THE DEMAND FOR INTERNATIONAL RESERVES AND EXCHANGE RATE ADJUSTMENTS: THE CASE OF LDC's, 1964-1972

by

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ABSTRACT

In this paper the relationship between the demand for international reserves and exchange rate adjustments is empirically investigated for a group of LDC's. It is shown that countries that have maintained a fixed exchange rate for a long period of time have a different demand function than countries that have occasionally used exchange rate adjustments for correcting payments imbalances. The dynamics of the adjustment for both groups of countries are also analyzed. The results show that while both groups tend to eliminate reserve disequilibria fast, those countries that have maintained a fixed rate tend to do it slower than countries that have occasionally devalued their currency. It is also shown that the year prior to a devaluation, international reserves have been, on average, 30% below their short-run desired level. These results are important since they indicate that not all LDC's should be aggregated for prediction purposes. The results also have implications for the analysis of the adequacy of international reserves in less developed countries.

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1. INTRODUCTION

In most recent empirical studies of the demand for international reserves a distinction has been made between developed and less developed countries, and separate functions for these two groups have been estimated.[1/] However, classifying countries only according to their degree of economic development does not allow one to discriminate between their willingness to use alternative tools to correct international payments imbalances. In particular, most of the recent empirical work on the demand for international reserves does not distinguish between countries that have been willing to use exchange rate adjustments (i.e., devaluations) to correct international payments difficulties from those countries that have practically ruled out the exchange rate as a policy tool.[2/]

From a theoretical point of view, however, the demand for international reserves will be different in countries that rely exclusively on expenditure-changing policies, and in countries that are also willing to use expenditure-switching policies to solve temporary payments problems. In general, it would be expected that countries that are willing to use the exchange rate as a tool for correcting transitory payments imbalances would want to hold less reserves (on average) as a buffer stock to finance those payments problems.[3/] This fact has been recognized by a number of authors. Kelly (1970, p. 656), for example, argues that "the final option is to alter the peg...[s]uch a policy would also require the holding of less reserves." Hippel (1974, page 30), on the other hand, has pointed out that "if a nation is willing to change its exchange rate frequently, it will have a reduced need for reserves."[4/] If this is the case, then it would be incorrect to pool these two groups of countries for prediction or other purposes. In particular, studies on the

adequacy and distribution of international reserves based on common (for all LDC's) demand estimates will be highly misleading.[5/]

In this paper, the demand for international reserves by less developed countries (LDC's) is analyzed, making an explicit distinction between countries that have maintained a fixed exchange rate for a long period of time and countries that have occasionally used devaluations as a means to correct payments imbalances. The results obtained indicate that both groups of countries have different demand functions for international reserves, with devaluation countries holding, on average, less reserves, and that they should not be pooled, as has often been done. Furthermore, the results indicate that the demand for international reserves function for those LDC's that have maintained a fixed exchange rate is very similar to estimates previously obtained by other authors (i.e., Frenkel, 1980) for developed countries. The dynamics of the adjustment of international reserves for these two groups of LDC's is also analyzed, and it is found that fixed exchange rate countries tend to correct discrepancies between actual and desired reserves slower than countries that occasionally adjust their exchange rates. Finally, the relationship between the devaluation episodes included in the sample, and reserves holdings, is investigated. The results show that the year prior to the devaluation, international reserves in these countries have been, on average, 30% below their short-run desired level.

2. The Demand for International Reserves by Less Developed Countries

This section presents estimates of the long-run demand for international reserves for a group of 21 LDC's that maintained a fixed exchange rate during 1964-1972, and for a group of 18 LDC's that devalued their currencies at least once during this period.[6/]

Most recent studies on the demand for international reserves have assumed that reserves are held both to finance international transactions and as a buffer stock to face unexpected payments difficulties.[7/] These studies have assumed that the demand for international reserves is a stable function of a small number of variables reflecting the scale of the country, the variability of its payments, its degree of openness and the opportunity cost of holding reserves. It has been postulated (Frenkel, 1974; Heller and Kahn, 1978) that the larger the scale of the country in question, the larger will be the volume of reserves it would want to hold. The scale of a country has usually been measured by its total imports or total income.

With respect to external disturbances, most authors have assumed that the higher the variability of a country's external payments, the higher the level of reserves it would desire to hold (Clark 1970a, Kelly 1971, Hippel 1974, Claasen 1976). Also, most models assume that the more open a country is to the world economy, the more vulnerable it will be to external shocks and, as a consequence, the higher the level of reserves it will demand (Frenkel 1974, Hippel 1974, Iyoha 1976). The degree of openness of a particular country has usually been associated with its marginal propensity to import.[8/]

Finally, since by holding resources in the form of international reserves a country foregoes income, it has usually been assumed that the higher the alternative cost of holding these reserves, the lower the demand for them

