = \phi_1(L)\ \theta_1^{-1}(L)\ m_{it} \qquad (15)$$

is approximately white noise. Apply the same filter to the output variable to obtain

$$\beta_t = \phi_1(L)\ \theta_1^{-1}(L)\ e_t \qquad (16)$$

then the original model may be written as:

$$\beta_t = \nu_1(L)\ \alpha_{1t} + \varepsilon_t \qquad (17)$$

Let $\rho_{\alpha\beta}(k)$ denote the correlation between $\alpha_{1,t-k}$ and β_t. Then the impulse response function is related to the cross correlation function by

$$\nu_{1k} = \frac{\rho_{\alpha\beta}(k)}{\sigma_\alpha}\ \sigma_\beta \qquad (18)$$

where σ_α and $_\beta$ denote the standard deviation of α and β respectively.

The impulse response function is estimated by

$$\nu_{1k} = \frac{\rho_{\alpha\beta}(k)}{S_\alpha}\ S_\beta \qquad (19)$$

where $\rho_{\alpha\beta}(k)$ is an estimate of $\rho_{\alpha\beta}(k)$ and S_α and S_β are estimates of σ_α and σ_β respectively.

The Data

The data in this study come from a variety of sources reporting monthly time series estimates from June 1969 to March 1979. The data on the exchange rate and money supply for Dominican Republic were made available by the Dominican Republic Central Bank. The data on the U.S. money supply, USM1, were attained from the Federal Reserve Bulletin monthly bulletin.

The Univariable ARIMA Models for the Different Variables

The first step in carrying out the empirical analysis is the identification and estimation of the univariate arima models for the different variables. The autocorrelation function is the data analysis tool employed for the identification of the univariate ARIMA models. Table 2 shows the estimated autocorrelation function for the different series. The autocorrelation function strongly suggest a model of multiplicative form with one ordinary and one seasonal parameter. Diagnostic checks for model adequacy include "overfitting" with additional parameters as well as testing for autocorrelations at particular lags as well as the Q^* statistic for the joint significance of the autocorrelation of residuals suggested by Lung and Box (1976). The estimated ARIMA models are shown in Table 3. The U.S. money supply appears to be adequately represented by an ordinary moving average parameter and a seasonal moving parameter. In turn, the Dominican money supply is represented by a seasonal moving average parameter while the exchange rate is represented by a slightly more complicated model, a seasonal autoregressive parameter and a second order moving average parameter. The models shown in Table 3 perform reasonably well in removing serial correlations from the respective series. For each equation, no single autocorrelation exceeded the two standard error limit, and the $Q^*(12)$ is below the expected value under the null hypothesis of no autocorrelations.

The Cross-correlation Function

The cross-correlation function between the exchange rates and the two money series is the data analysis tool employed here for the identification of the transfer function model. Table 4 shows the estimated cross-correlation between the input and forcing variables. The most striking feature of these cross-correlation functions between the USM1 and the exchange rate is the apparent lack of relationship between the two series. The cross-correlation between the exchange rate and DRM1 suggest that at most, a contemporaneous and a one month lag relationship.

The estimated cross-correlation function suggests that the impulse response function for DRM1 may be adequately represented by two coefficients, a contemporaneous and a one month lag coefficient. Similarly, the cross-correlation suggests that the impulse response function for USM1 may be adequately represented, at most, by a contemporaneous coefficient.

The Transfer Function Model

Three transfer function models are reported in Table 5. Upon inspection of the model reported in the first column, it is apparent that the coefficient for the USM1 is imprecisely measured. The second model estimates constraints the USM1 coefficient to be equal to zero. The validity of the restriction imposed in the second model can be tested by examining the ratio of the log likelihood function of the constrained equation to the unconstrained equation.[13] It leads us to accept the second model over the first one. Alternatively stated, no significant relationship between the U.S. money supply and the Dominican exchange rate was found. This result is consistent with the currency substitution hypothesis,[14] which explicitly distinguishes between the U.S. money supply and the world supply of money, for which a negative relationship is predicted.[15] The result does not support the negative relationship predicted by the nonsubstitution models which equate the USM1 with the world money supply.

