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THE DEMAND FOR INTERNATIONAL RESERVES: A COMPARATIVE STUDY

by

JIXIN XU

B.A., East China Normal University, 1982
M.A., University of Victoria, 1987

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Name: Jixin Xu

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Examining Committee:

Chairman: Dr. Zane Spindler - Chair

Dr. Herbert G. Grubel
Senior Supervisor

Dr. James W. Dean
Supervisor

Dr. Dennis R. Maki
Supervisor

Dr. Stephen T. Easton
Professor
Faculty of Arts, Dept. of Economics
Internal/External Examiner

Dr. Mario I. Blejer
Chief, Country Economics Department
The World Bank
External Examiner

Date Approved: June 1, 1992

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The Demand for International Reserves: A Comparative Study

Author: Jixin Xu
(signature)

Jixin Xu
(name)

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ABSTRACT

The purpose of this thesis is to explain theoretically and empirically the demand for international reserves by different economies. A comparative approach to a country's demand for reserves has been developed. The reserve demand behavior in developed, less developed, and centrally planned economies has been empirically examined and the results reported.

This study has revealed that a country's reserve demand is not determined only by economic variables but is also affected by the institutional and structural conditions in the economy. In general, less developed and centrally planned economies require larger reserve holdings and need a more rapid adjustment to a balance of payment deficit.

This study is the first to empirically examine China's reserve demand behavior. The general principle of the theory of demand for international reserves is applicable to China, although there are some unique characteristics in its reserve demand. It is found that reserves movements in China respond both to discrepancies between desired and actual reserves and between the desired and actual level of investment.

There are two policy implications of this study. As to the individual countries' reserves management, the structural and institutional deficiencies inherent in less developed or centrally planned economies may prevent these economies from achieving the optimal level of reserve holdings and the optimal speed of adjustment. In addition, the higher reserve holdings or the faster speed of adjustment imply either a waste of their scarce real resources or a reduction of the domestic economy. The crucial implication for these countries' reserves management is the progress of their economic and financial reforms as well as the structural changes in their economies.

With respect to implications for international monetary reform, so long as there is a stable relationship between a few key determinants and reserve demand, institutional mechanisms, such as the creation and distribution of SDRs and other lending facilities in the International Monetary Fund, can provide some assurance that the supply of reserves grows in step with demand. The issue of higher reserve demand required by less developed and centrally planned economies in their transition period can also be resolved in these mechanisms.

DEDICATION

To my parents

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Chapter 1. Introduction.

Traditionally the dominant topic of debate among international monetary analysts has been international reserves. During the 1960's in particular, the major topic of discussion in international fora was the question of international liquidity. The theoretical and empirical studies on the demand for international reserves have revealed that a country's reserve demand is a function of certain variables, and such a functional relationship is relatively stable over a long-term period. Does this functional relationship apply to different economies, such as developed, less developed, and centrally planned economies? Will the institutional and structural differences between different economies affect their reserve demand behaviors? If so, in which direction? What are the implications of these differences for an individual country's reserve demand management and for international monetary reform? The purpose of this thesis is to answer these questions.

This introductory chapter first states the objective of the thesis in Section (1.1). Then, Section (1.2) briefly describe the definition and development of international reserves. Finally, Section (1.3) contains an overview of the thesis.

(1.1) Objective of Thesis.

Traditional studies on the demand for international reserves have left two obvious issues yet to be resolved. First, empirical results obtained from various tests have showed that the impact of different explanatory variables in a reserve demand function, and their statistical significance in explaining countries' reserve demand behavior, are mixed and inconclusive. Second, the reserve demand behavior between different country groups has not been theoretically analyzed and empirically investigated in a systematic way. The demand for international reserves in centrally planned economies has been given little attention and no empirical work with respect to these economies has been found.

The purpose of the thesis is to explain theoretically and empirically the demand for international reserves by different economies over the last three decades when dramatic changes in international financial conditions have been observed. A comparative approach to the demand for international reserves will be developed. The different country groupings' reserve demand behavior, such as developed economies vs. developing economies, and market economies vs. centrally planned economies, will be empirically investigated. The results will be used to make inferences about the future demand for international

reserves and to derive implications for international monetary reform.

The main differences between this study and previous work are as follows. First, to conduct a comparative study on countries' reserve demand behavior in a systematic way will be a new effort. This study attempts to show that a country's demand for international reserves is not only determined by economic variables but is also affected by the institutional as well as structural conditions in the economy. Second, it is the first time in the literature that the reserve demand in a centrally planned economy has been theoretically and empirically studied. The results obtained have helped to widen knowledge and understanding in this area. Third, this study tests theories based on the current development of reserve demand over the last three decades, when there were exceptional changes in international financial conditions. The identified new explanatory variables in the reserve demand function add to the literature.

(1.2) Demand for International Reserves: Definition and Developments.

What are international reserves? Why do countries' monetary authorities demand international reserves? What are the developments in international reserves in the last two

decades? These issues will be discussed in this section. The concept, features, and functions of international reserves are defined in Section (1.2.1). Section (1.2.2) gives a brief review of the development of international reserves since the early 1970's.

(1.2.1) Defining international reserves.

Generally speaking, international reserves are defined as those assets that a country's monetary authorities can use either directly or by converting them into other assets to support the exchange rate when the country's balance of payments moves into deficit. The precise classification of reserves is, in fact, rather arbitrary, although reserves are conventionally defined to incorporate gold, convertible foreign exchange, reserve positions in the International Monetary Fund (IMF), and Special Drawing Rights (SDRs).

To understand the concept of international reserves, one should look into the features and functions of international reserves. Grubel (1971) defined international reserves "to be assets or credits which can be used directly for such intervention (foreign exchange), or which can be turned into foreign exchange quickly and with capital certainty (gold, IMF reserve positions and credits)" (Grubel, 1971, p. 1150). However, if we accept Group of Ten's definition of international reserves as "those assets

of [a country's] monetary authorities that can be used directly, or through assured convertibility into other assets, to support its rate of exchange when its external payments are in deficit" (Ossola Report of Group of Ten, 1965, p. 21), we should exclude gold. It is not now used by national exchange funds for intervention in support of exchange funds, nor is it often exchanged into currencies for that purpose. Scammell (1987) argued that "although central banks have large gold holdings they hold these rather as 'reserves for reserves' conscious of the fact that the wide fluctuations in price to which gold is subject render it undesirable to switch frequently from gold to currencies, or vice versa" (Scammell, 1987, p. 52).

There are a range of assets in the international financial system that are normally included in most definitions and measurements of reserves. Some of these, basically certain foreign currencies or foreign exchange such as the US dollar, Deutsche mark, Japanese Yen, British pound and French franc, may be directly used to buy goods and services or other currencies; others, including that part of a country's borrowing from the IMF that may be drawn automatically and unconditionally, SDRs may not be directly used in this way but must be first swapped into foreign exchange.

All the above mentioned components of reserves share the feature that they may be used relatively quickly should the need arise; in other words, they are all relatively liquid. Gold is rather more ambiguous in this respect. In principle countries might pay off their debts in gold or could sell it in order to raise the necessary foreign exchange. In practice, however, gold is not used in this way and is not considered be a very liquid asset. Still, the principle remains and the gold is counted as a reserve asset rather than merely as a speculative commodity stock. "..., gold did not play a role of decreasing importance in the international monetary system" (Grubel, 1982, p. 195).