(Heller, 1966; Kelly, 1970; Clark, 1970a; Frenkel and Jovanovic, 1981). However, most empirical studies on the demand for international reserves have found that the coefficient of the opportunity cost of holding reserves -- usually measured by the domestic interest rate -- is not significant.[9/] For these reasons, and considering the difficulties in obtaining reliable data on interest rates in LDC's, in this study, as in those by Clark (1970b), Frenkel (1974, 1978, 1980), Heller and Kahn (1978), Bilson and Frenkel (1979), and Saidi (1981), the opportunity cost variable has been dropped from the empirical analysis. Based on these considerations, the following demand function for international reserves -- suggested by Bilson and Frenkel (1979) -- was estimated, using cross-section data for 1964-1972, for both groups of LDC's:[10/]

$$\log R_n = b_o + b_1 \log Y_n + b_2 \log m_n + b_3 \log \sigma_n + u_n \qquad (1)$$

where Y is income, and is included as a measure of the country's scale; m is the average propensity to import -- used as a proxy for the marginal propensity to import; σ represents payments variability; and u is a random element.[11/] According to the above discussion, it would be expected that $b_1>0$, $b_2>0$, and $b_3>0$.

According to the hypothesis that countries willing to use exchange rate adjustments have a different demand function than fixed exchange rate countries, it would be expected that (at least some of) the b's would be significantly different for these two groups of countries. In this paper, this hypothesis is tested using Gujarathi's (1970) dummy variable procedure. Additionally, if countries that are willing to adjust their parity to correct payments imbalances hold, on average, less reserves, it would be expected that the residuals from a common regression (for all countries) would be significantly negative for devaluation LDC's and significantly positive for fixed-rate LDC's.

Tables 1 and 2 present the cross-section results obtained from the estimation of equation (1) for fixed exchange rate LDC's and for countries that have adjusted their parity, or devaluation countries.[12/] As may be seen, these results are quite different for both groups. While for the case of fixed-rate countries most coefficients (except the constants) are significant, for the case of devaluation countries only the coefficient of log Y_n is significant in all periods. The results for fixed exchange rate LDC's (Table 1) contrast sharply with the results obtained by Frenkel (1980) for a group of 32 LDC's that include both countries that have adjusted their parity and fixed rate LDC's.[13/] While in Frenkel's case the variability term was only significant in two of the nine years, in the results reported in Table 1 it is significant in all but two of the nine years.

These results (Tables 1 and 2) indicate that while for the case of fixed-rate countries (Table 1) the variability (σ) term plays an important role, it is of no importance in determining the level of reserves demanded by the devaluation countries. On the other hand, the scale and openness variables (y and m) are in most years significantly different from zero for both groups of countries. These results suggest that while fixed-rate countries demand reserves both for transactions and precautionary motives, devaluation countries tend to neglect the precautionary motive in their holdings of international reserves.[14/] In addition, the results show that while for the case of fixed-rate countries there are diseconomies of scale in the holdings of reserves ($b_1>1.0$), for the case of devaluation countries, reserves holdings move proportionally to the country's scale (b_1 for them is not significantly different from 1.0). The results for both groups of countries, however, contradict the "square-root" hypothesis of the demand for

Table 1

The Demand for International Reserves
by Fixed Exchange Rate LDC's
Cross-Section Results: 1964-1972

(OLS)

Year	Constant	log Y_n	log m_n	log σ_n	F	R^2
1964	1.591 (1.233)	1.392 (.118)	2.017 (.386)	.303 (.201)	47.9	.883
1965	-.472 (1.339)	1.248 (.120)	1.858 (.378)	.372 (.213)	39.0	.860
1966	-.101 (1.181)	1.324 (.122)	1.929 (.353)	.677 (.204)	41.6	.868
1967	.032 (1.140)	1.391 (.123)	2.175 (.365)	.758 (.192)	43.8	.874
1968	.237 (1.113)	1.327 (.123)	2.012 (.353)	.750 (.187)	42.5	.870
1969	-.101 (1.061)	1.321 (.119)	1.894 (.332)	.679 (.178)	43.4	.873
1970	.009 (1.185)	1.302 (.135)	1.703 (.380)	.816 (.205)	32.9	.838
1971	-.715 (1.051)	1.346 (.121)	1.660 (.346)	.658 (.212)	42.1	.869
1972	-.206 (1.187)	1.211 (.114)	1.611 (.315)	.471 (.225)	39.8	.863

Note: Standard errors in parentheses.

Table 2

The Demand for International Reserves by LDC's
That Have Occasionally Adjusted Their Parity
Cross-Section Results: 1964-1972

(OLS)

Year	Constant	$\log Y_n$	$\log m_n$	$\log \sigma_n$	F	R^2
1964	-1.805 (.992)	.837 (.158)	1.125 (.493)	.533 (.221)	17.1	.786
1965	-.271 (.865)	.997 (.144)	1.222 (.471)	.383 (.178)	29.0	.862
1966	-2.078 (1.500)	.844 (.202)	.237 (.484)	-.149 (.230)	12.4	.726
1967	-1.923 (2.357)	1.007 (.321)	.913 (.722)	-.005 (.349)	5.4	.534
1968	-1.309 (.879)	1.141 (.117)	1.414 (.283)	.199 (.162)	40.6	.897
1969	-1.701 (1.135)	1.008 (.125)	.783 (.297)	.071 (.241)	32.9	.876
1970	-2.878 (1.373)	1.007 (.128)	.496 (.316)	-.166 (.280)	33.7	.878
1971	-3.002 (1.331)	1.105 (.135)	.694 (.306)	-.084 (.263)	33.7	.878
1972	-.883 (1.174)	1.075 (.106)	.787 (.268)	.360 (.244)	53.2	.919

Note: Standard errors in parentheses.

international reserves advanced by Olivera (1969).

