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The Demand for International Reserves and their Opportunity Cost

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Abstract

An empirical study that shows that countries' reserve holdings are sensitive to the rates at which they can borrow on international financial markets, this analysis confirms the view that holding major currencies as reserve assets has costs that are frequently unrecognized. Between 1978-82 for 24 sample countries, and between 1978-86 for the same sample less those countries with debt-servicing difficulties, international borrowing costs were found to be a highly significant determinant of reserve holdings--particularly before 1982 for the group with debt difficulties.

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Contents

I. Introduction

Monetary authorities hold international reserves for a variety of reasons that arise out of their policy priorities and economic circumstances. These reasons include financing cyclical and seasonal external payments imbalances to smooth current consumption, intervening in exchange markets, and providing a buffer to cushion the economy against future exigencies.

Understanding the motivation for reserve holding is an important part of analyzing and predicting how far individual countries will be able to withstand payments shocks, and, by extension, the interaction between the reserve holdings of individual countries and international financial conditions.

But in spite of a considerable literature on the determinants of reserve holdings by different groups of countries, some aspects of reserve behavior are ill understood. After such structural shifts in conditions in reserve markets as the advent of floating rates, for example, and the financial market disturbances of the early 1980s, it was widely expected that countries would make a large adjustment in the level of their reserves. But most studies show a relatively stable long-run demand for reserves since the 1960s. 1/

In an effort to increase understanding of how reserves function, this paper reports empirical work showing that the reserve holdings of countries that also borrow on international capital markets--particularly of countries that have debt-servicing difficulties--are in fact significantly affected by the cost of holding these assets. When a country's reserve holdings are assessed in terms of the interest rates it pays on international borrowing, two conclusions emerge: international reserves can be costly to hold, and they are vulnerable to changes in terms on international financial markets. When international interest rates rise, spreads increase, and, according to the results of this analysis, countries economize on reserves. When, in particular, the range of spreads expands, so that the less creditworthy countries face higher borrowing costs, these countries, which are shown by the analysis to be more responsive to international borrowing costs than others, will adjust reserve holdings more quickly. The result is that those economies with the greatest need for reserves economize more than others on their reserves when international financial markets are tight.

1/ Studies specifically asking whether reserve demand shifted after 1973 (Frenkel (1984), Frenkel and Hakkio (1980), and Frenkel (1978)) consistently show that there was no significant shift. Lizondo and Mathieson (1985), in a study that updated earlier work, found some instability in equilibrium formulations of the equation but not in disequilibrium formulations.

Theory has traditionally argued that, unlike money demand by individuals, the motivation for reserve demand is based not on the need of domestic residents to meet payments for current transactions in foreign exchange, which is met by commercial banks and foreign exchange dealers, but for the authorities to have a cushion to dampen the impact of future shocks on the domestic money supply. 1/ A country's demand for reserve holdings is conceptually equivalent to an individual's precautionary money demand, and is a positive function of wealth and the cost of covering an unplanned deficit, and a negative function of returns on other assets. 2/ Traditional analysis therefore included in reserve demand equations some scale factor, such as imports, some measure of potential payments fluctuations, and a proxy for the cost of adjustment, such as imports as a ratio of GNP. 3/ The proposition was that the precautionary need for reserves arose out of the payments identity that required some balancing item to cover deficits on the trade and capital accounts.

However, while the opportunity cost of reserve holdings was recognized as important in theory, empirically the measures chosen were found not to be significant. Virtually every study that included a measure of forgone investment--such as the domestic discount rate or the international bond rate--to proxy the opportunity cost of reserve assets found that all determinants except the opportunity cost measure were significant. 4/

The present analysis begins with two propositions: first, that when the opportunity cost of reserve holdings as assets is appropriately defined, it should be a significant independent determinant of the demand for reserves; and, second, that the appropriate opportunity cost is the rate on the individual country's international liabilities less the rate on the short-term liquid assets which countries typically hold as reserves.

1/ See Heller (1966).

2/ See Williamson (1973), Hipple (1974), Edwards (1984), and Frenkel (1984) for reviews of the literature.

3/ See Frenkel (1984) for a representative equation. See also Edwards (1984) and Harberger and Edwards (1982) for an integration of reserve demand equations with monetary analysis.

4/ Several authors (Heller (1966) and Frenkel (1978 and 1984)) noted the need to include some proxy for forgone earnings in reserve demand equations; others attempted to proxy it but found it not significant--Kenen and Yudin (1965) and Kelly (1970) tried per capita income, Courchene and Youssef (1967) used the domestic interest rate, while Hipple (1974) used the inverse of the gross marginal capital output ratio. Frenkel, and Jovanovic (1981) took (with payments fluctuations) the government bond yield or discount rate and found it had the right sign and was significant. Other authors dropped the opportunity cost variable.

The empirical results reported in this paper extend and update work by Edwards (1985) that also included a net opportunity cost concept in a regression for reserve demand, defining this as the gross forgone income from holding one unit of reserves, less the return on investing that unit. In a regression based on data for 17 countries for 1976-80, this opportunity cost concept was found to be significant and of the correct sign. Edwards defined gross forgone income as a country's international borrowing cost, on the principle that countries borrow abroad as long as the cost of borrowing is less than or equal to the social marginal product of the funds when invested.

The rest of this paper is organized as follows. The next section presents the theoretical basis for the empirical work of this study, while the following section reports the results. A concluding section highlights some of the implications of the sensitivity of reserve holdings to international borrowing costs.