According to IMF, the *International Financial Statistics* (*IFS*) measure of international reserves represents a country's primary source of liquidity for purposes of international settlements. The definition "includes all internationally acceptable means of payment that are readily available to the country's monetary authorities, either to finance payments imbalances or to manage these imbalances by intervening in financial markets to influence fluctuations in the exchange rates of their national currency" (IMF's *IFS Supplement on International Liquidity*, 1987, p. 9). Accordingly, the *IFS* measure of international reserves comprises the monetary authorities' holdings of gold, foreign exchange, SDRs, and its reserve positions in the Fund. This definition is considered as

being capable of measurement and cross-country comparison. However, non-gold reserves have been widely used in the empirical studies for the above mentioned reasons for which the transaction and precautionary demand for reserves are the main purpose of the study.

In the literature, we often see both international reserves and international liquidity used. Sometimes, both concepts are employed interchangeably. "The term 'international liquidity' is most often used as a synonym for reserves" (Williamson, 1973, p. 687). However, international liquidity is a rather broad concept, being defined generally as access to the means of international settlement. A country's *gross* international liquidity consists of all the resources actually or potentially available to it for financing balance of payments deficits. So far as actual resources are concerned, in addition to official monetary reserves, a country's gross international liquidity also includes the external liquid assets of the private sector, i.e., private holdings of foreign currencies and short-term trade-related claims on other countries. A country's potential international resources includes their conditional credit facilities at the IMF and their borrowing potential in the international banking and capital markets. To measure a country's *net* international liquidity, the other side of the balance sheet should be taken into account, by subtracting from the external assets the

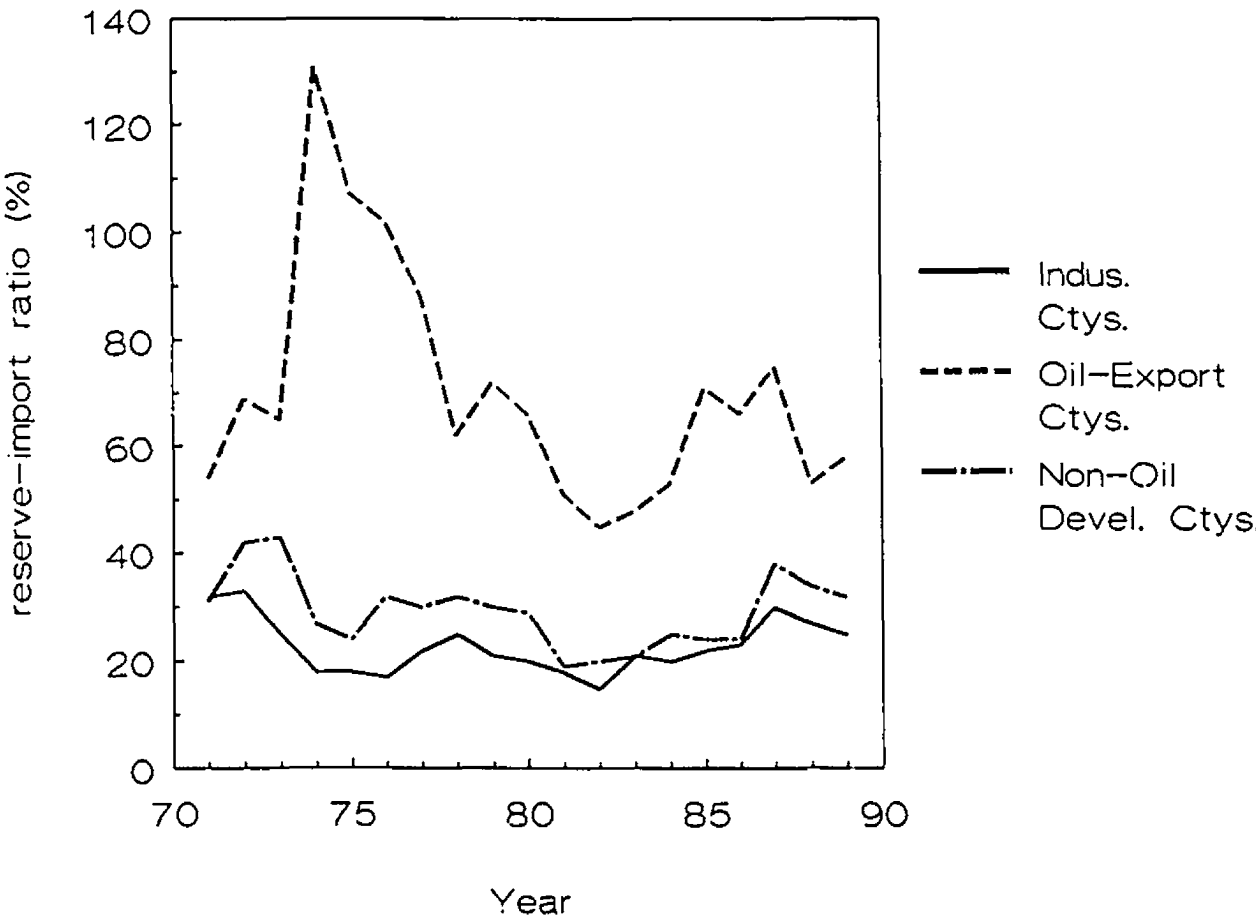
external liabilities and, in particular, those which are short-term in character. In this study, we shall concentrate on international reserves, although the concept of international liquidity will be used in certain cases.

(1.2.2) International reserves developments since the early 1970's.

We turn now to an examination of the development of international reserves during the 1970's and 1980's, in order to explore the extent to which the system has adapted to changes in the demand for international reserves. Two most commonly used measures of reserve demand are the reserve-import ratio (measure of reserve ease or tightness) and the stock of reserves and their growth and distribution among countries.

Figure 1.1 shows, for the main groups of countries in the system, but excluding the United States from the group of industrial countries, the development of three major country groups' total non-gold reserves in relation to their total imports since 1971. Two important facts are observed. The first is the close relationship between the changes in countries' reserve-import ratio and the major developments in the world economy. After an increase in non-gold reserves in the early 1970's, 1974 and 1975 brought major declines in the ratios for all groups of oil-importing countries,

Fig. 1.1 Ratios of Non-Gold Reserves to Imports



Source: International Financial Statistics, various issues.

followed by further increases during 1976-78, before the second oil shock. The continued very large expansion of international bank lending after 1974, as a result of recycling petro-dollars, not only moderated the decline in oil-importing countries' reserve-import ratio after the first oil shock but was a major factor in their recovery after 1976. From 1979 onwards, after the second oil shock and the beginning of industrial countries' major efforts to reduce inflation, which produced strong increases in interest rate levels, the international liquidity situation of many countries progressively deteriorated. Reserve-import ratio declined. Between the end of 1978 and the end of 1982 the reserve-import ratio for industrial countries other than the United States declined from 25 to 15 percent. For non-oil developing countries as a whole this ratio declined over the same period from 29 to 19 percent. Since then there has been a substantial increase in global reserves. The non-gold reserve to import ratio has increased for all three country groups. This increase continued until the end of 1987.