Transfer functions reported in the second and third column of Table 5 differ only in that the third model contrains the contemporaneous parameter to be equal to zero. The rationale for constraining the contemporaneous coefficient to equal zero is that it is less than two standard errors away from zero. However, neither the negative contemporaneous coefficient nor the zero contemporaneous effect for the innovations in the Dominican money supply in the estimated equations are inconsistent with the currency substitution model developed in this paper. A necessary condition for either of these results to obtain is a high elasticity of substitution[16] in which case the contemporaneous coefficient simplifies to

$$\lim_{\gamma \to \infty} \frac{1 + (\theta_j - \theta_2)\sigma}{1 + \gamma} = \theta_j - \theta_2. \quad (20)$$

A second necessary condition for a negative or zero coefficient is readily apparent from equation 20. It is that the contribution of the U.S. dollar to the exchange rate variance, θ_2, be greater than that of the Dominican peso, θ_2.[17]

The validity of the restriction imposed on the equation reported in the third column of Table 5 can be tested by examining the ratio of the log-likelihood function of the constrained equation to the unconstrained equation reported in the second column of Table 5. Since the ratio of the log likelihood function has a P-value of .645, it seems fairly safe to impose the restrictions that the contemporaneous coefficient of DRM1 is equal to zero and thus choose the model reported in the last column as the final model.

The final estimated transfer function model reported in Table 5 performs quite well by conventional standards. Diagnostic checks on model adequacy include the Q^* statistic for autocorrelation of residuals as well as the S^* statistic for cross correlation of residuals suggested by Haugh (1976). None of the individual cross-correlation between residual and forcing variable exceeded two standard errors and the $S^*(12)$ corresponds to a P-value of .400. Also, no single autocorrelation of residual exceeded two standard errors and the $Q^*(12)$ corresponds to a P-value of .674.

The estimated impulse response function for the Dominican Republic money supply variable has a positive one-month lag effect on the exchange rate, resulting in a positive steady state gain. The response coefficient is more than two standard errors away from unity, and also more than two standard errors away from zero.[18]

The empirical results suggest that the innovations on the Dominican Republic money supply have a smaller than unity effect on the exchange rate. This result can be interpreted as evidence against the standard monetary approach to exchange rates (i.e., zero elasticity of substitutions case). The lack of feedback effects between the exchange rate and money supply can also be interpreted as evidence against the managed float hypothesis. The results are consistent only with the crawling peg and currency substitution hypothesis. However, given the estimated coefficient on the U.S. money supply, the overall results are consistent only with the currency substitutions hypothesis.

A high elasticity of substitution has several interesting implications for Dominican monetary policy. It suggests that even though the domestic monetary authorities control the supply of Dominican money, they do not control the quantity of money, inclusive of U.S. dollars, circulating in the economy. In short, the quantity of money circulating in the economy is endogenously determined.

Summary and Conclusions

The purpose of this study has been to develop and estimate an exchange rate model that accounts for currency substitution.

The theoretical framework can be used to analyze the effects of monetary policy on exchange rates. For example, it shows that anticipated increases in the world supplies of the two monies will have a proportionate effect on exchange rates. Unanticipated increases in the world supplied of the two monies have a less than proportionate effect on the exchange rate. Finally, if a currency is used by residents of other countries for transaction purposes as well as their domestic currency (i.e., there is currency substitutions), one would not expect the domestic money supply of the international currency to be systematically related to the exchange rate.