From Tables 1 and 2 it may also be noted that the coefficients have been quite stable through time for both groups of countries. The proposition of stable demand functions through time was tested using an F-test. This statistic had a value of $F(32,175) = .545$ for fixed exchange rate countries, and $F(32,130) = .930$ for devaluation LDC's, indicating that for both groups of LDC's the demand functions for international reserves had been stable through 1964-1972.

In order to formally analyze if the long-run coefficients of the demand for reserves functions for both groups of countries are statistically different, Gujarathi's (1970) dummy variables method was used.[15/] In Table 3 the estimated values for dummy variables for each coefficient (excluding the constants) corresponding to devaluation LDC's are presented.[16/] As may be seen, with the exception of two cases, these dummy variables are always negative. Furthermore, in most cases, they are significantly different from zero: out of 27 dummy variables coefficients, 17 are significant, indicating that the long-run coefficients of the demand for reserves tend to be significantly different as between these two groups of countries. These demand functions seem to be particularly different with respect to the variability (σ) and openness (m) coefficients. For each of them, in six out of nine years, the dummy variables are significant. These results suggest that studies that constraint the coefficients for both groups of countries to be equal tend to generate misleading conclusions.

In order to analyze if, after correcting for scale, openness, and variability, countries that are willing to devalue their currencies hold less reserves

Estimated Dummy Variables for
LDC's that have Adjusted Their Parity:
Cross-Section Results, 1964-1970

Year	log y	log m	log σ
1964	-.554 (.195)	-.893 (.619)	.230 (.297)
1965	-.251 (.058)	-.636 (.590)	.011 (.283)
1966	-.481 (.228)	-1.691 (.586)	-.826 (.304)
1967	-.384 (.305)	-1.262 (.749)	-.763 (.375)
1968	-.186 (.188)	-.598 (.485)	-.551 (.269)
1969	-.313 (.182)	-1.111 (.462)	-.608 (.306)
1970	-.295 (.200)	-1.207 (.521)	-.982 (.398)
1971	-.241 (.117)	-.966 (.469)	-.741 (.353)
1972	-.136 (.167)	-.824 (.406)	-.111 (.365)

Note: Standard errors in parentheses.

on average, than fixed exchange rate countries, common OLS regressions (for all countries) were run, and the residuals were analyzed. The average values of these residuals, for each group of LDC's for 1964-1972, are presented in Table 4. As may be seen, the average residuals for devaluation LDC's are negative for all years. On average, during 1964-1972 reserves holding by LDC's willing to adjust their parity was 12.5% below the average reserves holding of all LDC's. Of course, for fixed exchange rate countries, the average residuals are positive for all years. These results support the hypothesis, advanced in the introduction of this paper -- and suggested by a number of authors -- that countries that are willing to use expenditure-switching (i.e., devaluations) policies will have different demand functions, and hold less reserves, than fixed exchange rate countries.

Table 4

Average Residual for Each Group of Countries from Cross-Section Common Regressions

Year	Average Residuals for Fixed-Rate Countries	Average Residuals for LDC's That Occasionally Adjusted their Parity
1964	.031	-.039
1965	.054	-.069
1966	.163	-.209
1967	.229	-.293
1968	.112	-.154
1969	.109	-.139
1970	.036	-.046
1971	.096	-.123
1972	.024	-.052
Average	.095	-.125

3. The Dynamic Adjustment of the Demand for International Reserves by Less Developed Countries

The estimates presented in the preceding section assumed that countries are permanently "on" their long run demand for international reserves. However, in a well-known article, Clark (1970a) has developed a model that distinguishes between long-run and short-run demand functions for international reserves. According to this model there is a trade-off between the speed of adjustment and the level of reserves a country is willing to hold. Depending on the country's preferences, the monetary authority chooses an optimal combination between the speed at which disequilibria are corrected and the optimal level of reserves. If a country chooses a higher speed of adjustment, it will require a lower level of reserves in order to face a given probability of running out of reserves.[17/] In this section the dynamics of the adjustment of the demand for international reserves is investigated for both groups of countries. In particular, I inquire whether the fact that devaluation countries hold, on average, less reserves than fixed-rate countries can be partially explained by a higher speed of adjustment by these countries.