II. Theoretical Foundations

Countries are assumed to minimize the total costs of reserves held as a precaution against future payments shocks by minimizing and equating in equilibrium two types of cost: first, the cost of holding reserves in terms of forgone domestic credit expansion, and, second, the cost of reserves held as an asset. The first cost can be defined as the cost of the adjustment that would occur if, assuming the money supply is held constant, the country assigned the marginal dollar to reserves instead of to increased domestic credit. The opportunity cost of reserves as assets is the cost of holding the marginal dollar as reserves instead of repaying the marginal unit of debt. It is assumed, therefore, that countries minimize the following equation:

$$E(TC) = rR + \int [[(D-R)/MPM]\ p(D)]dD$$

where TC = total costs; E = the expectations operator; r = the net opportunity cost of forgone debt repayment; R = the level of nongold foreign exchange reserves held by the monetary authorities; D = the gross payments deficit; MPM = the marginal propensity to import; [(D-R)/MPM] = the cost of a forgone reflation of the economy; and p(D) = a random function reflecting the probability of the deficit occurring.

To deal with each of these terms in turn, the net opportunity cost of holding reserves in terms of debt repayment is defined here as the gross average unit cost of a country's borrowing on international markets (denominated in dollars) less the average unit return from reserves invested in short-term, secure, and liquid investments in money-center instruments.

Since reserves are an asset, theory would suggest that they should be costed at the marginal rate of the highest-yielding alternative asset in which they might be invested. In principle, with perfect capital markets, free entry and otherwise perfectly competitive conditions, yields would be equalized, given exchange rate changes, across all assets, domestic and foreign. In practice, yields differ, reflecting differing perceptions of risk on the part of lenders, differing needs for liquidity by borrowers, and differing expectations regarding relative exchange rates and inflation rates and so on. The cost of a syndicated loan to a given country consists of the basic interbank rate, LIBOR (which can be a three-month, six-month, or an annual rate), plus a spread set for the maturity of the loan which varies by borrower. It is the spread over LIBOR that varies according to market perceptions of the creditworthiness of the borrower. There are also fees associated with loans for the borrower--participation fees, the praecipium (paid to the lead bank of a syndicate), and front-end fees. But since all studies on these fees conclude that they form a stable share of the spread, the assumption will be made that they can be ignored, since they change all costs by a constant. 1/

Between 1978 and 1987 every country in the sample (except the debt countries after 1982, which were excluded from the analysis for that period) contracted sovereign loans over the period examined. Whether or not these countries borrowed abroad to finance reserves directly (which is difficult to ascertain), at any given time all countries held both reserves and some debt intermediated by the international banking system.

The rate on dollar-denominated borrowing was taken to be representative of the opportunity cost of reserves since the information available on the currency denomination of reserve holdings shows that the majority are indeed denominated in dollars. 2/ In addition, a significant percentage of international transactions that gives rise to

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1/ On the basis of an analysis of front-end fees and LIBOR spreads for 183 Eurocurrency credits arranged in 1981-83, Mills and Terrell (1984) found (see p. 2): "A close statistical relationship exists between the level of fees and the level of spreads. This relationship indicates that fees are utilized to raise the level of total compensation to banks in a very consistent manner." Johnston (1982), also found "What evidence is available tends to suggest that the level of fees moves in line with spreads....The spread is therefore a reasonable indicator of the price of the loan" (p.169).

2/ The Fund's Annual Report shows that about 60 percent of total official placements were denominated in dollars over the sample period. This is confirmed by the survey by the Group of Thirty (1982) of reserve management by central banks holding more than half global foreign exchange reserves, which shows that between 1978 and 1981 industrial countries held, on average, 82 percent of their reserves in dollars, while developing countries held an average of 60 percent.

precautionary demand for reserves is also made in dollars. Most international borrowing was in dollars over this period and required servicing in dollars. Again, individual country data are hard to obtain, but the Bank of International Settlements, in its quarterly reports, shows that the bulk of transactions filed by its reporting banks is in dollars. 1/ As for the current account, a large number of commodities traded have prices quoted in dollars. Since it makes sense for countries to hold dollar reserves against prospective dollar liabilities, it is assumed to be appropriate to use the interest rate on dollar assets as their opportunity cost. Given the competitiveness of the international financial markets, it is also reasonable to assume that returns on assets denominated in different currencies are equated at the margin.

The assumption that international borrowing rates are the appropriate definition of the opportunity cost measure calls for some elaboration. When some reserves are borrowed and borrowing rates are higher than marginal returns on domestic investment, the marginal cost of borrowed funds will clearly raise the average cost of any reserves that are owned and the definition of the opportunity cost measure arises directly from asset theory. But it is argued here that even when reserves are not borrowed, but the government issues or guarantees international liabilities, the value to the monetary authorities of paying off these liabilities on time will always be higher than investing domestically, even where the marginal returns on domestic capital are higher than those on foreign borrowing. There are benefits to the authorities of maintaining the country's credit standing in international markets by repaying foreign liabilities on schedule and there are costs to not doing so. The advantages of timely repayment for the authorities are continued access to financial and trade credit, and to swaps with other monetary authorities; these benefits raise the effective cost of the nonrepayment of foreign liabilities. Thus, on the assumption that the authorities aim to equalize marginal returns on all assets, domestic and foreign, they will pay off external debt before investing domestically. 2/

The opportunity cost chosen is the prevailing quarterly average market interest rate on syndicated loans to a given country (weighted by the size of the loan), less returns on investing reserves. The issue arises whether marginal rates would be more appropriate.

1/ Between 1978 and 1984, an annual average of 72 percent of the external assets of BIS reporting banks were denominated in dollars. Between 1984 and 1986, this share fell, but was still, on average, 69 percent of the total.

2/ This concept of opportunity cost assumes that the monetary authorities have priorities that are independent of those of the government; whether these can be acted upon is another question.