In contrast, the standard monetary approach to exchange rates or to the crawling peg, which assumes that residents of a given country hold only the domestic money (i.e., the world supply of the domestic money is the quantity of money circulating the domestic economy), predicts a negative relationship between the exchange rate and the foreign money. In the case of the monetary approach to the balance of payments, the effect of unanticipated increase in the foreign money supply on the exchange rate is expected to be proportional.

Monthly data spanning the period from June 1969 to March 1979 were used to study the effects of the U.S. and Dominican Republic money supplies on the Dominican black or parallel market exchange rate. The model was estimated using the methodology developed by Box and Jenkins(1970).

The predictions of the model regarding the sign and magnitude of the different parameters appear to be sustained by the data. Overall, the theoretical framework is consistent with the sample information. The empirical results are consistent with the currency substitution hypothesis. In particular, the relationship between innovations in the Dominican money supply is positive, more than two standard errors away from zero and unity--as predicted by the currency substitution model, as opposed to the unit coefficient predicted by the standard monetary approach to exchange rates of zero substitutions across curriencies. In addition, the results fail to uncover any relationship between the U.S. money supply and the exchange rate. Again this result is consistent with the currency substitution hypothesis which distinguishes between the world supply of U.S. dollars and the U.S. money supply, as opposed to the nonsubstituions hypothesis which assumes the two measures of dollar denominated money to be the same, and as a consequence predicts a negative relationship between the U.S. money supply and the exchange rate.

Due to the structure of the model, there was no direct measure of the elasticity of substitution. The estimated coefficients are consistent with a high degree of substitutability. This has profound implications for the monetary policies pursued by the Dominican authorities. The high degree of substitutability suggests that the Dominican Republic cannot be insulated from the U.S. inflation and that even though the domestic authorities control the quantity of domestic money, they cannot control the amount of money (domestic plus foreign) circulating the economy. Thus, it is entirely possible that the actions of the domestic monetary authorities are being completely offset by the actions of the private sector. Any attempts to regulate the Dominican money supply will only reduce the credit creation ability of domestic financial institutions. Furthermore, the distortion induced by these actions will only serve to misallocate resources.

REFERENCES

Barro, R., "Rational Expectations and the Role of Monetary Policy," Journal of Monetary Economics, 2 (January 1976): 1-32.

Bilson J. "Recent Developments in Monetary Models of Exchange Rate Determination," International Monetary Fund Staff Papers, 26, (June 1976): 201-23.

Blejer M. and L. Leiderman, "A Monetary Approach to the Crawling-peg System: Theory and Evidence," Journal of Political Economy, 89, (February 1981).

Box, G. E. P. and G. M. Jenkins, Time Series Analysis: Forecasting and Control, 2nd ed. San Francisco: Halden Day (1976).

Cukierman, A. and P. Watchtel, "Differential Inflationary Expectations and Variability of the Rate of Inflation," American Economic Review, 69, (September 1979): 595-609.

Durbin J. "Testing for Serial Correlation in Least-Squares Regression when some of the Regressors are Lagged Dependent Variables" Econometrica, 38, (May 1970): 410-21.

Federal Reserve Bulletin.

Fisher, I., The Purchasing Power of Money, New York: MacMillan (1911).

Girton L. and Roper D., "The Theory and Implications of Currency Substitution," Journal of Money, Credit and Banking, (1981)

Granger, C., "Investigating Causal Relations by Econometric Models and Own Spectral Methods," Econometrica, 37, (July 1969): 424-28.

Haugh, L., "Checking Independence of Two Covariance Stationary Time Series: A Univariate Residual Cross-Correlation Approach," Journal of American Statistical Association, 71, (June 1976).

Haugh, L. D. and D. Pierce, "Causality in Temporal Systems: Characterizations and a Survey", Journal of Econometrics, 5, (May 1977): 265-94.

Johnson, H. G. "The Monetary Approach to the Balance-of-Payments Theory," Further Essays in Monetary Theory, London: Allen & Unwin, 1972.