If it is assumed that, at any period of time, a country adjusts (the log of) its actual reserves in a proportion of the discrepancy between desired and actual reserves, the following expression can be written:

$$\log R_t - \log R_{t-1} = \pi(\log R^*_t - \log R_{t-1}) \qquad (2)$$

where π is the speed of adjustment coefficient and R^*_t is the desired stock of reserves in period t. The higher is π, the faster will a current disequilibrium in the stock of reserves be corrected. If it is assumed that the long-run demand for international reserves is represented by equation (1), the following equation can be estimated:

$$\log R_t = \pi b_o + \pi b_1 \log Y_t + \pi b_2 \log m_t + \pi b_3 \log \sigma_t + (1-\pi) \log R_{t-1} + e_t \quad (3)$$

A problem with the estimation of (3) is that the time period for which data is available for any particular country is extremely short. A solution for this problem is to use pooled time-series and cross-section data. This procedure to estimate dynamic relationships has been previously followed by a number of authors (i.e., Balestra and Nerlove, 1966; Nerlove, 1971; Bilson and Frenkel, 1979; Edwards, 1980). The equation to be estimated then is:

$$\log R_{nt} = \pi b_o + \pi b_1 \log Y_{nt} + \pi b_2 \log m_{nt} + \pi b_3 \log \sigma_{nt} + (1-\pi) \log R_{nt-1} + e_{nt} \quad (4)$$

where n=1,....K refers to the K countries in the sample and t=1,....T refers to the T time periods considered for each country.

In the estimation of this kind of model, it has generally been assumed that the error term is of the following form (see Balestra and Nerlove, 1966; Nerlove, 1971; Anderson and Hsiao, 1981):

$$e_{nt} = u_n + w_{nt} \quad (5)$$

where,

$E(u_n) = E(w_{nt}) = 0$ for all n and t

$E(u_n\, w_{nt}) = 0$ for all n, m and t

$$E(u_n\, u_m) = \begin{cases} \sigma_u^2 & \text{for } n = m \\ 0 & \text{for } n \neq m \end{cases}$$

$$E(w_{nt}\, w_{ms}) = \begin{cases} \sigma_w^2 & \text{for } n = m \text{ and } t = s \\ 0 & \text{otherwise} \end{cases}$$

Clearly, if the error structure is represented by (5) the estimation of of (4) by OLS will result in inconsistent estimates.[18/] Furthermore, the

coefficient of R_{nt-1} will be seriously biased upwards, incorrectly indicating that once off their long-run demand function, countries will only tend to return to it very slowly. In order to avoid this problem, equation (5) was estimated using Nerlove's (1971) two rounds GLS estimation.[19/] If the error term is characterized by (5), this estimator would be:

$$\hat{\beta} = (X' \hat{\Sigma}^{-1} X)^{-1} X' \hat{\Sigma}^{-1} Y \qquad (6)$$

where,

$$\hat{\Sigma} = \begin{bmatrix} A & 0 & . & . & 0 \\ 0 & A & . & . & 0 \\ . & & & & \\ 0 & 0 & & & A \end{bmatrix}$$

and,

$$A = \begin{bmatrix} 1 & \hat{\rho} & \hat{\rho} & . & . & \hat{\rho} \\ \hat{\rho} & 1 & \hat{\rho} & & & . \\ \hat{\rho} & \hat{\rho} & 1 & & & . \\ . & . & & & & . \\ . & & & & & \hat{\rho} \\ & & & & \hat{\rho} & 1 \end{bmatrix}$$

where $\hat{\rho} = \hat{\sigma}_u^2 / (\hat{\sigma}_u^2 + \hat{\sigma}_w^2)$ is the estimated intra class correlation coefficient.

According to Nerlove's procedure in the first round, the country-specific elements (u_n's) are estimated as fixed terms using individual country dummy variables. From this first round estimation $\hat{\sigma}^2_w$ is obtained as the regression variance and $\hat{\sigma}^2_u$ is calculated as:

$$\hat{\sigma}^2_u = \frac{\sum_i^N (\hat{u}_n - \Sigma\hat{u}_n/N)^2}{N} \tag{7}$$

In the second round (6) is estimated using the $\hat{\rho}$'s obtained from the first round.

In the estimation of (4) the variables were expressed in real terms. The reason for this is that, from a theoretical point of view, reserves are demanded as a buffer stock to finance payment problems of a certain real magnitude.[20/] Using Nerlove's (1971) procedure, the following result was obtained for fixed-rate countries:

$$\log R_{nt} = \underset{(.343)}{-.957} + \underset{(.105)}{.501} \log Y_{nt} + \underset{(.131)}{.264} \log API_{nt} + \underset{(.023)}{.042} \log \sigma_{nt} + \underset{(.057)}{.679} \log R_{nt-1}; \tag{8}$$

$$\hat{\rho} = .844$$

where the numbers in parentheses are the asymptotic standard errors. According to these results, fixed-rate LDC's will correct 32.1% of a unitary disequilibrium in the stock of reserves in one year. The long-run coefficients of the demand for reserves for these countries are $b_o = -2.981$; $b_1 = 1.560$; $b_2 = .822$; and $b_3 = .130$. On the other hand, the estimation of (4) yielded the following result for the devaluation countries:

$$\log R_{nt} = \underset{(.415)}{-1.602} + \underset{(.118)}{.404} \log Y_{nt} - \underset{(.145)}{.155} \log API_{nt} - \underset{(.084)}{.040} \log \sigma_{nt} + \underset{(.071)}{.580} \log R_{nt-1}; \tag{9}$$

$$\hat{\rho} = .775$$

As may be seen, in this case the speed of adjustment coefficient is higher than for fixed-rate LDC's -- $(1-\hat{\pi}) = .420$ -- indicating that devaluation countries tend to correct disequilibria in the stock of reserves faster than fixed-rate countries.[21/] According to (9), the long-run coefficients of the demand for reserves by devaluation LDC's are $b_o = -3.814$; $b_1 = .962$; $b_2 = -.369$; and $b_3 = -.095$.

