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

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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 more slowly 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.<sup>1/</sup> 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.<sup>2/</sup>

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.<sup>3/</sup> 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." Hipple (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." See also Clark (1970a), Crockett (1978), Claasen (1976), Flanders (1971) and Makin (1974). 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.<sup>4/</sup>

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 23 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. In this study fixed rate countries were defined as those that adjusted their parities less than 1% a year. On the other hand, devaluation countries were defined as those that had devaluations of at least 10%.<sup>5/</sup>

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. 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 Khan, 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, Hipple 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, Hipple 1974, Iyoha 1976). The degree of openness of a particular country has usually been associated with its marginal propensity to import.<sup>6/</sup>

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.<sup>9/</sup> 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 Khan (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 (for alternative specifications, see Edwards, 1981):

$$\log R_n = b_0 + b_1 \log Y_n + b_2 \log m_n + b_3 \log \sigma_n + u_n \quad (1)$$

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;  $\sigma$  represents payments variability; and u is a random element.<sup>8/</sup> 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.

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. 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. 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.

Table 1

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

(OLS)

<u>Year</u>	<u>Constant</u>	<u>log Y<sub>n</sub></u>	<u>log m<sub>n</sub></u>	<u>log σ<sub>n</sub></u>	<u>F</u>	<u>R<sup>2</sup></u>
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)

<u>Year</u>	<u>Constant</u>	<u>log Y<sub>n</sub></u>	<u>log m<sub>n</sub></u>	<u>log σ<sub>n</sub></u>	<u>F</u>	<u>R<sup>2</sup></u>
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.

These results (Tables 1 and 2) indicate that while for the case of fixed-rate countries (Table 1) the variability ( $\sigma$ ) 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.<sup>9/</sup>

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. In Table 3 the estimated values for dummy variables for each coefficient (excluding the constants) corresponding to devaluation LDC's are presented.<sup>10/</sup> 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 ( $\sigma$ ) 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. Additionally, an analysis of the residuals from common (for all countries) regressions show that, on average, these are significantly negative for devaluation countries, being significantly positive for fixed-rate countries (see Edwards, 1981). This result indicates that, as expected, countries willing to use exchange rate adjustments tend to hold less reserves on average than fixed-rate countries.

The results presented in this section suggest that the decisions to hold international reserves and to adjust the exchange rate should be viewed as jointly determined endogenously. Once these two decisions are jointly derived from an optimizing problem, it should be possible to explicitly incorporate the determinants of a devaluation into the empirical analysis of the demand for international reserves, allowing the reunification of the two groups of countries considered in this paper. This could be done, for example, by simultaneously estimating the demand for reserves and the probability of devaluation using a maximum likelihood procedure.

Finally, it is worth mentioning that there might be an alternative interpretation to the results reported in this section. It is possible that some of the devaluation countries adjusted their parities because they were "forced" to do so, and not because they were more willing to do it. This possibility, discussed in Harberger and Edwards (1982), is consistent with the hypothesis that fixed-rate countries have a more prudent attitude towards international reserve holding than devaluation countries.

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

Year	log y	log m	log $\sigma$
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.

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. 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:

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

where  $\pi$  is the speed of adjustment coefficient and  $R_t^*$  is the desired stock of reserves in period  $t$ . The higher is  $\pi$ , 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:

$$\log R_t = \pi b_0 + \pi b_1 \log Y_t + \pi b_2 \log m_t + \pi b_3 \log \sigma_t + (1-\pi) \log R_{t-1} + e_t \quad (3)$$

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:

$$\log R_{nt} = \pi b_0 + \pi b_1 \log Y_{nt} + \pi b_2 \log m_{nt} + \pi b_3 \log \sigma_{nt} + (1-\pi) \log R_{nt-1} + e_{nt} \quad (4)$$

where  $n=1, \dots, K$  refers to the  $K$  countries in the sample and  $t=1, \dots, T$  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,

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

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

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

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

Clearly, if the error structure is represented by (5) the estimation of (4) by OLS will result in inconsistent estimates.<sup>11/</sup> 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.<sup>12/</sup>

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.<sup>13/</sup> Using Nerlove's (1971) procedure, the following result was obtained for fixed-rate countries:

$$\log R_{nt} = - .957 + .501 \log Y_{nt} + .264 \log m_{nt} + .042 \log \sigma_{nt} + .679 \log R_{nt-1}; \quad (6)$$

(.343)
(.105)
(.131)
(.023)
(.057)

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

where  $\hat{\rho}$  is the estimated intra-class correlation coefficient (see Nerlove, 1971) and

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  $b_0 = -2.981$ ;  $b_1 = 1.560$ ;  $b_2 = .822$ ; and  $b_3 = .130$ . On the other hand, the estimation of (4) yielded the following result for the devaluation countries:

$$\log R_{nt} = -1.602 + .404 \log Y_{nt} - .155 \log m_{nt} - .040 \log \sigma_{nt} + .580 \log R_{nt-1}; \quad (7)$$

(.415)
(.118)
(.145)
(.084)
(.071)

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

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.<sup>14/</sup> According to (9), the long-run coefficients of the demand for reserves by devaluation LDC's are  $b_0 = -3.814$ ;  $b_1 = .962$ ;  $b_2 = -.369$ ; 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. 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.