An examination of the average spreads on loans to selected countries between 1978 and 1986 shows that there is evidence that countries believed to be more risky than others were charged higher spreads. Table 1 shows that Australia, Norway, and Korea were, in the early years, generally able to borrow more cheaply than the Philippines (which was to have an official debt rescheduling in early 1985) and Mexico (which was to have an official rescheduling in mid-1983). However, this was not consistently so. During 1981, when Mexico's debt problems were already in the news, it was borrowing at about the same rate as Korea. (There is a possibility of lags in reporting syndications, but it is unlikely that these would have been consistent, particularly given the interest in the loan markets in the financial journals at the time.) In the first quarter of 1982, when articles were being published about the possibility of Mexico's inability to repay its debt, it was being charged only 0.04 percent more than Australia. Nor did spreads seem to rise systematically with the size of the loans being made. In the fourth quarter of 1981, for example, Colombia borrowed almost $200 million more than in the third quarter, but at a spread that was 4 basis points lower. In the first quarter of 1982, it borrowed $300 million less, at a spread that was 4 basis points higher.

In addition to inconsistencies in the links between higher spreads, loan amounts, and risk, spreads on loans to all countries followed similar fluctuations over time, suggesting that more general forces were at work. Even the selected data show peaks around late 1978 and early 1979, with a trough a year later, and rates picking up again over the next 6-9 months. It has in fact been argued (see Johnston 1982) that international banking activity is more sensitive to domestic banking conditions in the main industrial countries than to circumstances in the international markets. 1/

Following most work on international capital markets, therefore, it is assumed that these markets are competitive and that an individual monetary authority determining borrowing costs for reserve accumulation can take the average interest rate on syndicated loans as the gross cost, without being concerned about the marginal impact of the new loan on spreads.

Finally, the rate on short-term U.S. Treasury bills was taken to represent returns on the investment of reserves. The legislation underlying the management of the reserve holdings of many central banks

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1/ In a test that estimated spreads during the 1970s as a function of domestic interest rates in the major currency countries, the banks' source of funds, and two variables reflecting specific Euromarket conditions, Johnston (1982) found that the domestic interest rates had the strongest and most significant effect on spreads, while loan volume exerted a significant but negative impact.

Table 1. Spreads on Syndicated Borrowing, Selected Countries

(Quarterly averages of spreads over 6-month LIBOR)

Year and Quarter		Norway	Australia	India	Korea	Colombia	Mexico	Philippines
1978:	I	0.69	--	1.00	0.90	1.50	1.30	1.07
	II	1.65	0.88	1.00	1.25	1.34	1.11	1.02
	III	0.72	0.82	--	0.91	1.35	1.07	1.05
	IV	--	--	--	0.97	0.90	0.89	0.89
1979:	I	0.58	--	0.64	0.73	1.00	0.77	0.97
	II	0.57	0.61	--	0.57	0.97	0.80	0.95
	III	0.92	--	--	0.72	1.14	0.63	0.96
	IV	0.61	0.75	--	0.69	0.74	0.77	0.82
1980:	I	0.54	0.55	0.52	0.78	0.65	0.60	0.78
	II	--	0.64	0.75	0.84	--	0.62	1.00
	III	0.70	0.58	--	0.92	0.81	0.54	0.79
	IV	0.53	0.65	0.55	0.87	0.69	0.66	0.90
1981:	I	0.60	0.48	0.46	0.90	0.73	0.84	1.04
	II	0.64	0.41	--	0.62	0.63	0.51	0.88
	III	0.63	--	0.44	0.70	0.65	0.74	0.75
	IV	0.38	0.50	0.35	0.66	0.61	0.71	0.77
1982:	I	0.46	0.70	--	0.63	0.65	0.74	0.97
	II	--	0.36	0.41	0.59	0.93	1.05	0.83
	III	0.67	0.47	0.42	0.61	0.50	1.62	1.01
	IV	0.61	0.45	0.38	0.58	1.25	--	0.94
1983:	I	1.00	0.58	0.49	0.68	--	--	0.99
	II	0.76	0.76	--	0.79	1.00	--	1.04
	III	--	0.89	0.50	0.73	1.63	--	--
	IV	0.56	0.70	0.47	0.76	--	--	--
1984:	I	0.38	0.75	0.38	0.75	1.63	--	--
	II	--	--	0.38	0.75	1.62	--	--
	III	--	1.41	0.38	0.68	1.63	--	--
	IV	0.45	--	0.42	0.58	--	--	--
1985:	I	0.15	--	--	0.68	1.75	--	--
	II	0.81	--	0.26	0.65	--	--	--
	III	--	0.25	0.24	0.52	--	--	--
	IV	0.26	--	0.06	0.58	--	--	--
1986:	I	--	--	0.10	0.61	--	--	--
	II	--	--	0.10	0.56	--	--	--
	III	0.37	0.15	0.29	0.58	--	--	--
	IV	0.19	0.38	0.38	--	--	--	--

Source: Bank of England.

Note: Mexico had a rescheduling agreement in August 1983, while the Philippines requested an extension for payments on principle in early October 1983.

specifies treasury bills as an example of the type of secure, liquid asset in which they should be invested. 1/

The cost of reserve holdings in terms of deflation is measured by [(D-R)/MPM], where D-R is the net deficit (the deficit less reserves) and MPM is the marginal propensity to import. By adding the marginal unit of foreign exchange earnings to reserves instead of expanding domestic credit by one unit, holding the money supply constant, monetary authorities force the country to deflate sufficiently to reduce the net deficit by one unit of foreign exchange. This cost can be seen as similar to the cost imposed on an economy by money hoarding and can be derived directly from the money identity, where the authorities are assumed to be holding the money supply constant to prevent the payments position from further deteriorating.