The speed of adjustment coefficients obtained in this study, using Nerlove's two round estimates, are higher than most of the results obtained in previous works, and they indicate that, for devaluation countries, after five years, 94 percent of a reserves disequilibrium would be corrected.[22/] For the case of fixed-rate countries, after five years, 85% of a unitary disequilibrium would be corrected. This is an important result, since it indicates that not only is there a stable long-run demand for international reserves by LDC's, but that these countries tend to correct reserves disequilibria quite fast.

It is interesting to note that, as in the previous section, the results obtained from the dynamic analysis indicate that while for the fixed-rate countries all the coefficients are significantly different from zero and of the expected sign, for the devaluation countries the coefficients of the openness and variability terms are insignificantly different from zero and of the wrong sign. This suggests that, even though crisis countries tend to correct discrepancies between actual and desired reserves at a speed higher than fixed-rate countries, they have a less prudent attitude towards the demand for international reserves, as measured by their long-run coefficients.

4. Devaluation Crises and International Reserves

It has usually been argued that countries devalue their currencies when they "run-out" of international reserves.[23/] However, the level of international reserves that triggers a devaluation should be measured in relation to the desired level of reserves, and not with respect to some absolute arbitrary level. In this section the relationship between the level of international reserves actually held by these countries the year before the devaluation and the short-run desired level of reserves in that year is analyzed. This analysis gives additional information on the behavior of LDC's, indicating by how much, on average, actual reserves have fallen under their desired levels prior to a devaluation. In addition, this analysis would provide useful information that would help predict devaluation "crises" in LDC's.[24/]

An analysis of the residuals from Nerlove's two-round estimation procedure for devaluation countries (equation 9) shows that, for most countries, these residuals are negative the year prior to the devaluation. This indicates that when approaching a devaluation decision, reserves have indeed fallen below their short-run desired level. In order to investigate the magnitude of this reserves deficiency, equation (4) was estimated using a dummy variable for the year previous to the devaluation. The result obtained using Nerlove's two-round estimate was:

$$\log R_{nt} = \underset{(.417)}{-1.775} + \underset{(.120)}{.436} \log y_{nt} - \underset{(.145)}{.165} \log API_{nt} - \underset{(.084)}{.067} \log \sigma_{nt} \qquad (10)$$

$$+ \underset{(.071)}{.561} \log R_{nt-1} - \underset{(.085)}{.309} DEV, \qquad \hat{\rho} = .750$$

where DEV is a dummy variable for the year previous to a devaluation and the asymptotic standard errors are in parentheses. This result indicates that the year before a devaluation crisis countries are, on average, 31 percent short of their short run desired level of real international reserves.

5. Concluding Remarks

The results reported in this paper indicate that not all LDC's behave in the same way with respect to their demand for international reserves. In particular, it was shown that countries that have maintained a fixed exchange rate for a long period of time have a different demand for international reserves than countries that have occasionally used devaluations to correct payments imbalances. It was found that while devaluation countries hold, on average, less reserves than fixed-rate countries, they tend to adjust towards desired reserves faster. This tends to confirm Clark's (1970) hypothesis of the existence of a trade-off between the level of reserves a country wants to hold and the speed at which disequilibria are corrected.

It is interesting to note that the results obtained for fixed-rate less developed countries are very similar to those previously obtained for developed countries (Frenkel, 1978, 1980). This suggests that the relevant aggregation of countries for analyzing the demand for international reserves is not according to the countries' degree of development, but rather according to their optimizing attitude with respect to reserves holdings.

These results are important in at least three ways. First, they indicate that not all LDC's should be pooled for the analysis of international reserves. This is particularly important for the analysis of the distribution and "adequacy" of international reserves. Usually, in these studies the "adequacy" of reserves is measured by comparing actual reserves with desired reserves, as computed from some demand function.[25/] However, if, for one group of countries, the demand function used as a benchmark for the comparison does not correspond to the actual demand function, the results from these adequacy studies will be misleading. Second, these results may help explain why, in studies that have not made an explicit distinction between countries that are willing to adjust their parity, and countries that maintained a fixed rate,

persistent negative residuals were found for some countries (i.e., the United Kingdom and New Zealand), and persistent positive residuals were found for others (i.e., Switzerland). (See Frenkel, 1978, p. 128.) In light of the results presented in this paper, the reason for these persistent patterns of residuals is that these countries have different demand functions for international reserves. In fact, both the U.K. and New Zealand had used exchange rate adjustments (even before 1973) to correct payments imbalances, while Switzerland had traditionally ruled out a devaluation as a policy tool. Thirdly, the results reported in this paper are important since they not only indicate that LDC's have a stable demand for international reserves, but that they tend to correct disequilibria situations quite quickly. This is important since, as Bilson and Frenkel (1979, p. 1) have argued, "evidence of a stable long-run demand function is of little value if it cannot be shown that discrepancies between actual and desired stocks are eliminated over time".