Johnson, H. G, "The Monetary Approach to the Balance of Payments: A Nontechnical Guide," Journal of International Economics, 5, (May 1975): 107-51.

Laidler, D., The Demand for Monev: Theories and Evidence, 2nd ed. New York: Harper & Row, (1977).

Ljung G. and G. Box, "A Modification of the Overall X^2 Test for Lack of Fit in Time Series Models," Department of Statistics, Technical Report No. 477, University of Wisconsin (October 1976).

Magee, S., "Empirical Evidence on the Monetary Approach to the Balance of Payments and Exchange Rates," American Economic Review, 66, (May 1976): 163-70.

Miles M., "Currency Substitution, Flexible Exchange Rates and Monetary Independence," American Economic Review, 68, (June 1978): 428-436.

Mundell, R., "International Trade and Factor Mobility," American Economic Review, 57, (June 1957): 231-35.

Mundell, R. A., International Economics, New York: McMillan (1968).

Mundell, R. A., Monetary Theory: Inflation, Interest and Growth in the World Economy, Pacific Palisades, California: Goodyear (1971).

Mussa, M. "The Exchange Rate, The Balance of Payments and Monetary and Fiscal Policy Under a Regime of Controlled Floating," Scandinavian Journal of Economics, 78, (1976): 229-48.

Muth, J., "Rational Expectations and the Theory of Price Movements," Econometrica, 29, (1961): 315-35.

Pierce, D. A., "Relationships - and the Lack Therof - Between Economic Time Series with Special Reference to Money and Interest Rates", Journal of the American Statistical Association, 72, (March 1977): 11-32.

Samuelson, P., "Equalization by Trade of the Interest Rate Along With the Real Wage," in Baldwin, et al, Trade, Growth and the Balance of Payments. Chicago: Rand McNally & Co. (1965).

Sims, C.A., "Comment" Journal of the American Statistical Association, 72, (March 1977): 23-24.

Whitman, M. V. N., "Global Monetarism and the Monetary Approach to the Balance of Payments," Brookings Papers of Economic Activity, (1975): 491-536.

FOOTNOTES

1. Implicit in this framework is the assumption of incomplete future markets as well as the lack of a well-developed bonds market. Therefore, in this setup estimates of a forward exchange rate are not available.

2. "Money" is defined in this paper rather narrowly to be the medium of exchange: coins and currency or checking account for making payments to third parties. As such, our analysis does not take into account the substitutability between money and near monies. This assumption precludes consideration of some important issues in economics. One is regarding the appropriate definitions of money, an issue that has a long history in economics as reflected in the banking school/currency school controversy of the last century. Another issue is whether the liabilities of financial intermediaries are such close substitutes for money that monetary policy may be substantially offset through substitutions of currency and bank deposits, or any other financial claims backed by a fractional reserve system--in short, whether the money supply is indogenous or exogenous. However, irrespective of the substitutability between monies and near monies, the quantity of narrowly defined money will be exogenous to the small open economy and it is this aggregate that will be of interest since they will be using the foreign currency as a substitute for transactions purposes. The use of narrowly defined money for the small open economy is justified by the effective regulation interest rate by the domestic monetary authorities, which amounts to holding constant the relative price of money in terms of near monies, thus, no substitution effects are generated among domestic aggregates.

3. Notice that the assumption of a small open economy allows one to neglect the impact of the small open economy demand for foreign money (equation 8) in the world demand for the foreign money (equation 4).

4. Alternatively, one could argue as Cukierman and Wachtel (1979) do, that the price differences across markets reflect the possession of heterogeneous information set by individuals, where the amount of information in a set directly depends on the frequency of transactions by market participants.

5. See the appendix for a formal derivation.

6. Since the derivation of the equilibrium exchange rate explicitly accounts for the U.S. dollar substitution effects, this characterization of the world demand for U.S. dollars amount to neglecting the impact rest of the world substitution effects on the U.S. price level. The magnitude of this effect remains an empirical issue. However, since no attempt is made to estimate the effect of the world supply of dollars on exchange rates, this assumption does not directly affect the empirical analysis performed in this paper.