Following Heller (1966), this cost is assessed in the context of the current account of the balance of payments. Assuming an initial equilibrium at full employment and payments balance, and abstracting from exchange rate actions, the feedthrough of reserve changes onto the domestic money supply, and the longer-term saving propensity, the financial value of a fall in foreign demand for the country's goods can be expressed in terms of the country's marginal propensity to import. For a relatively open economy, the loss from lower export demand is far less than for a relatively closed economy. This loss can be expressed as the reciprocal of the marginal propensity to import. 2/ One can, therefore, identify the opportunity cost to a country of reserves withheld from credit creation, given a payments deficit, as being the net imbalance, D-R (the deficit less reserves) as a ratio of the marginal propensity to import, 1/MPM.

The deflation cost concept must be qualified by the probability that a given country will incur an imbalance. Let the probability distribution of expected net deficits be a continuous random variable and be defined over some positive range,

$\underline{D}$ and $\bar{D}$. More formally, $D \in [\underline{D},\bar{D}]$.

Let the function have a mean of zero and a dispersion defined by the standard deviation. Given the probability density function p(D), the probability distribution function can be defined as

$$P(\hat{D}), \text{ with } P(\hat{D}) = \text{prob. } (D \leq \hat{D}) = \int_{\underline{D}}^{\hat{D}} p(D)d(D).$$

1/ Fund studies on reserves have also used the Treasury bill rate to proxy earnings on invested reserves. Edwards (1985) used LIBOR to proxy these returns.

2/ See Heller (1966), p. 297.

Since costs are only positive where deficits are greater than reserve holdings, the total expected costs of reserve holding are defined as:

$$E(TC) = rR + \int_{R}^{\bar{D}} \{[(D-R)/MPM]p(D)\}dD \qquad (1)$$

where

rR = the opportunity cost in terms of forgone debt repayment;

r = the borrowing cost less the investment cost, which is given;

(D-R)/MPM = the deflation cost of forgone credit expansion.

The lower bound of the integral, R, is where a country is assumed to be in payments balance, since it incurs no deflationary costs where reserve holdings are greater than or equal to the payments deficit. The upper bound is the size of the random payments deficit D, which could go to infinity.

Using Leibniz's rule 1/ and differentiating with respect to R:

$$\partial[E(TC)]/\partial R = r+[(D-R)/MPM]\bar{D}'-[(D-R)/MPM]R'+ \int_{R}^{\bar{D}} \{\partial[((D-R)/MPM]p(D)dD\}/\partial R$$

$$= r + 0 - 0 - (1/MPM) \int_{R}^{\bar{D}} p(D)\, dD$$

$$= r - (1/MPM) [P(\bar{D}) - P(R)]$$

$$= r - (1/MPM) [1 - P(R)] = 0 \qquad (2)$$

from the first-order condition for minimum total costs. The second derivative is positive,

$$P'(R) = p(R),$$

so the minimum is a true one.

From the minimization equation,

$$[1 - P(R)] = r * MPM,$$

and the reserve demand equation can be derived as:

$$R = f[r, MPM, p(D)]. \qquad (3)$$

1/ This approach draws on Sargent (1987), p. 117.

To derive the signs of the determinants of reserve holdings, consider changing the riskiness of the probability distribution while preserving the mean of the original. 1/ Graphically, Chart 1 shows p(D) as the original probability function, and p*(D) as the new, mean-preserving function. Then for given r and MPM, it can be seen that if D was the original deficit (and, therefore, R the original optimum reserve holdings) the new distribution has caused [1-P(R)] to increase. To maintain equality with the right-hand side of the equation, P(R) must also increase. Therefore, when the risk of a deficit rises, reserve holdings must also rise. Similarly, when either r or MPM rise, [1-P(R)] must also rise, so P(R) and R must fall.

More formally, let

$$p(D) + \delta g(D) = p^*(D)$$

be the new riskier distribution that preserves the original mean, where:

$$0 \leq \delta \leq 1. \quad G(\hat{D}) = \int_R^{\hat{D}} g(D)\, dD$$

where

$$E(G) = 0, \; p(D) + g(D) > 0 \text{ for } D \epsilon (R, \bar{D}) .$$

Substitute in the equality condition and totally differentiate:

$$1 - [P(R) + \delta G(R)] = r*MPM$$

$$\{-[p(R) + \delta g(R)]\}dR - G(R)d\delta = 0$$

$$dR/d\delta = - G(R)/[p(R) + \delta G(R)] \; > 0 \text{ for } \delta = 0$$

The positive sign on the final equation comes from the fact that G(R) must be negative if the mean of the spread is to be preserved as the riskiness of the function increases. From the diagram, with p*(D) flatter than p(D), the original hatched area under the curve above R must fall at the peak of the distribution if the area in the tails is to increase. This loss is captured by G(R). Thus, when risk rises, reserves also increase.

For the sign of r, totally differentiate the equality condition again.