Another important feature is that the reserve-import ratio for oil-exporting countries remains more volatile than those for industrial countries and non-oil developing countries. The calculated coefficient of variation of the non-gold reserves to import ratio for oil-exporting countries for the entire sample period is 31.8, while those

for industrial countries and non-oil developing countries are 22.0 and 23.2 respectively.

Developments in international reserves are intimately linked with exchange rate movements and with the monetary and exchange rate policies that countries pursue in view of their macroeconomic objectives. The global stock of reserves is influenced in a number of ways by developments in the exchange markets and by the response of monetary authorities to temporary imbalances. First, the authorities of many countries may at times intervene in the same direction, thereby increasing or reducing aggregate holdings of the principal reserve currency. Second, the SDR prices of reserve currencies may change and cause a change in the value of foreign exchange reserves measured in SDRs. Third, movements in the rates at which interest can be earned on short-term investments in reserve currencies affect the growth of these currency holdings.

Table 1.1 shows the broad composition and growth of identified reserves over the 1970's and 1980's. The global reserves show a steady increase in the 1970's. After a slight decline during 1981 and 1982, there has been a substantial increase since 1983. Countries' total reserve assets more than doubled in current dollar terms during the end of 1982 and August 1990, from $398.78 to 893.07 billion. Nearly one-quarter of the increase may be estimated to have

Table 1.1 Global Reserve Developments
(Billions of US Dollars, End of Period)

	Foreign Exchange	Reserve Position[1]	SDRs	Gold[2]	Total
1971	81.88 (61)	6.90	6.38	39.08	134.24
1972	104.90 (66)	6.87	9.43	38.75	159.95
1973	124.11 (67)	7.44	10.62	43.16	185.33
1974	156.15 (71)	10.83	10.85	43.72	221.55
1975	162.42 (71)	14.78	10.26	41.74	229.20
1976	187.78 (72)	20.61	10.06	41.24	259.69
1977	247.40 (77)	21.98	9.88	43.75	323.01
1978	291.88 (79)	19.33	10.56	42.27	369.06
1979	329.44 (81)	15.49	16.44	43.60	404.97
1980	373.50 (83)	21.47	15.06	42.57	452.60
1981	340.50 (80)	24.82	19.10	38.86	423.28
1982	314.48 (79)	28.08	19.57	36.65	398.78
1983	322.83 (78)	40.95	15.10	34.73	413.61
1984	342.11 (79)	40.75	16.14	32.48	431.48
1985	382.60 (79)	42.54	20.00	36.50	481.64
1986	444.99 (81)	43.23	23.85	40.63	552.70
1987	645.64 (84)	44.64	28.67	46.85	765.80
1988	663.78 (86)	38.04	27.14	44.47	773.43
1989	713.84 (87)	33.47	26.92	43.18	817.41
1990[3]	786.34 (88)	32.91	28.30	45.52	893.07

( ) is the percentage of the total reserves;
1. A country's reserve position in IMF;
2. Valued at SDR 35 per ounce;
3. Values at the end of August 1990.
Sources: International Financial Statistics, various issues;
IMF: *IFS* Supplement on International Liquidity, 1987.

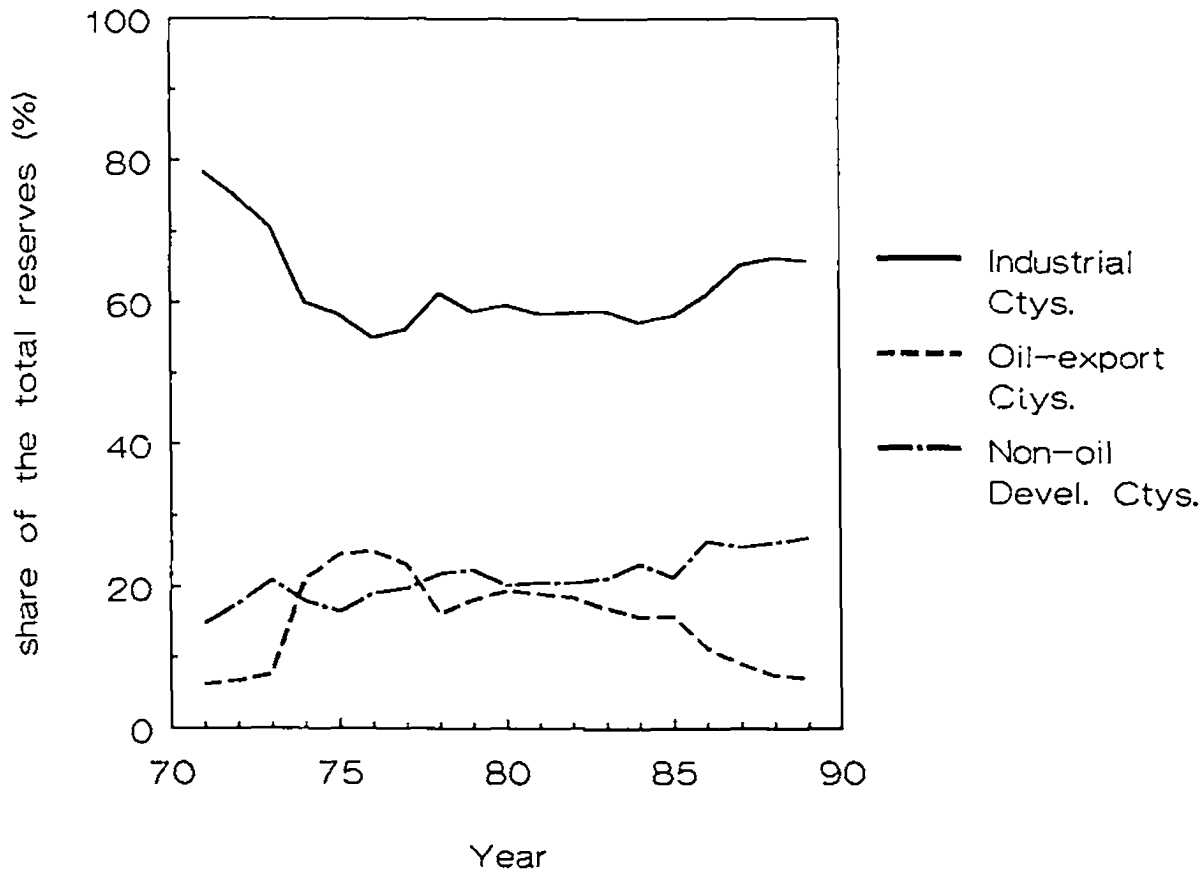
come about through the rise in the current dollar value of non-gold reserves held in forms other than US dollars which resulted from the decline in the external value of the dollar over the period as a whole. Between the end of 1986 and the end of 1987, the value of the US dollar per SDR depreciated from $1.223 to $1.418, which brought the dollar value of global reserves from $552.7 to $765.8 billion. However, most of the absolute increase in reserves since the end of 1982 has been in US dollars and the unique role of the US balance of payments position is particularly relevant to the analysis. Dollar reserves rise when central banks (other than the Federal Reserve) purchase dollars on the foreign exchange market to support the dollar or prevent their own currencies appreciating. However, the link between dollar reserve growth and the US balance of payments position is complex. Dealtry (1988) noted that between 1983 and 1987 the US had a cumulative current account deficit of $572 billion. Within that period, between 1983 and 1985 there was little growth in dollar reserves though in 1986 and 1987 reserves rose considerably. In the former case the deficit was covered by substantial autonomous private capital inflows to the US, while in the latter case the inflow was significantly reduced and replaced by central bank purchases of dollars to prevent depreciation. Thus the portfolio behavior of the private sector and central banks determines, in large part, the link between the US deficit and reserve growth.