Appendix

A. Data Sources

All variables have been defined as in Bilson and Frenkel (1979) and Frenkel (1980).

International Reserves: Taken from the International Financial Statistics tape. The nominal series are expressed in U.S. dollars and correspond to line 1.d of the IFS. These series were converted into real terms using the U.S. GNP implicit deflator.

Real Income: Measured as GNP in domestic currency units, converted into U.S. dollars using the average exchange rate. The raw data was taken from the IFS tape.

Average Propensity to Import: Defined as the ratio of imports (line 71.d of the IFS) to GNP.

Variability Measure (σ): To calculate σ^2_{Tn} for year T for country n, the following regression was first run for that country:

$$R_t = a_o + a_T t + e_t \text{ over } t = T-14,\ldots T,$$

then using the estimated value of $\hat{a}_T$, $\tilde{\sigma}^2_T$ was defined as:

$$\tilde{\sigma}^2_T = \sum_{t=T-14}^{T} (R_t - R_{t-1} - \hat{a}_T)^2/14$$

The variability measure -- σ -- was then defined as:

$\sigma_T = \tilde{\sigma}_T/IM_T$. For further details, see Bilson and Frenkel (1979).

B. Countries Considered

Fixed Rate Countries

Burma
Costa Rica
Dominican Republic
El Salvador
Egypt
Greece
Guatemala
Haiti
Honduras
Iran
Iraq
Jordan
Malaysia
Mexico
Morocco
Nicaragua
Nigeria
Paraguay
Portugal
Syria
Sudan
Thailand
Venezuela

Devaluation Countries

Bolivia
Colombia
Ecuador
Ghana
Guyana
Iceland
India
Indonesia
Israel
Jamaica
Korea
Pakistan
Peru
Philippines
Spain
Sri Lanka
Trinidad
Turkey

FOOTNOTES

1/ In the studies by Bilson and Frenkel (1979), Clark (1970b), Frenkel (1974), (1978), (1980), Heller and Kahn (1978), Hipple (1974), and Kelly (1970), for example, different demand functions for developed and less developed countries were estimated. The literature on the demand for international reserves has been extensively reviewed. See, for example, Clower and Lipsey (1968), Gruebel (1971), and Williamson (1973). See also the studies published by the International Finance Section of Princeton University and by the International Monetary Fund. On the demand for international reserves by LDC's, see Bird (1978).

2/ An exception to this are the studies by Kelly (1970), Flanders (1971) and Hippel (1974). These authors have used dummy variables to capture countries' attitudes towards maintaining a fixed exchange rate. Their results, however, have been inconclusive.

3/ This proposition can be easily derived from a model of the demand for international reserves for precautionary motives. In this case, the desired level of reserves can be written as (see Whalen, 1966)

$$R^* = \left(\frac{2\ \sigma^2\ C}{i}\right)^{1/3}$$

where C is the (fixed) cost of running out of reserves, σ^2 is the variability of net external payments, and i is the opportunity cost of holding reserves. In this context, it is possible to think that both σ^2 and C will be lower in countries that are willing to adjust their parity to correct payments imbalances than in fixed exchange rate

In a more complicated model, derived by Frenkel and Jovanovic (1980), it can be shown that if σ^2 is different for both groups of countries, the

elasticities of the demand for reserves with respect to its determinants will differ among groups of countries.

4/ Other authors that have pointed out this fact include Clark (1970a), Crockett (1978), Claasen (1976), Flanders (1971), Bird (1978) and Makin (1974).

5/ Ripley and Suss (1974), for example, estimate a common demand function to analyze reserves "needs" and distribution for 104 countries. However, their results -- that show that reserves are unequally distributed -- depend heavily on the incorrect assumption that all countries have the same demand function.

6/ The period of analysis has been confined to 1964-1972 for two reasons: first, in this way, the problem that arises after 1972, when major industrialized countries turned to a (managed) floating system, is avoided. Secondly, in this way we can make sure to have enough observations for the cross-section analysis for fixed exchange rate countries. For a list of the countries considered, see the Appendix.

7/ Hippel (1974), for example, has classified the studies on international reserves into two groups -- one that focuses on the use of reserves for transaction purposes; another that emphasizes the role of payments variability. Most recent studies, however, have recognized that international reserves are demanded both to finance transactions and to face unexpected disturbances. See, for example, Brown (1964), Machlup (1966), Clark (1970b), Kelly (1970), Flanders (1971), Frenkel (1974), (1978), Heller and Kahn (1978) and Saidi (1981).

8/ There is, however, an alternative view with respect to the role of the marginal propensity to import in the demand for international reserves. Some authors -- Heller (1966), Kelly (1970), Heller and Kahn (1978) -- have considered the marginal propensity to import as a measure of the adjustment cost. According to this approach the higher the marginal propensity to import, the smaller will be the reduction of income required to generate a given positive response of the balance of payments. According to this view, then, there should be a negative relationship between the marginal propensity to import and the demand for international reserves.