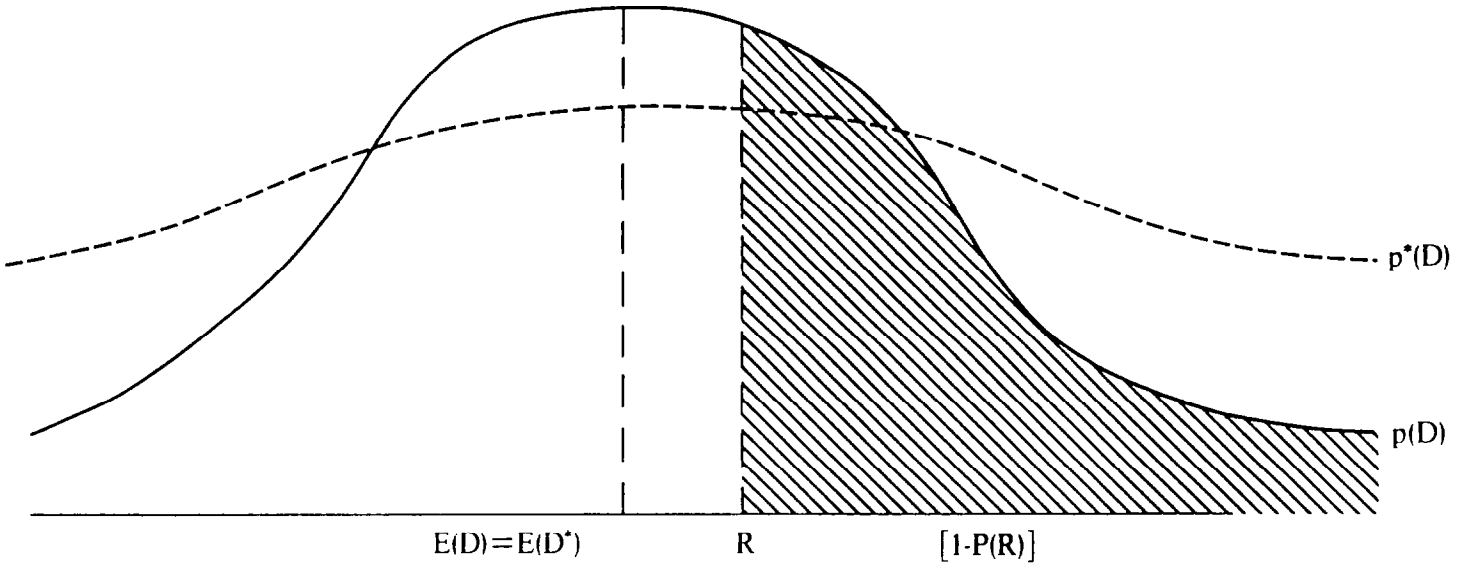
$$[1 - P(R)] = r*MPM$$
$$- P'(R)dR = dr*MPM$$
$$dR/dr = -MPM/P'(R) \qquad < 0$$

Reserves fall when the borrowing cost rises.

1/ See Rothschild and Stiglitz (1970), pp. 225-43.

CHART 1

Original and More Risky Probability Distribution
with Mean Preserving Spread



Similarly, to derive the sign for MPM, differentiate the equality condition totally:

$$[1 - P(R)] = r*MPM$$
$$- P'(R)dR = r*dMPM$$
$$dR/dMPM = -r/P'(R) \qquad < 0$$

Reserves fall when the marginal propensity to import rises because this reduces the cost of deflation in terms of output of home goods.

This makes sense; it is reasonable to assume that reserves increase when the average absolute magnitude of past imbalances rise, but fall as the opportunity cost of reserves rise, and fall as a country's marginal propensity to import rises, since, as explained earlier, the cost of a deficit in terms of home goods falls.

However, there is one further qualification to make to equation (3). It is an empirical fact that reserve holdings increase with the scale of imports--whatever the marginal propensities, the absolute size of the demand for foreign exchange is an important factor. 1/ (This is the conceptual equivalent of wealth in precautionary money demand equations.) The final specification of the equation to be tested for the sample group of countries over the period 1978-86 is:

$$R = f(Imp, VARB, r, MPM) \qquad f_1 > 0 \quad f_2 > 0, \; f_3 < 0, \; f_4 < 0$$

Where Imp is the scale variable (here proxied by imports), VARB is the proxy for the entire distribution of the function that captures the probability of deficits occurring, r is the net borrowing cost on international markets, and MPM is the marginal propensity to import. (See Appendix 1 for details on the data used to estimate the regression.)

III. Estimation and Results

Two approaches have been used in the literature to estimate reserve demand: the first assumes that adjustment to determinate desired reserve levels occurs in the estimating period (Frenkel (1974) and (1983),

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1/ The impact of scale is emphasized in all the literature; a Fund study by Lizondo and Mathieson has a convenient presentation of the results of several equations over an extended time period. Frenkel (1978), pp. 130-34, shows that using small-country assumptions there is a positive link between openness defined as the average propensity to import and reserve holdings. The assumptions in question are that the price of imports is given (so that any exogoenous change occurs in export prices), and that the income elasticity of money demand is greater than or equal to unity. Frenkel maintains that empirical work on money demand shows that this assumption is well founded.

and Frenkel and Hakkio (1980)), while the second assumes a slower adjustment process in which changes in actual reserves reflect the gap between desired and actual levels (Bilson and Frenkel (1979), Edwards (1980), (1984)). (The determinants of reserve demand were very similar in each approach.) Both approaches yielded significant results. This study, following the findings of recent literature on the speed of adjustment of reserves (see Edwards (1980)), uses the "equilibrium" approach and estimates reserve demand directly. The level of reserves rather than the rate of change was estimated, on the principle that reserve demand is demand for a stock rather than a flow. 1/

The equation was tested according to pooled cross-section methodology on the principle that determinants of reserve holdings have not shifted over the time period considered. The available evidence shows that the most important influence on reserve management is the maintenance of a currency mix appropriate to the pattern of foreign trade and external debt; since trade patterns and creditors do not change very rapidly, this supports the assumption that pooled analysis is appropriate. 2/ OLS regressions were used with dummy variables to capture individual country characteristics. While the constant slope assumption of OLS regressions seems reasonable--the sensitivity of reserve demand to its independent determinants is not expected to change a great deal among countries or over time--it seems unreasonable to expect the intercept to remain constant over countries since these will have different demand for reserves as a result of different policy priorities and structural conditions. 3/

Several authors have argued that reserve holdings are used by banks in determining the spreads to be charged to individual countries, while others have noted that countries manipulate published reserve figures to control borrowing costs. 4/ This points to possible simultaneity between reserve holding and borrowing costs, and would suggest that OLS regressions would produce biased estimators. However, a review of

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1/ Niehans, in International Monetary Fund (1970), p. 50: "Basically reserves are useful because of what they are, not because of the way they grow."