Other obvious features are the relative insignificance of IMF-based sources of liquidity (reserve positions in the Fund and SDRs) and the sharp rise and rising proportion of reserves in the form of foreign currency holdings of countries' central banks. The share of foreign exchange holdings as a percentage of total reserves has increased from 61 in 1971 to 88 in August 1990. The share of gold reserves has been relatively small. The amount of gold reserves varied between roughly 30 to 50 billion US dollars if valued at SDR 35 per ounce.

Since the end of 1982 there have been marked shifts in the distribution of total reserves between different groups of countries. Figure 1.2 shows the distribution of the global reserves among industrial, oil-exporting, and non-oil developing countries. Reversing the trends of the 1970's and the early 1980's, the industrial countries' share in total reserves rose in current dollar terms from 58.6 to 67 percent between the end of 1982 and August 1990, while that of the oil-exporting countries has declined dramatically, from 17 to 5.7 percent. The share of non-oil developing countries in the total rose from 21.2 to 27.2 percent.

Finally, Table 1.2 shows that the currency composition of foreign exchange reserves has been changing, though the US dollar still dominates. Since the middle of the 1970's,

Fig. 1.2 Global Reserves Distribution



Source: International Financial Statistics, various issues.

Table 1.2 Currency Composition of Foreign Exchange Reserves (Percentage of Total, End of Year)

	US dollar	Deutsche mark	yen	British pound	Swiss franc	French franc	others[1]
1973[2]	84.5	6.7	-	5.9	1.4	1.2	0.3
1974[3]	84.3	6.6	-	6.1	1.6	1.0	0.4
1975	85.2	6.6	0.6	4.1	1.7	1.3	0.5
1976	86.7	7.3	0.7	2.1	1.6	1.0	0.6
1977	85.2	8.3	1.2	1.8	2.2	0.8	0.5
1978	82.8	10.1	1.9	1.6	2.1	1.0	0.5
1979	71.9	13.1	2.6	3.1	2.9	1.6	4.8
1980	68.6	14.9	4.4	2.9	3.2	1.7	4.3
1981	71.5	12.8	4.2	2.1	2.7	1.3	5.4
1982	70.5	12.4	4.7	2.3	2.7	1.0	6.4
1983	71.4	11.8	5.0	2.5	2.4	0.8	6.1
1984	70.1	12.7	5.8	2.9	2.0	0.8	5.7
1985	64.9	15.2	8.0	3.0	2.3	0.9	5.7
1986	67.1	14.6	7.9	2.6	2.0	0.9	4.9
1987	67.2	14.4	7.5	2.4	2.0	0.8	5.7
1988	64.9	15.7	7.7	2.8	1.9	1.0	6.0
1989	60.2	19.3	7.9	2.7	1.7	1.3	6.9

1. The residual is equal to the difference between total identified reserves and the sum of the reserves held in the six currencies listed in the table;
2. Values at the end of the first quarter;
3. Values at the end of the second quarter.
Sources: IMF Annual Report, various issues.

there has been a decline trend in the proportion of foreign exchange reserves held in US dollars and a rise in the significance of the Deutsche mark and Japanese yen. Developing countries were the first to diversify in the early 1970's and there was some switch away from the dollar by industrial countries after 1978.

The US dollar's share in the currency composition of foreign exchange reserves is closely related to the dollar's exchange rate movements. During 1975-77, the composition had remained relatively stable. The sharp depreciation of the dollar between 1977 and 1980 was accompanied by a decline in the share of the dollar in total foreign exchange reserves from 85.2 to 68.6 percent. This diversification away from the dollar was partly reversed in the early 1980's, when the dollar appreciated strongly relative to the other major currencies. As a result, the share of the dollar in reserves rose to 71.4 percent by the end of 1983. However, by the end of 1985, the share had declined by 6.5 percentage points and the proportion of foreign exchange reserves denominated in the Deutsche mark, Japanese yen, and, to a lesser extent pound sterling, increased. The extensive foreign exchange market intervention by some major industrial countries that occurred during 1986 and 1987 was accompanied by a rise in the proportion of reserves held as dollar-denominated assets (to 67.2 percent in 1987). However, the dollar share of foreign exchange reserves fell again to 60.2 percent at the

end of 1980's. The counterpart of the fall in the share of dollar was a sharp increase in the share of the Deutsche mark, which increased from 14.4 percent at the end of 1987 to 19.3 percent at the end of 1989.

(1.3) Overview of Thesis.

This thesis is organized into five chapters. A general review of the literature and empirical evidence of the demand for international reserves will be outlined and discussed in Chapter 2. A theory of reserve demand using a comparative approach and the empirical results of this study will be presented and discussed in Chapter 3. Chapter 4 studies China's demand for international reserves as a case study of a centrally planned economy. Chapter 5 will include the conclusions and implications.

Chapter 2. Review of the Literature

This chapter gives a general review of the literature and empirical evidence for the demand for international reserves. Section (2.1) outlines the evolution of the theory of demand for international reserves. Models of the demand for international reserves essentially involve optimizing analysis based on the cost-benefit approach. Empirical studies of the demand for international reserves will be reviewed in Section (2.2). The literature is divided into three parts: the identification of the determinants of reserve demand, stability analysis of the demand for international reserves and studies on the dynamics of adjustment in reserve demand. Section (2.3) will close the chapter with a brief summary.

(2.1) The Evolution of the Theory of Demand for International Reserves.

Generally speaking, the theory of demand for international reserves is derived and developed from mainstream economic theory. Microeconomic theory tells us that in order to achieve maximum economic welfare goods should be produced up to a point at which the marginal cost of producing them equals the marginal benefit from consuming them. This same notion of optimality has been applied to the output of international reserves. Studies by Heller (1966,

1968), Clark (1970), Kelly (1970), Frenkel and Jovanovic (1981), Grubel (1976, 1977, 1981) and Bird (1988) are among the major contributions to the theory of demand for international reserves. Section (2.1.1) outlines Heller and Frenkel and Jovanovic's models. The Clark and Kelly version of the optimizing analysis is introduced in Section (2.1.2). Section (2.1.3) outlines Grubel's theoretical model of the determination of optimal reserves and Bird's institutional approach to the issues.

(2.1.1) Heller, Frenkel and Jovanovic models.

The cost-benefit approach to international reserve holdings implies that the demand for reserves results from an optimizing decision. Such a decision may be expressed as juxtaposing reserve holdings on the one hand and the speed of adjustment on the other. An individual country's demand for international reserves depends on the expected costs of adjustment to external imbalances compared to the costs of holding reserves. Two branches of literature have been developed, depending on whether the marginal cost of adjustment is assumed to be constant or increasing with the amount of adjustment.