7. Among others, these include imports of "necessity" items such as certain staple foods, and raw materials for the import substitution industries, industrial machinery and equipment, excepting those protected by the import substitution policies.

8. Reviews of the empirical evidence on the monetary approach to the balance of payments are found in Magee (1976), Johnson (1977), and Whitman (1975). They present comprehensive reviews of the recent contributions to the monetary approach literature.

9. For an analysis of the monetary approach to the crawling peg see Blejer and Leiderman (1981).

10. The parallel market major sources of foreign exchange are: remittance of Dominicans residing abroad (mostly New York), nontraditional exports, foreign investments not registered at the Central Bank (these in turn do not qualify to exchange pesos for dollars at the official rate where the capital is repatriated) overvaluation of imports for which the central bank provides foreign exchange, and undervaluation of traditional exports who are supposed to turn foreign exchange they generate over to the central bank at the official rate. The volume of transaction in the parallel market has been estimated around 1 to 1.5 millions of dollars annually, roughly 25% of the Dominican GNP.

11. The ability of the central bank to collect the information has been largely due to the policy of not regulating the parallel market. In fact, the system has worked so well that dealers voluntarily call the central bank daily to inform the average transaction price. For obvious tax reasons, no information is provided on the volume transacted.

12. In general, people do not voluntarily acquire government bonds. Usually, they are acquired when the government declares some property private property a public utility and pays a fraction of the purchase price in government bonds which are redeemed at maturity or during yearly lotteries held to redeem a fraction of the outstanding debt.

13. The ratio of the log likelihood function is given by:

$$\lambda = \left(\frac{\sigma_a}{\sigma_o}\right)^n$$

where σ_o denotes the standard error of the constrained model and σa denotes the standard error of the unconstrained model. The quantity $-2 \ln \lambda$ has a χ^2 distribution in large samples with degrees of freedoms equal to the number of restrictions. The high value of λ (i.e., $\lambda=1$) leads one to accept the second equation as the final model.

14. Currency substitution is only one necessary condition: in addition, for this result to hold, the magnitude elasticity of substitution, must be fairly high.

15. No attempt to measure the world money supply of dollars was made due to the lack of available reliable data.

16. The high degree of substitution is also quite possible since there is essentially no inconvenience in transacting in U.S. dollars. (The denominations of the Dominican currency are the same as those of the U.S. dollar.) The U.S. dollar provides a very convenient vehicle to avoid the differential inflation tax imposed by the gradual and steady depreciation (30% cumulative) experienced by the Dominican peso in the last twenty years.

17. This result is not entirely implausible if one considers that the fit of the DRM1 is much better than USM1. This result is consistent with the larger degree of uncertainty regarding the supply of dollars (i.e., $\theta_2 > \theta_1$). Finally, the deterioration of the peso against the dollar is explained by the higher (and more predictable) average growth rate of the Dominican Republic money supply.

18. In the theoretical section it is argued that the long-run effect of DRM1 on the exchange rate should equal unity. Nevertheless, the estimated gain is significantly smaller than unity. It is possible that the sample size does not allow one to accurately measure the long-run gain.

TABLE 1

Crosscorrelation Between the Prewhitened
Values of e and DRM1

Lead	12	.053
"	11	-.106
"	10	.013
	9	-.040
	8	.026
	7	-.203
	6	-.023
	5	.110
	4	.202
	3	-.063
	2	-.113
	1	.080
Concurrent	0	-.201
Lag	1	.189
	2	-.075
	3	.180
	4	-.022
	5	.057
	6	.074
	7	.193
	8	.079
	9	-.062
	10	.145
	11	-.011
	12	.068
Standard Error		.098