2/ Group of Thirty (1982).

3/ Pindyck and Rubinfeld (1981), pp. 254-55.

4/ Williamson (1984), p. 17, quotes examples of underreporting (by the capital-surplus exporters) and overreporting (by Mexico, Brazil, and the Philippines).

published accounts of bank creditworthiness analysis shows that reserves are only one of many indicators used. 1/

Finally, these propositions were tested for the years 1978-86 for 24 countries falling into three main economic categories: a sample of non-reserve center industrial countries; some developing countries that were not to develop debt-servicing problems after 1982; and some developing countries that were to develop such problems for the years 1978-82. After 1982 this group were credit rationed and the rate at which they borrowed was not a market rate and could not, therefore, be used as an independent determinant of reserve holdings. (See Appendix II for a list of sample countries.) The sample countries were chosen on the basis of quarterly data availability; the core group of countries had no more than two sequential missing observations in the syndicated loan series. Reserve currency countries were excluded since they have a demand for reserves that depends on that of other countries and cannot be compared with reserve demand in non-reserve-currency countries. 2/

The pooled cross-section analysis was initially applied to quarterly data on the entire sample of 24 countries for 1978-82. Table 2 shows the results. Highly significant results are shown for all the variables chosen. Most of the signs are as predicted. The ratio of imports to GNP, the proxy for the marginal benefit to a country for holding reserves, measured in terms of the cost of the deflation that would otherwise occur, is, as predicted, consistently negative. Imports are consistently and strongly positive; the higher the level of foreign exchange needs for imports, the higher the level of reserves demanded. And the opportunity cost of holding reserves has a consistently negative effect on reserve holdings.

The one surprising result is that of the variability of past reserves in the GLS and first OLS regression, in which reserves decline as reserve variability rises. This seems counterintuitive. However, in the OLS regression the variable is insignificant, so the sign is immaterial, while, as will be shown below, the GLS regression is the least satisfactory explanation of reserve demand of all those tested.

1/ Kapur (1977) states that the banks' political assessment of countries has a 20 percent weight in creditworthiness analysis, while a review of the published quantitative indicators used by banks showed that 3 out of 56 indicators contained reserves. Moreover, a review of four econometric studies of creditworthiness analysis (Edwards (1983 and 1985), Feder and Just (1977), and Feder and Ross (1977)), showed that each study used four indicators, of which reserves formed part of one ratio.

2/ A Fund study on reserves notes that in any case the net cost of reserve holding for reserve center countries would not be large, since the opportunity cost would be the rate of interest on their public sector money market obligations net of returns from comparable domestic assets. As the difference in the returns on these two instruments is not large, costs would be minimal.

Table 2. Determinants of Reserve Demand:
Pooled Cross-Section Results for Full Sample, 1978-82 and 1978-86

	VARB	MPM	Imp	Net Rate	Adj.R^2	F
GLS	-0.06297**	-1.12898**	1.25925**	-1.13494**	0.4	76.8
	(5.5413)	(-9.1994)	(15.7135)	(-4.71657)		
OLS1	-0.61258	-0.8461**	0.81241**	-0.33**	0.6	161.6
	(-1.4112)	(-12.926)	(21.5712)	(-2.596)		
OLS2	0.5629**	-0.6375**	0.74579**	-0.22718**	0.9	135.9
	(7.4539)	(-3.3884)	(7.6656)	(-3.2147)		
OLS3	0.2962**	-0.6175**	0.53759**	-0.1213**	0.9	229.9
	(5.3264)	(-6.9204)	(8.6696)	(-3.0248)		

Note: GLS is a generalized least squares regression. OLS1 is a straightforward OLS regression on the entire sample from 1978-82. OLS2 is the OLS regression adjusted for country-specific dummies. OLS3 is OLS2 run on all countries less the debt-problem group for 1978-86.

Data: All data are in natural logarithms and denominated in dollars while observations are quarterly. T statistics are in parentheses. See Appendix I for definitions of variables, and Appendix II for sample countries.

Three regressions were run on the entire sample. The GLS regression, the least constrained, had a low R^2, even for cross-section analysis. It seemed that a more constrained regression might be more appropriate and give stronger support for the hypothesis. Constraining the constants of all countries to be the same via the OLS regression, OLS1 in Table 2 gave a respectable fit in terms of R^2 and the F statistic improved.

Plots of the reserve levels indicated some correlation from observation to observation; this could be due to qualitative determinants of reserve demand that were constant over time for each country, perhaps to do with institutional objectives for reserve holdings that were not captured by the other variables. A country

relying for a large share of its foreign exchange earnings on remittances (from low-skilled migrant labor, for example, that fluctuates with labor demand in host countries), and with little access to international capital markets, would justifiably consider it needed higher reserves than a country with diversified exports and ready access to foreign capital markets. These "structural" needs for reserves are country specific, they tend not to vary over time, and, following the model developed by Balestra and Nerlove (1965), they can be captured by an "error components" adjustment to the OLS equation that consists of using dummy country variables.

The OLS regression was therefore adapted to include country specific dummies and the results are shown in the Table as OLS2. This regression gives the best results. Adding the dummies increases the fit in terms of R^2 to 0.9, while the F statistic shows a significant ratio of explained to unexplained errors.

This adjusted OLS equation was also used to see if the opportunity cost variable was significant for the longer time period, 1978-86, shown as OLS3 in Table 2. The regression over the earlier period had assumed that no countries in the sample faced credit rationing, so the spread plus LIBOR could be taken to be the unconstrained market rate at which they could borrow. This assumption was supported by the Bank of England data on spreads on syndicated loans, which contained observations for all countries for almost every quarter. For no country were there more than two sequential quarters with no observations. For the regression over the longer period, the debt-problem countries had to be dropped. This group consisted of those that had debt reschedulings after 1982. In fact, logically enough, many countries in this group received no--or very few--syndicated loans after than year and the Bank of England reports no spread data for them.