Heller (1966) introduced the theoretical notion that the demand for international reserves involves countries in a cost-benefit analysis where the cost is equal to the

opportunity cost of holding reserves and the benefit is the avoidance of income adjustments for dealing with external deficits. Heller assumed that the marginal cost of adjustment is constant and thus the adjustment is postponed to the last minute. The payments imbalance at a given exchange rate is assumed a discrete random variable which takes on the value $\pm h$ with equal probabilities. Given initial reserves R, the probability of running out of reserves in R/h steps is $(1/2)^{R/h}$. The cost of a unit adjustment at that time by means of a reduction in income is assumed to be $1/m$, where m is the marginal propensity to import. The expected cost of a unit adjustment is then $[(1/2)^{R/h}]/m$. Equating this expected marginal cost to the opportunity cost of holding a unit of reserves r, we have

$$r = [(1/2)^{R/h}]/m. \quad (2.1.1).$$

The optimal reserve holdings is then derived as

$$R^* = h[(\log(rm))/(\log(0.5))]. \quad (2.1.2)$$

The significance of Heller's paper lies in its theoretical formulation of the basic issue of reserve demand as a cost-benefit analysis involving probabilities of future deficits and the structural characteristics of countries determining the costs of holding reserves and of using income adjustments to deal with deficits.

Frenkel and Jovanovic (1981) developed a stochastic model for determining the optimal stock of international reserves. They generalized the analysis by assuming an adjustment from zero to R in one step, in an intertemporal optimizing framework that also considers the cost of holding reserves until exhaustion. The change in reserve holdings $dR(t)$ was characterized by a stochastic equation:

$$dR(t) = -\mu dt + \sigma dW(t);\ R(0) = R_0,\ \mu \geq 0 \quad (2.1.3)$$

where $W(t)$ is the standard Wiener process (i.e. a process which is the continucus time analogue to the simple random walk) for which, the change in reserve holdings in a small time interval dt is a normal variate with mean $-\mu dt$ and variance $\sigma^2 dt$ and is temporally independent. Frenkel and Jovanovic calculated the expected cost of adjustment and opportunity cost of holding reserves from a dynamic programming recursion relationship, which yielded the present value of total expected cost:

$$(R+\alpha C)/(1-\alpha) - \mu/r, \quad (2.1.4)$$

where α is the Laplace transform of the first passage of reserves through the boundary point zero, C is the marginal cost of adjustment, and r is the percentage cost of holding reserves. The optimal stock of reserves was derived as:

$$R^* = [(2C\sigma)/((\mu^2+2r\sigma^2)^{1/2}-\mu)]^{1/2}. \quad (2.1.5)$$

Assuming that on average balance of payments are balanced, and thus that the stochastic process governing the difference between payments and receipts in international transactions is without drift, the optimal stock of reserves was then obtained by evaluating equation (2.1.5) at $\mu = 0$,

$$R^* = [(2C\sigma^2)/(2r\sigma^2)^{1/2}]^{1/2}, \quad (2.1.6)$$

which has economies of scale with respect to the measure of variability σ, in contrast to the linearity of the Heller's formula with respect to h. Frenkel and Jovanovic derived formally the explicit solution for optimal reserve holdings as a function of the rate of interest, the variance of the stochastic process governing international payments and receipts.

(2.1.2) Clark and Kelly models.

In this branch of the literature, the marginal cost of adjustment is assumed to increase with the size of the adjustment. The typical example of this analysis is that of Clark (1970) and Kelly (1970). It was assumed that each country optimizes by simultaneously choosing a target level of reserves, R^*, and an adjustment parameter τ which

measures the proportion of any discrepancy between R^* and its actual reserve level in the preceding period that the country aims to eliminate in the current period. As long as reserves depart from the desired level, the country will wish to induce a balance of payments surplus (deficit), S^*_t, which is given by equation

$$S^*_t = \tau(R^*-R_{t-1});\ 0\leq\tau\leq 1. \quad (2.1.7)$$

In theory, reserve holdings and the speed of adjustment are inversely related. A high level of reserves and a low speed of adjustment involve the economy in a relatively low but stable level of national income. National income is low because reserves are lower-yielding assets than the alternative possible forms of investment and therefore are relatively unproductive in terms of real resources. It is stable because payments imbalances may be financed without the need for demand deflation. A combination which involves a lower level of reserve holdings and a faster speed of adjustment implies a higher but less stable level of national income. The optimizing decision is then interpreted in terms of choosing the most desirable location on a tradeoff between the level of income, to which utility is positively related, and the variability of income, to which utility is negatively related.

The Clark and Kelly analyses can be summarized in Figure 2.1. The optimizing decision is illustrated schematically by concentrating on four determinants of the optimal level of international reserves: the opportunity cost of holding reserves; the speed of adjustment to the balance of payments disequilibrium; the openness of the economy and the instability of the balance of payments; and the tradeoff between the level and the variability of national income. The locus of combination of reserve level R^* and adjustment speed τ is shown in the S.E. quadrant of Figure 2.1, which are consistent with the maintenance of a constant probability of reserve depletion. The problem of optimization is viewed as that of determining the best point on this curve, taking account of the effects of the choice on both the level and variability of income.

Assuming that adjustment takes the form of demand management policy, the S.W. quadrant reflects the costs of adjustment in terms of the variability of domestic income; the faster the speed of adjustment the greater is the variance in income, since a reserve deficiency implies deflation which on turn means a reduction in imports. This must be more severe the greater the chosen speed of adjustment.

The costs of adjustment will depend on both the openness of the economy measured by the marginal propensity