#### 4. Devaluation Crises and International Reserves

It has usually been argued that countries devalue their currencies when they "run-out" of international reserves (See Bilson, 1979, and Harberger and Edwards, 1982). 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.

An analysis of the residuals from Nerlove's two-round estimation procedure for devaluation countries (equation 7) 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:

$$\log R_{nt} = -1.775 + .436 \log y_{nt} - .165 \log m_{nt} - .067 \log \sigma_{nt} \quad (8)$$

$(.417) \quad (.120) \quad (.145) \quad (.084)$

$$+ .561 \log R_{nt-1} - .309 \text{ DEV}, \quad \hat{\rho} = .750$$

$(.071) \quad (.085)$

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.

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 (See Kenen and Yudin, 1965, and Bird, 1978). 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. Also, the results obtained indicate that LDC's tend to correct disequilibria situations between desired and actual reserves quite quickly. Finally, the analysis presented in this paper suggests that the decisions about reserve holdings and exchange rate adjustments should be viewed as simultaneously determined endogenously. This indicates that international reserve models should be able to generate, from a maximizing framework, the joint determination of these decisions.

APPENDIX

A. Data Sources

International Reserves: Taken from the International Financial Statistics (IFS) tape.

Income: Measured as GNP in domestic currency units, converted into U.S. \$ using the average exchange rate. Raw data taken from the IFS tape.

Average Propensity to Import: Defined as the ratio of imports to GNP.

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

$$R_t = a_0 + a_T t + e_t \text{ over } t = T-14, \dots, T,$$

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

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

The variability measure --  $\sigma$  -- was then defined as:

$$\sigma_T = \tilde{\sigma}_T / IM_T, \text{ where } IM \text{ are imports. For further details, see Bilson and}$$

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 Khan (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 Hipple (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,  $\sigma^2$  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  $\sigma^2$  and C will be lower in countries that are willing to adjust their parity to correct payments imbalances than in fixed exchange rate countries.

In a more complicated model, derived by Frenkel and Jovanovic (1980), it can be shown that if  $\sigma^2$  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/ 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.
- 5/ The period of analysis has been confined to 1964-1972 for two reasons: first, in this way, the problem that arises after 1972, when the international monetary system turned to a (managed) floating system, is avoided. Second, 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. Most of these countries had one devaluation during the period considered, not allowing to test the relevance of alternative country groupings (i.e., groupings according to the number of devaluations). By only including countries with devaluations of at least 10%, a distinction is being made between countries that adjust their exchange rate in order to correct international payments imbalances (or balance of payments crises) and countries that have followed managed float, crawling peg, or institutionalized devaluation systems. For further discussion on these countries' classification, see Harberger and Edwards (1982).
- 6/ However, some authors -- Heller (1966), Kelly (1970), Heller and Khan (1978) -- have considered the marginal propensity to import as a measure of the adjustment cost. In this case there should be a negative relationship between the marginal propensity to import and the demand for international reserves.
- 7/ See, for example, Frenkel (1974, 1978), Hipple (1974), Heller and Khan (1978) and Saidi (1981). A possible reason for these findings is that international reserves are usually held in some form of interest-bearing assets. Iyoha (1974) and Frenkel and Jovanovic (1981) have been able to

find significant coefficients for the opportunity cost of holding reserves.

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

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

10/ 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). The dummies for the constants were never significant.

11/ The reason for this is that the  $e_{nt}$ 's will be serially correlated [i.e.,  $E(e_{nt} e_{nt-1}) = \sigma_u^2$ ] in the presence of a lagged dependent variable.

12/ This procedure consists of estimating, in the first round, the  $u_n$ 's as fixed terms using individual country dummy variables.  $\hat{\sigma}_w^2$  is estimated as the first round regression variance. In the second round,  $\hat{\sigma}_u^2$  and  $\hat{\sigma}_w^2$  are used to obtain the GLS estimator. See Nerlove (1971) for further details. Recently Anderson and Hsiao (1981) have suggested an equivalent consistent estimator.

13/ 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 significant way if (4) is estimated in nominal terms. See Edwards (1981).

14/ 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.

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