As Table 2 shows, for the 12 countries in the sample that had consistent access to credit markets between 1978 and 1986, all variables were highly significant, of the expected sign, the R^2 was high and the F statistic respectable.

It is interesting to note that in this study, the sign on the coefficient of the average propensity to import is consistently negative as predicted and the variable itself is consistently significant. This contrasts with the results in other studies, in which the average propensity to import frequently turned out to be positive, and was interpreted as a measure of the openness of the economy (see Hipple (1974), and Iyoha (1976). Actual results for this variable were, therefore, generally contradictory, with coefficients often approaching zero.

It is helpful to look at the relative importance of the four determinants for the level of current reserves. Out of the four regressions, the measure of deflation costs, imports scaled by GNP, had the largest coefficient in two regressions and the level of imports had the largest in the other two. Both the opportunity cost measure and the proxy for payments variability had coefficients of widely varying magnitudes, with the variability measure fluctuating most, from -0.063 in the GLS regression to 0.563 in the adjusted OLS regression. The opportunity cost variable ranged from highly negative in the GLS regression to -0.121 in the regression for the smaller sample during the longer period.

In the strongest regression, OLS2, imports, imports scaled by GNP, and the variability measure all have coefficients hovering around 0.6, with the coefficient on the opportunity cost measure being less important at -0.22. This would accord with common sense. On the whole, one would expect deflationary costs and the expected shortfalls in foreign exchange reserves to have a larger weight in authorities' calculations than their opportunity cost of holding reserves.

In an effort to isolate the importance of different variables in the reserves demanded by different country groups, classified by income and debt vulnerability, the pooled cross-section analysis was run separately for the three first regressions on quarterly data for 1978-82 for an industrial country group, a group of developing countries without debt problems, and a group of developing countries that were to develop debt problems after 1982. The results are shown in Table 3. Again, the test statistics are generally more satisfactory for the adjusted OLS regression for each group.

The significance of the variables, however, differs in interesting ways from those of the regressions on the entire sample. In general, all significant variables are of the predicted sign except, as in the regression on the entire sample, for the variability measure in the GLS equation. The disaggregated regression, however, shows that the counterintuitive negative sign on this variable comes from the nondebt developing countries, which seem to reduce their reserves as their past variability increases. Since the cost of deflation also induces reserves to fall, while the level of imports causes them to rise, these countries act as predicted otherwise. Since the nondebt developing countries generally had ready access to syndicated markets over the period, the odd sign on the variability measure might be capturing the effect of a downward shift in their reserve demand schedules as their ability to borrow reserves rose. But, as noted earlier, the GLS equation is the weakest of those tested, so it would seem reasonable not to lay too much weight on this result.

Table 3. Determinants of Reserve Demand by Country Groups, 1978-82

	VARB	MPM	Imp	Net Rate	Adj.R^2	F
GLS:						
1.	0.0788**	0.3128	0.36774	-0.2759	0.4	23.2
	(3.8185)	(1.0732)	(1.5181)	(-0.8434)		
2.	-0.0643**	-0.8957**	1.06379**	-0.145	0.6	51.4
	(-5.7863)	(-6.248)	(7.9472)	(-0.5066)		
3.	0.003	-1.5122**	1.241**	-1.6383**	0.5	45.0
	(0.140)	(-7.307)	(8.407)	(-3.841)		
OLS1:						
1.	0.4126**	0.17897	0.7281**	-0.2861	0.6	42.0
	(4.69)	(1.0183)	(8.454)	(-0.1456)		
2.	-0.1956**	-0.107**	0.77447**	0.10687	0.6	49.7
	(-3.5238)	(-13.1365)	(9.2179)	(0.6008)		
3.	0.2452	-0.7956**	0.7435**	-0.72096**	0.5	53.8
	(0.289)	(-6.104)	(10.4644)	(-3.073)		
OLS2:						
1.	0.937**	-0.1109**	0.98015**	-0.6477	0.9	193.5
	(6.1777)	(-3.8386)	(6.4948)	(-0.825)		
2.	0.8258**	-0.10424**	0.7576**	0.33992	0.9	106.8
	(7.5723)	(-3.4965)	(4.8038)	(0.3428)		
3.	0.23396	-0.3243	0.71552**	-0.4607**	0.9	89.1
	(1.9062)	(-1.3111)	(4.6391)	(-3.4557)		

Note: Regressions and data as defined in Table 2. 1., 2., and 3., refer to industrial, nondebt, and debt developing countries, respectively.

One striking difference between the results for the country groups and those for the entire sample is the significance of the opportunity cost measure. Only for those countries which are to encounter debt problems after 1982 is it significant, and for these countries it is highly and consistently significant across all regressions. For two out of the three regressions both imports scaled by GNP and imports are also significant; for the third, OLS2, only imports are significant. Out of all the country groups, the opportunity cost measure is least significant for those countries that were not to encounter debt problems later in the adjusted OLS regression.

This varying significance of reserve costs for the different groups supports the view discussed earlier that monetary authorities manage their reserves both to provide a buffer against future crises and to maintain confidence in the country's financial management. Even as early as 1978, observers were aware of the size of debt being accumulated by some countries. The first multilateral reschedulings were arranged in 1975; there were two in 1976, three in 1977, four in 1979 and 1980, and a large increase thereafter. Although these varied, interest rates were also generally higher for the large debtor countries. At the same time, their current account deficits were high, and owned reserves were likely to be low. It is reasonable to suppose that their reserve holdings were partly borrowed, so net borrowing costs would be expected to be an important factor in the level, that were held. In addition, however, these countries would have been very concerned to maintain their reputation in international financial markets for as long as they could.