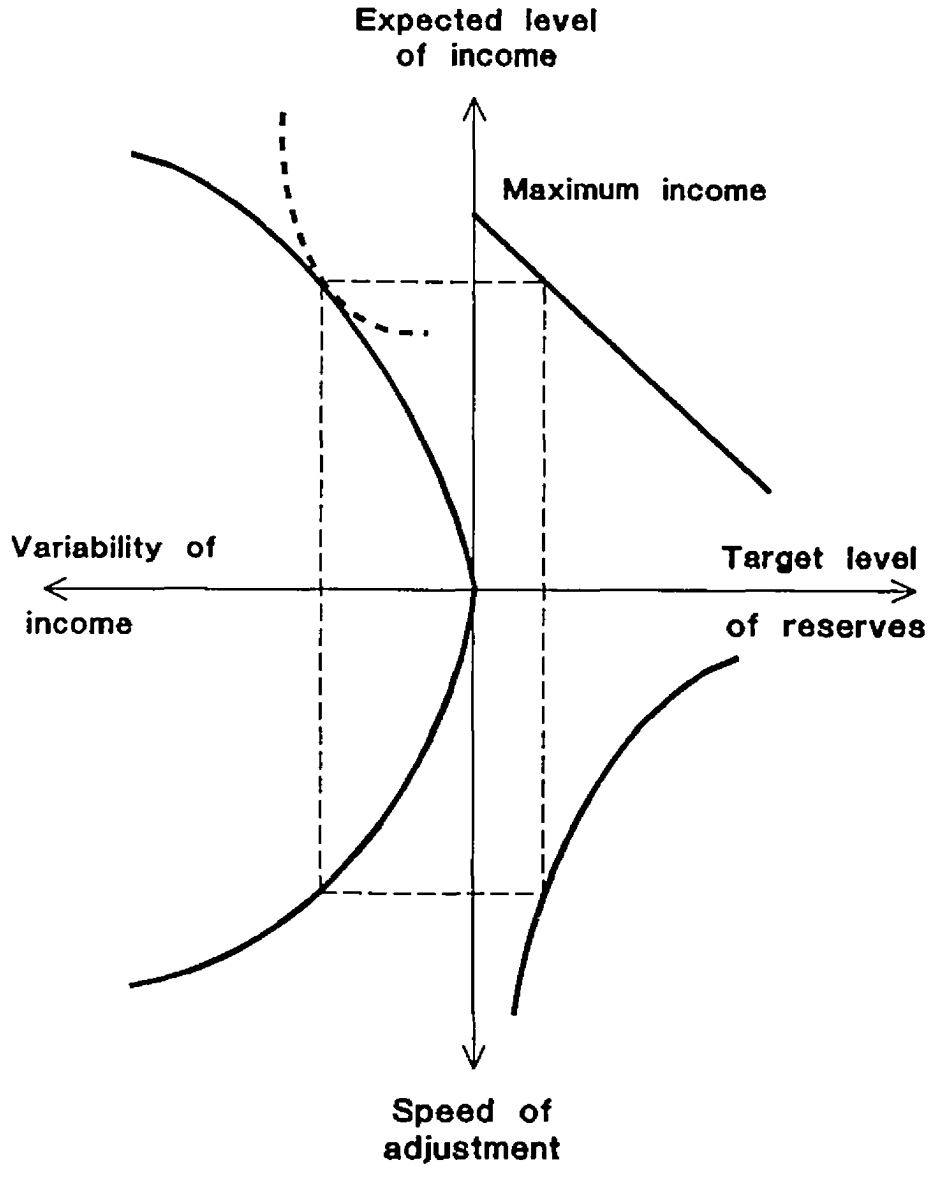


Fig. 2.1

to import, and the size of the random component in the balance of payments. The less open the economy and the more variable the balance of payments the larger will be the costs associated with any given adjustment speed. The choice of a low adjustment speed and a correspondingly high target level of reserves will involve a sacrifice in the form of expected level of income, since reserves are relatively inefficient at creating income.

In the N.E. quadrant the opportunity cost of holding reserves is illustrated by the slope of the tradeoff. These three curves therefore trace out the relationship between the expected value of income and its variability (shown as the solid curve in the N.W. quadrant) implied by the choice of a combination of R^* and τ. The country's monetary authorities make this choice on the basis of a conventional quadratic utility function (dotted curve in N.W. quadrant). Optimal reserves will be held at a point where the marginal rate of substitution between income level and income variability equals their marginal rate of transformation. The level of reserves which is optimal for a country thus depends on the shape of the monetary authorities' indifference curves between the stability of income and the level of income.

The model predicts that average reserves will vary positively with wealth and the instability of the balance of

payments, and negatively with the marginal propensity to import and the opportunity cost of holding reserves. Furthermore, the greater the monetary authorities relative preference for stable income the greater will be the demand for reserves.[1]

(2.1.3) Grubel and Bird models.

Grubel (1977) showed that international reserves have a positive marginal social productivity or marginal benefit when used in reducing the variance of exchange rate movements and in the elimination of externalities associated with exchange rate instability. His model of the optimum quantity of international reserves is illustrated in Figure 2.2. *MCR* represents the marginal cost of producing reserves; it is assumed to be both low and constant. *DD* curve represents the marginal benefit derived from holding international reserves or the individual countries' reserve demand curves. Under the assumption of diminishing returns to reserve holdings, the *DD* curve has been drawn as

1. A mathematical representation of the model can be stated as:
$U = u[E(Y), \sigma_y, P]$, $dU/dE(Y)>0$, $dU/d\sigma y<0$, $dU/dP<0$; (1)
$E(U) = a + bE(Y) - c[E(Y)]^2 - c\sigma^2_y - dP$, (2)
where P is the probability of running out of reserves. Converting (1) to a simple linear function form, we have
$U = \alpha + \beta E(Y) - \delta\sigma_y - {}^{n}P$. (3)
Using equation (2) and (3), the following derivation of the optimum values of reserve holding, R^* and the speed of adjustment, τ, are derived as:
a) $dR^*/d\sigma_\epsilon>0$, b) $d\tau/d\sigma_\epsilon<0$, c) $dR^*/dm<0$, d) $d\tau/dm>0$,
e) $dR^*/dr<0$, f) $d\tau/dr>0$, g) $dR^*/dY_{MAX}>0$, h) $d\tau/dY_{MAX}<0$,
where m is the marginal propensity to import, Y_{MAX} is full-employment output in the case where no resources are invested in reserves.

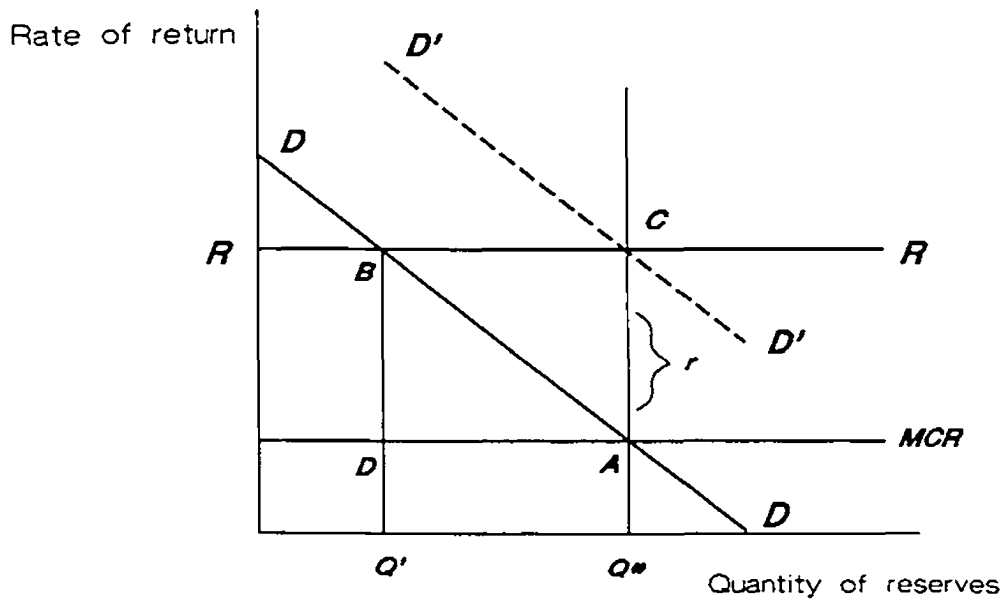


Fig. 2.2

downward sloping. The optimum quantity of international reserves (Q^*) exists at point *A* where the marginal cost of producing reserves equals their marginal social productivity.

Monetary authorities' willingness to hold reserves depends on the marginal opportunity cost of holding reserves, which may be interpreted as being equal to the rate of return on other assets. In Figure 2.2 this is represented by the *RR* curve. Monetary authorities will demand reserves up to the point at which the marginal benefit they derive from extra reserves equals the marginal cost of holding them. This occurs at point *B* in Figure 2.2 where a quantity of reserves Q' will be demanded. In order to ensure that the optimum quantity of reserves is demanded a rate of interest will have to be paid on reserves so that the sum of financial return to holding reserves (as represented by the interest rate) and the security yield (marginal benefit) from holding reserves equals the marginal cost of holding them. By paying a rate of interest on reserves equal to *r* the *DD* curve is shifted upwards and to the right until it cuts *RR* curve at point *C*, where the demand for reserves equals Q^*. The size of the welfare gain is represented by the triangle *ABD* in Figure 2.2.