9/ See, for example, Frenkel (1974, 1978), Hippel (1974), Heller and Kahn (1978) and Saidi (1981). A possible reason for these findings is that international reserves are usually held in some form of interest-bearing assets. In this case, the opportunity cost of holding reserves would be the difference between the marginal return to capital in the domestic sector and the interest rate earned on the holding of reserves. It is important to note, however, that Iyoha (1974) and Frenkel and Jovanovic (1981) have been able to find significant coefficients for the opportunity cost of holding reserves.

10/ This is only one alternative way to specify the demand function. Other specifications -- Kenen and Yudin (1966), for example -- have assumed an additive form. In other studies, imports have been used as a measure of scale. However, the results obtained in this paper are not affected by the specification of (1). See Edwards (1981b).

11/ See the Appendix for the exact definition, and sources, of the variables involved.

12/ These equations were also estimated using Zellner's (1962) seemingly unrelated regressions procedure. The results obtained -- available from the author -- support the results reported in Tables 1 and 2.

13/ It is important to note that both the specification of the demand function and the definitions of the variables used in this study correspond to those used by Frenkel (1980).

14/ On the precautionary motive to hold reserves, and exchange rate adjustments, see Makin (1974). See, also, Frenkel and Jovanovic (1981).

15/ This method consists of estimating a common equation with dummy variables for the coefficients corresponding to one of the groups. If these dummy variables are significantly different from zero, then the hypothesis of a common demand function is rejected. See Gujarathi (1970) and Maddala (1977).

16/ The dummy variables for the constants were never significant.

17/ Hippel (1974) also develops an optimizing model for the dynamic adjustment of the demand for international reserves. Bilson and Frenkel (1979) and Edwards (1980) have investigated this issue empirically.

18/ If e_{nt} is given by (5), then $E(\log R_{nt-1}, e_{nt}) = \sigma_n^2 \neq 0$.

19/ Recently, Anderson and Hsiao (1981) have suggested an equivalent consistent estimator.

20/ Traditionally, however, most studies have used nominal data. Machlup (1976) challenged this practice, and Von Furstenberg (1980) has recently argued that the demand for reserves should be estimated in real terms. Recent studies have recognized that the correct specification of the demand for international reserves should be in real terms. See, for example, Saidi (1981). In the present case, however, the results are not altered in any sisnificant way if (4') is estimated in nominal terms. See Edwards (1981a).

21/ It is important to note that the estimated speed of adjustment coefficients using Nerlove's (1971) GLS procedure are, as expected, significantly higher than those obtained using OLS. The following result was obtained from the estimation of (4) for fixed-rate LDC's using OLS:

$$\log R_{nt} = \underset{(.130)}{-.106} + \underset{(.045)}{.061} \log y_{nt} + \underset{(.076)}{.091} \log m_{nt} - \underset{(.034)}{.043} \log \sigma_{nt} + \underset{(.031)}{.947} \log R_{nt-1}$$

The OLS estimate for devaluation LDC's yielded the following result:

$$\log R_{nt} = \underset{(.235)}{-.690} + \underset{(.061)}{.159} \log y_{nt} - \underset{(.087)}{.011} \log m_{nt} - \underset{(.048)}{.071} \log \sigma_{nt} + \underset{(.049)}{.829} \log R_{nt-1}$$

22/ An exception to this is the study by Bilson and Frenkel (1979). In this study it was found that for a group of LDC's that included both fixed-rate and devaluation countries, $\pi = .420$.

23/ See, for example, Harberger and Edwards (1982).

24/ Bilson (1979) has suggested using the ratio of reserves to high-powered money in LDC's to help predict devaluation crises. However, a comparison between actual and desired level of reserves seems more appropriate for this purpose.

25/ For an analysis of the adequacy of international reserves, see Edwards (1981b). See also Bird (1978), Kenen and Yudin (1965) and Ripley and Suss (1974).

REFERENCES

Anderson, Theodore W. and Cheng Hsiao, "Estimation of Dynamic Models with Error Components," Journal of the American Statistical Association, 76 (1981), 598-606.

Balestra, Pietro and Marc Nerlove, "Pooling Cross Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas," Econometrica, 34 (July 1966), 585-612.

Bilson, John F.O., "Leading Indicators of Currency Devaluation," unpublished paper, The University of Chicago, 1979.

Bilson, John F.O. and Jacob A. Frenkel, "Dynamic Adjustment and the Demand for International Reserves," NBER Working Paper 403 (September 1979).

Bird, Graham, The International Monetary System and the Less Developed Countries, London: MacMillan, 1978.

Brown, Weir M., The External Liquidity of an Advanced Country, Studies in International Finance No. 14, Princeton, N.J., 1964.

Claasen, Emil-Maria, "The Optimizing Approach to the Demand for International Reserves: A Survey," in Emil-Maria Claasen and Pascal Salin (Eds.), Recent Issues in International Monetary Economics (Amsterdam: North-Holland, 1976), 73-116.

Clark, Peter B., "Optimum International Reserves and the Speed of Adjustment," Journal of Political Economy, 78 (March-April 1970a), 356-76.