IV. Conclusions

The significance of financial costs in the demand for reserves of a range of different types of economies adds to our understanding of how countries determine the level of reserves they hold, and emphasizes the sensitivity of reserves to market conditions. The payments balances of a great number of countries have undergone a fundamental change over the past ten to fifteen years. On the one hand, unprecedented sums have been intermediated by the international banking system, giving rise to very large and variable payments surpluses and deficits. This, according to the findings of traditional reserve demand studies, should increase the need for reserves. In addition, some countries have been able to augment their reserves directly through borrowing from the syndicated loan markets. On the other hand, the financial resources shifted have been on terms that have been increasingly differentiated by borrower. These facts have two important effects: short of the appearance of debt-servicing problems, they have frayed the links that existed under the gold exchange standard between domestic economic conditions and the balance of payments (since countries could borrow to finance current consumption), and they have made reserve holdings vulnerable to international market conditions.

The first effect may be more apparent than real. As long as a country is creditworthy, it can go to the market as and when it needs reserves, and may, therefore, hold less than it would if it could not borrow. Alternatively, it might borrow reserves in order to maintain expansionary domestic policies for longer periods before encountering in due course the reserve constraint. But market perceptions of creditworthiness impose their own discipline: a country seen to be holding too few reserves, or pursuing inflationary policies, might find its access to the market suddenly altered. (Sudden changes in market perceptions of creditworthiness have been a feature of the international banking system since 1982.)

The second effect--the vulnerability of reserve holdings to international financial market conditions--is more serious. The fine terms on borrowing on the international markets give opportunities for profit as well as for loss. Surplus countries may, because of a good credit rating, add to their reserves when investment conditions are good, while deficit countries with increasing real resources absorbed by debt repayments will be forced to borrow at a premium to maintain desired reserve levels. For both groups of countries, reserves should be sensitive to their opportunity cost. The present study shows that the more vulnerable economies with the greatest need for reserves economize more than others on their reserves when international financial markets are tight.

APPENDIX I

The Data

Sample countries. 24 countries (see Appendix II), subdivided into a small industrial country group (major currency countries are excluded for reasons given in the text), a set of nondebt problem countries, and a set of debt problem countries. The difference between the last two groups was whether the country had entered into a rescheduling arrangement during the period. The debt problem group was dropped for 1982-86 since it faced credit rationing.

Data. All aggregates are measured in U.S. dollars. In addition to the reasons quoted in the text for using dollar figures, the primary source of data is the Fund's International Financial Statistics (IFS), which reports reserve and trade statistics in dollar terms. It is, therefore, sensible to use data converted into dollars by a consistent methodology at the same time, since this should minimize distortions from the effects of converting different exchange rates. Following Frenkel (1978), this study looks at nominal rather than real reserve demand.

Reserves. The IFS definition of total reserves of the monetary authorities minus gold (line 11.d in the monthly publication) was used. Gold was excluded for two reasons; first, there is some question whether central banks consider gold to be as liquid as, say, foreign currency holdings. Apart from the fact that large sales might depress the market price, central banks seem to regard gold as reserves that are truly "of last resort" which are only to be sold in extremis. The second reason for excluding gold holdings is that if they are valued at the official price, the value will be vastly underestimated, but if valued at current market prices, they will be overvalued. The price of gold has varied quite a bit over the period considered, and unless one considers that a country was ready to realize the capital gain whenever the price rose, the price increase does not reflect a higher value of reserves.

Net Rate. Individual country spreads over the 6-month LIBOR on syndicated loans to the sample countries, denominated in U.S. dollars, plus the six-month LIBOR rate, and less the three-month U.S. Treasury bill rate. (Ideally the term structure of the interest rates should be matched. The three-month TB rate was chosen because the shorter-maturity assets were thought to correspond to authorities' needs for liquid assets more closely than the longer-term maturities, while almost all syndicated loans are quoted over six-monthly LIBOR. As a practical matter, the three-monthly TB rates move closely with the six-monthly rates.) The loan rates chosen are average rates for loans to a given country in each quarter between 1978 and 1986, weighted according to its share in total loans to that country in that quarter. Syndicated borrowing spreads over six-monthly LIBOR are from the Bank of England and the 6-monthly LIBOR and the three-month Treasury bill rate are from Data Resources Inc.

Probability of Deficits (VARB). The literature has found that the variability of reserves over fourteen past periods is a consistently significant determinant of reserve holdings for all types of economy. We therefore assume that reserve variability (denoted VARB), measured over this time frame and detrended to exclude persistence, can be used to proxy p(D), or the probability distribution of a future imbalance. Thus, the probability of deficits arising and of using reserves becomes:

$$\log R = \log VARB - \log m - \log r.$$

The definition for reserve variability is that used by most authors:

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

for country i and time t, where $\hat{a}_T$ is the result of a regression to estimate the trend in R;

$$R_t = a_0 + a_T t + \varepsilon_T \quad \text{over } t = T-14, \ldots, T$$

The marginal propensity to import (MPM), is proxied here by the average propensity to import--that is, by imports as a ratio of GDP. Both these aggregates are taken from the Fund's IFS.

Scale Variable (Imp). The dollar value of imports, from the Fund's IFS.

APPENDIX II

Sample Countries

Industrial Countries:	Australia
	Denmark
	Italy
	Norway
	Spain
	Sweden
Nondebt Developing Countries and Territories:	Greece
	India
	Indonesia
	Korea
	Portugal
	Taiwan Province of China
	Thailand
Debt Developing Countries:	Argentina
	Brazil
	Chile
	Colombia
	Ecuador
	Mexico
	Morocco
	Peru
	Philippines
	Venezuela
	Yugoslavia

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