The cost-benefit approach has frequently been used to estimate the "adequacy of reserves"[2] in particular countries. Again the approach attempts to identify the costs and benefits of holding reserves and to calculate the level of reserves at which marginal cost equals marginal benefit. Most studies adopting this approach have used the reciprocal of the marginal propensity to import to reflect the cost of adjustment (and therefore the marginal benefit of reserves) and the difference between the social return on capital and the return on reserves to represent the marginal cost of holding them.

The cost-benefit models have a number of limitations. First, reserve adequacy is usually judged purely on the basis of random variations in the current account of the balance of payments; the problems caused by secular changes and by capital movements are largely ignored. Second, the use of the reciprocal of the marginal propensity to import as means of estimating the cost of adjustment implicitly assumes that such cost may be expressed in income terms and

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2. The concept of "reserve adequacy" was a central issue of dispute under the Bretton Woods system. According to Grubel (1965, 1971), the demand for reserves can be estimated from a set of independent variables such as countries' level of imports in a regression analysis. The supply of such reserve quantities is defined "to be 'adequate' in permitting the world economy to operate with the same level of restrictions on trade and capital flows and adjustment policies as were used during the period from which the data for the demand equation estimate were taken." This projected adequate level of reserves "is also 'optimal' in the sense that, at this level, world welfare is at its maximum and adjustment policies to disturbances are the most efficient" (Grubel, 1971, p. 1162).

that adjustment takes the form of expenditure-reducing policies. There may in practice be important distributional issues. Furthermore, if expenditure-switching policies imply lower (or indeed higher) adjustment costs, then the use of import propensity will serve to misrepresent the optimum level of reserves. Finally, the factors which may influence the choice of the adjustment-financing-mix have not been considered.

Bird (1988) showed that differences in the values of the various determinants between developing and developed countries seem likely to account for any observed differences in the mix chosen by individual countries. Features such as a relatively high opportunity cost of reserve holding, limited or expensive access to international borrowing, a relatively strong preference for income level as opposed to income stability, and a relatively high degree of openness are likely to persuade developing countries to opt for more adjustment and less financing. A hypothetical comparison between a "typical developing country" and a "typical developed country" is made. The former may be distinguished from the latter in terms of the stronger preference for current expenditure, the lower initial cost of financing, and the existence of a financing constraint.

According to Bird's model, if developing countries face relatively high financing costs as compared with developed countries then, other things being equal, they will be encouraged to make relatively greater use of adjustment. While if they possess a relatively strong preference for current expenditure they will, other things being equal, tend to make relatively greater use of financing. Where the financing constraint has been effective, developing countries have been forced to make greater use of adjustment and less use of financing than they would have preferred. These institutional differences will have an important impact on the individual countries' behavior of demand for international reserves.

The theory of demand for international reserves has been extensively applied in the empirical studies on the reserve demand. These empirical studies and their results will be outlined and discussed in the following section.

(2.2) Survey of the Empirical Studies on the Demand for International Reserves.

Empirical investigation of the theory of demand for international reserves has been extensively conducted in the last three decades. Many papers have been published dealing with the issues. There are at least eight review articles relevant to this study. Among them are Clower and Lipsey

(1968), Niehans (1970), Salant (1970), Grubel (1971), Williamson (1973), Cohen (1975) and most recently, Bahmani (1985a) and Black (1985).

Empirical studies of the demand for international reserves try to answer the following questions: Could the demand for international reserves be specified as a function of some quantitative variables from which an inference could be made about the rate of growth of international reserves? Has the demand for international reserves remained stable over time? The different equations and testing procedures have been applied in order to answer these questions. The development of the empirical studies on the reserve demand can be categorized into three parts. The first part, the identification of the determinants of reserve demand is discussed in Section (2.2.1); Part two and three, the stability analysis of the demand for international reserves, and the studies on the dynamics of adjustment in reserve demand are discussed in Sections (2.2.2) and (2.2.3) respectively. Section (2.2.4) comments on the empirical studies of the demand for international reserves.

(2.2.1) The Identification of the determinants of reserve demand.

The central issue of most of the empirical studies was to identify the determining factors on the demand for

international reserves. The earliest attempts to use empirical analysis to estimate the reserve demand were based mainly on ratio comparisons.

Triffin (1947) suggested that the demand for international reserves could be expected to grow in line with trade, so that the reserve-import ratio could be taken as a measure of reserve adequacy. Later, in his 1960's book he generalized about desired ratios of reserves to imports of major industrialized countries. Supported by the data in his sample of countries, Triffin concluded that major industrialized countries would target at maintaining a reserve level of not less than 40 percent in most years. The reserve-import ratio as a measure of reserve adequacy was used by other authors such as the IMF (1958, 1970), Franks (1958), Stamp (1958) and Grubel (1965). Several issues were raised against this measure. Johnson (1958) argued that, on welfare grounds, reserves should be large relative to the money supply so as to permit the public to execute a desired shift out of money into goods without obliging the authorities to intervene to prevent a payments crisis, which would frustrate the public's profit- and utility-maximising decisions. A second criticism of the use of the reserve-import ratio stems from recognition of the fact that reserves are used to finance deficits, not trade. The IMF study (1958) argued that theoretically the demand for reserves by individual countries depends on many factors

rather than a single arithmetic relationship. Machlup (1964) emphasized the existence of economies of scale due to the development of clearing arrangements, and thus questioned the theoretical basis for the assumed rigid reserve-imports ratio. Machlup (1966) found that reserve-import ratios are very different for the countries and periods under examination. He concluded that the reserve demand is not a function of any identifiable variables, but is determined by the desire of countries to have their reserves grow.

The criticisms on the use of reserve-import ratio as a measure of reserve adequacy provoked a good deal of discussion which gave birth to some constructive developments.

Brown (1964) suggested that one should measure the adequacy of a country's liquidity by dividing its reserves by the absolute value of its payments imbalance in a particular year and that reserves are held as a protection against uncertain future balance of payments deficits - for which past balances are a proxy. Grubel (1971) indicated that this approach neglected the fact that net external balances tend to adjust to the available reserves for both the individual country and the average of all countries. Thus, average net external balances and average reserve holdings are determined simultaneously and tend to show a constant ratio at all levels of reserves. The ratio of

reserves to net balances therefore cannot tell anything about the demand for reserves and the adequacy of supplies. Grubel concluded that the usefulness of ratio analysis in projecting reserve demand is extremely limited and that more sophisticated theoretical and econometric techniques are required.

Since the middle of the 1960's, regression has become the popular technique used in the empirical estimation of the demand for international reserves. The major advantage of the regression technique over the ratio approach is that regression allows for the inclusion of more explanatory variables in the analysis and for more sophisticated specification of relationships with the dependent variables. In the following discussions we shall outline and discuss the different explanatory variables in the reserve demand function analyzed from the various econometric studies.

Some common notations used in the discussion are denoted as follows (or otherwise specified):

R = stock of international reserves;

σ = variability measure of the balance of payments;

IM = level of imports;

Y = level of income or gross national product;

m = propensity to import (IM/Y);

r = opportunity cost of reserve holdings;

M = money supply;

P = level of price;

α, ß = regression coefficients;

μ, ϵ = random error terms.