_____, "Demand for International Reserves: A Cross-Country Analysis," Canadian Journal of Economics, 3 (November 1970b), 577-594.

Clower, Robert and Richard Lipsey, "The Present State of International Liquidity Theory," American Economic Review, 58 (May 1968), 586-595.

Crockett, Andrew D., "Control Over International Reserves," IMF Staff Papers, 25 (March 1978), 1-24.

Edwards, Sebastian, "A Note on the Dynamic Adjustment of the Demand for International Reserves by LDC's," Economics Letters, 5 (1980), 71-74.

_____, "Aspects of the Economics of Exchange Rates," unpublished Ph.D. dissertation, The University of Chicago, 1981a.

_____, "A Note on the Demand for International Reserves by Less Developed Countries," UCLA Working Paper No. 222 (November, 1981b).

Fisher, Frank M., "Tests of Equality Between Sets of Coefficients in Two Linear Regressions: An Expository Note," Econometrica, 38 (1970), 361-66.

Flanders, M. June, The Demand for International Reserves, Studies in International Finance, No. 27, N.J. 1971.

Frenkel, Jacob A., "The Demand for International Reserves by Developed and Less Developed Countries," Economica, 41 (1974), 14-24.

_____, "International Reserves: Pegged Exchange Rates and Managed Float," in Brunner, K. and Meltzer, A.H. (Eds.), Economic Policies in Open Economies (North-Holland, 1978), 111-140.

_____, "The Demand for International Reserves Under Pegged and Flexible Exchange Rates and Aspects of the Economics of Managed Float," in D. Bigman and T. Taya (Eds.), The Function of Floating Exchange Rates, Cambridge, Mass. (Ballinger, 1980).

Frenkel, Jacob A., and Boyan Jovanovic, "On Transactions and Precautionary Demand for Money," Quarterly Journal of Economics, 95 (1980), 25-43.

_____, "Optimal International Reserves: A Stochastic Framework," Economic Journal, 91 (1981), 507-14.

Gruebel, Herbert G., "The Demand for International Reserves: A Critical Review of the Literature," Journal of Economic Literature, 9 (December, 1971), 1148-1166.

Gujarathi, D., "Use of Dummy Variables in Testing for Equality Between Sets of Coefficients in Two Linear Regressions: A Note," American Statistician, 24 (Feb., 1970), 18-22.

Harberger, Arnold C. and Sebastian Edwards, "Lessons of Experience Under Fixed Exchange Rates," in Mark Gersowitz, et al. (Eds.), The Theory and Experience of Economic Development (George Allen & Unwin, forthcoming, 1982).

Heller, H. Robert, "Optimal International Reserves," Economic Journal, 76 (June 1966), 296-311.

Heller, H. Robert and Mohsin S. Kahn, "The Demand for International Reserves Under Fixed and Floating Exchange Rates," IMF Staff Papers, 25 (December 1978), 623-49.

Hippel, F. Steb, The Disturbance Approach to the Demand for International Reserves, Studies in International Finance No. 35, N.J., 1974.

Iyoha, Milton A., "Demand for International Reserves by Less Developed Countries: A Distributed Lag Specification," The Review of Economics and Statistics, 58 (August 1976), 351-55.

Kelly, Michael G., "The Demand for International Reserves," American Economic Review, 60 (September 1970), 655-667.

Kenen, Peter B. and Elionor B. Yudin, "The Demand for International Reserves," Review of Economics and Statistics, 47 (August 1965), 242-250.

Machlup, Fritz, The Need for Monetary Reserves, reprinted in International Finance, Princeton, N.J., 1966.

_____, "Further Reflections on the Demand for International Reserves," in his International Payments, Debts and Gold (2nd Edition, New York: New York University Press, 1976), 260-277.

Maddala, G.S., Econometrics (McGraw-Hill, 1977).

Makin, John H., "Exchange Rate Flexibility and the Demand for International Reserves," Weltwirtschafliches Archiv, 110 (1974), 229-243.

Nerlove, Marc, "Further Evidence on the Estimation of Dynamic Economic Relations from a Time Series of Cross-Sections," Econometrica, 39 (March, 1971): 359-82.

Olivera, Julio H.G., "A Note on the Optimal Rate of Growth of International Reserves," Journal of Political Economy (March 1969), 245-48.

Ripley, Duncan and Esther C. Suss, "An Approach to the Estimation of Inequality in Reserve Distribution," IMF Staff Papers, 21 (November 1974), 789-799.

Saidi, Nasser, "The Square Root Law, Uncertainty and International Reserves Under Alternative Regimes: Canadian Experience, 1950-1976," The Journal of Monetary Economics, forthcoming 1981.

Von Furstenberg, George M., "Price Deflators for SDR's Over the Past Decade," unpublished paper, March 1980.

Whalen, Edward L., "A Rationalization of the Precautionary Demand for Cash," Quarterly Journal of Economics, 80 (1966), 314-24.

Williamson, John, "International Liquidity: A Survey," Economic Journal, 83 (1973), 685-746.

Zellner, Arnold," An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," Journal of the American Statistical Association, 57 (1962), 348-68.