TABLE 2

Autocorrelations of the Double Differences of Logs of USM1, DRM1 and e

	$\nabla\nabla_{12}$USM1	$\nabla\nabla_{12}$DRM1	$\nabla\nabla_{12}$e
Lag 1	-.12	-.12	-.09
2	-.09	.07	-.01
3	.06	-.08	-.11
4	-.17	-.02	.19
5	.03	-.11	.06
6	.07	-.02	.01
7	-.09	.15	.06
8	.11	.03	-.21
9	.15	-.02	.03
10	.07	-.03	-.04
11	.15	.14	.07
12	-.37	-.36	-.27
Standard Error	.10	.10	.10

NOTE: ∇ denotes the first difference operator $\nabla x = x_t - x_{t-1}$.

TABLE 3

Univariate ARIMA models for the Different Time Series for the Period Including June 1969 to March 1979

	$\nabla\nabla_{12}$ ln USM1	$\nabla\nabla_{12}$ ln DRM1	$\nabla\nabla$ ln e
Constant Term	Suppressed	Suppressed	Suppressed
Moving Average Parameters			
θ_1	.172 (.098)	--	Suppressed
θ_2	--	--	.184 (.101)
Seasonal Moving Average Parameter			
θ_{12}	.706 (.089)	.884 (.0447)	--
Seasonal Autoregressive Parameters			
ϕ_{12}	--	--	-.742 (.104)
Q(12)	8.28	7.53	9.14
d.f.	(10)	(11)	(10)
P-value	.655	.767	.593
Summary Statistics			
Adjusted R^2	.229	.385	.190
F	16.6	66.7	13.3
d.f.	(2,103)	(1,104)	(2,103)
Standard Error of Regression	.00708	.0392	.00921

NOTE: Standard errors in parenthesis below parometers estimates
∇ denotes the first differences operator $\nabla X_t = X_t - X_{t-1}$
d.f. denotes the degrees of freedom

TABLE 4

Estimated Crosscorrelation Functions Between
The Exchange Rate and the Money Variables

	$\nabla\nabla$ ln USM1	$\nabla\nabla$ ln DRM1
Lead 12	-.022	-.011
11	.012	.022
10	-.123	-.024
9	.109	-.051
8	.051	-.043
7	-.060	-.158
6	-.259	-.011
5	-.032	.048
4	.065	.178
3	-.007	.019
2	-.045	-.214
1	.044	.139
0	-.049	-.118
1	.055	.223
2	-.046	-.125
3	-.015	.071
4	-.057	-.034
5	.097	.060
6	-.076	.052
7	-.038	.046
8	.042	.003
9	-.036	-.026
10	-.011	-.066
11	-.055	.038
12	-.086	.070
Standard Error	.098	.098

TABLE 5

Transfer Function Model for $\nabla\nabla_{12}$ ln e_t

Constant Term	Suppressed	Suppressed	Suppressed
$\nabla\nabla$ ln DRM1			
ω_{10}	-.0344 (.0194)	-.0353 (.0193)	Suppressed
ω_{11}	-.0611 (.0196)	-.0625 (.0194)	-.0630 (.0197)
Gain	.0268 (.0195)	.0273	.0630
S*(12)			
d.f.	10.6 (9)	10.1 (10)	12.9 (11)
P-value	.409	.530	.400
$\nabla\nabla_{12}$ ln USM1			
ω_{20}	-.0495 (.125)	Suppressed --	Suppressed
Gain	-.0495		
S*(12)	8.88	--	--
d.f.	(9)	--	--
P-value	.544		
Noise Model			
θ_2	.281 (.107)	.281 (.107)	.266 (.107)
Seasonal Autoregressive Noise Parameter			
ϕ	-.607 (.125)	-.589 (.122)	-.603 (.126)
Summary Statistics			
Adjusted R^2	.277	.283	.263
F	7.88	9.91	11.80
d.f.	(5,87)	(4,88)	(3,89)
Standard Error of Regression	.00920	.00920	.00928
Auto Correlation of Residuals			
Q*(12)	7.8	7.76	8.01
d.f.	(10)	(10)	(10)
P-value	.690	.692	.674

APPENDIX

The undetermined coefficient method of solution has been used previously by Barro [1976], among others. Initially, the form of the solution for $e_t(z)$ is expressed in terms of the vectors of unknown coefficients on the set of independent variables. The functional form for $e_t(z)$ is expressed in log linear form as:

$$e_t(z) = \pi_o K + \pi_1 M^d_{t-1} + \pi_2 M^f_{t-1} + \pi_3 m^d_t + \pi_4 m^f_t + \pi_5 \varepsilon^d_t(z) + \pi_6 \varepsilon^f_t(z) \qquad (A.1)$$

If individuals know that expected prices in each period are determined by Equation A.1, then the additional information contributed by an observation of $e_t(z)$ amounts to an observation of the sum of

$$\pi_1[m^d_t + \varepsilon^d_t(1)] + \pi_2[m^f_t + \varepsilon^f_t(z)]$$

Estimates of the expectations of m^d_t and m^f_t, conditioned on the information set $I_t(z)$, which contains $e_t(z)$, can be obtained by regressing Em^d_t and Em^f_t on their unweighted sum mentioned above.

$$Em^d_f = \frac{\theta_1}{\pi_3}[\pi_3 m^d_t + \pi_4 m^f_t + \pi_5 \varepsilon^d_t(z) + \pi_6 \varepsilon^f_t(z)] \qquad (A.2)$$

where

$$\theta_1 = \frac{\pi_3^2 \sigma_d^2}{\pi_3^2 \sigma_a^2 + \pi_4^2 \sigma_f^2 + \pi_5^2 \sigma_{\varepsilon d}^2 + \pi_6^2 \sigma_{\varepsilon f}^2}$$

$$Em^f_t = \frac{\theta_2}{\pi_4}[\pi_3 m^d_t + \pi_4 m^f_t + \pi_5 \varepsilon^d_t(z) + \pi_6 \varepsilon^f_t(z)] \qquad (A.3)$$

where

$$\theta_2 = \frac{\pi_4^2 \sigma_f^2}{\pi_3^2 \sigma_d^2 + \pi_4^2 \sigma_f^2 + \pi_5^2 \sigma_{\varepsilon d}^2 + \pi_6^2 \sigma_{\varepsilon f}^2}$$

The coefficients θ_1 and θ_2 measure the relative contributions of m_t^d and m_t^f to the overall variance of the exchange rate, $\sigma^2_{e_{t+1}}$. The remaining variance is attributable to the relative variance of each market. At a point in time, the expected exchange rate can be expressed as:

$$E[e_{t+1} \mid I_t(z)[= \pi_1 M_{1t-1} + \pi_2 M_{2t-1} + \left(\frac{\theta_1}{\pi_3} + \frac{\theta_2}{\pi_4}\right) [\pi_3 m_t^d + \pi_4 m_t^f + \pi_5 \varepsilon_t^d(z) + \pi_6 \varepsilon_t^f(z) \quad (A.4)$$

The coefficients must be such that the market clearing equation (14) hold as an identity given equation A.1 and A.4. The solution to the coefficients is

$$\pi_0 = \pi_1 = -\pi_2 = 1$$

$$\pi_3 = \pi_6 = -\pi_4 = -\pi_5 = \frac{1 + (\theta_1 + \theta_2)\sigma}{(1 + \sigma)}$$

Substituting into Equation A.1 yields the solution to the spot exchange rate:

$$e_t(z) = M^d_{1t-1} - M^f_{t-1} + [m_t^d + m_t^f + \varepsilon_t^d(z) + e_t^f(z)] \left[\frac{1 + (\theta_1 - \theta_2)\sigma}{1 + \sigma}\right] \quad (A.5)$$