The **first** and most often used variable is some measure of payments variability. There are now at least a dozen studies that have used some measure of payments variability to explain reserve demand. Kenen and Yudin's work (1965) is among the earliest attempts. As a stochastic approach to the subject, Kenen and Yudin postulated that each country's reserve changes could be described by a simple Markov process

$$\Delta R_t = p\Delta R_{t-1} + \epsilon_t, \text{ where } 0<p<1 \text{ and } \epsilon_t \sim N(\epsilon, \sigma^2_\epsilon). \quad (2.2.1)$$

They estimated the parameters p, ϵ and σ^2_ϵ from monthly data for 14 countries over the period 1957-62 and then proceed directly to the estimation of a reserve demand function by a cross-section regression of average reserves on the estimated values of p, ϵ_t and σ^2_ϵ. They found the level of reserve holdings to be an increasing function of all three proxies of reserve instability (p, ϵ and σ^2_ϵ). Kenen and Yudin's statistical description of the behavior of reserves over time was challenged by other authors.

Thorn (1967) criticized Kenen and Yudin's claim by developing a theoretical argument that a country's demand for international reserves (R_t) is determined by a policy parameter, the target ratio of reserves to imports (rm_0), and the level of imports (IM_t):

$$R_t = IM_t rm_0. \quad (2.2.2)$$

The policy variable, rm_0, is not only affected by the size of past disturbances in the balance of payments but also takes into account such institutional and structural factors as a country's willingness to undertake adjustment policies rapidly in response to disturbances, the type of trade and payments regime being maintained, and the availability of secondary sources of liquidity. Changes in basic economic policy or structure result in changes in the target ratio. It is hypothesized that as long as a country's economic policies and structure remain relatively stable, it will maintain a relatively stable relationship between the level of its imports and international reserves. Equation (2.2.2) was transformed into a linear equation by rewriting it in logarithmic form and the target ratio of reserves to imports was set equal to the ratio that prevailed in 1960 so that:

$$\log R_{ti} = \alpha_0 + \alpha_1 \log IM_{ti} + \alpha_2 \log rm_{1960}. \quad (2.2.3)$$

Equation (2.2.3) was then fitted to Kenen and Yudin's cross-section data for 1957 and 1960 as well as for the additional data for 1954 and 1964. The regression results supported his hypothesis that there is a significant relationship between the target reserve ratio and the demand for international reserves. In their reply, Kenen and Yudin (1967) brought out the weakness of Thorn's procedure, stating that it contained a serious tautological element because of his reliance on observed levels of reserves. However, Archibald and Richmond (1971) again found little support for the Kenen-Yudin specification from monthly data for 14 countries over the period 1961-67.

Clark (1970) estimated an equation

$$R_t = \Gamma R^*_{t-1} + (1 - \Gamma)R_{t-1} + \epsilon_t \quad (2.2.4)$$

to test the hypothesis that countries responded to departure of R_t from the target level, R^*. His estimate of σ_ϵ was then used in a cross-country regression analysis to explain average reserves and proved highly significant. In Kelly's work (1970), the exogenous changes in the balance of payments were measured by the standard deviation of exports of goods and services over the preceding four years and the current year. Using data for 46 countries over 13 years, Kelly found again in his log linear regression a significant

positive result and an elasticity close to the predicted value of unity.

Frenkel (1974) used the trend-adjusted yearly disturbance in a country's stock of international reserves as a measure of the payments variability, σ. The value of σ for each year was estimated by computing the variance over the previous 15 years of the trend-adjusted annual changes of the level of reserves. The estimated equation is

$$\log R = \alpha_0 + \alpha_1 \log m + \alpha_2 \log \sigma + \alpha_3 \log IM + \mu. \quad (2.2.5)$$

With data covering 55 countries for 5 years, he found the cross-sectional estimate of σ has the expected (positive) sign and is significant at the 5 per cent level. However, Frenkel found that the demand for reserves in the LDCs is much less sensitive to σ than is the demand in the developed countries (elasticities of reserve demand with respect to σ range from 0.21 to 0.67 for 33 LDCs and from 0.78 to 0.92 for 22 developed countries). In his subsequent works (1978, 1980, 1981), with the new data base, the parameter estimates for the measure of variability of payments were reported significantly positive for developed countries and positive but nonsignificant for the developing countries between 1963 and 1977. He suggested this may reflect differences in: the character of the financial system, the financial organization, the role of government and the accessibility

to the world capital market. The insignificance of the coefficients of the variability measure was confirmed by Edwards (1983, 1984) in his estimation of a dynamic equation over the period 1965-72 for developing countries.

Bahmani (1987) found that, by correcting for serial correlation and heteroscedasticity, the OLS estimate of σ is significantly positive for both developed countries and developing countries. However, contrary to Frenkel's result, he found that the elasticity of payments variability with respect to reserve demand is higher for LDCs (0.35) than for developed countries (0.0906). The reserve demand equation

$$\log(R/P) = \alpha_0 + \alpha_1 \log(Y/P) + \alpha_2 \log\sigma + \mu \quad (2.2.6)$$

is estimated using quarterly pooled cross-section and time-series data over 1973-80 period for a group of 17 developed countries and 15 LDCs.

In her most recent study on the demand for international reserves, Landell-Mills (1989) showed a surprising result. Using quarterly pooled cross-section and time-series data on the entire sample of 24 developed and developing countries for 1978-82, the sign of the estimated coefficient of variability of past reserves in a generalized least-squares (GLS) and an OLS regression turned out to be negative. Reserves decline as reserve variability rises.

However, the estimate of reserve variability from an OLS regression adjusted for country-specific dummies is significantly positive (0.5629).

The **second** variable which is traditionally included in the reserve demand function is the level of imports, a scaling variable measuring the size of international transactions, or the level of real national income. The inclusion of this variable is justified by a qualified reference to the quantity theory of money and its international implications. It is argued that both the private individual and the public sector require cash to even out receipts and payments. In the case of the private sector, the volume of receipts and payments is measured by real national income, *GNP*, while in the case of governments the proper measure is imports. Heller (1968) and Olivera (1969, 1971) derived and generalized a square root law, analogous to the Baumol's (1952) inventory-theoretical approach to the demand for money.

Officer (1976) tested the validity of the square root law in the demand for international reserves. Using a sample of 25 countries for the period 1959-70, he found, in his regression results, that the theory's prediction of a transactions elasticity of demand for reserves within the interval 0.5 to 1 is satisfied for most countries in the sample, and that the theory's assumption that the variance

of changes in reserves is determined by the volume of international transactions is strongly confirmed. However, Heller's hypothesis, which stated that, due to economies of scale in financing an increased number of transactions, the elasticity of demand for transactions balances of international liquidity is between 0.5 and 1 is rejected by the evidence. Nearly all countries in the sample exhibit elasticities substantially above unity. Officer's results were further confirmed by the late studies.

Frenkel (1980) found that for a group of 22 developed countries and a group of 32 LDCs over the period 1963-77, the import elasticity of reserve demand is consistently positive and statistically significant. Landell-Mills (1989), in her multivariate regression analysis, showed that imports are consistently and strongly positive (import elasticities of reserve demand obtained from the different regression equations are between 0.53 and 1.25); the higher the level of foreign exchange needed for imports, the higher the level of reserves demanded.

Using real national income as a scaling variable of measuring transactions to test the validity of square root law of demand for reserves receives support from other studies. Saidi (1981), in a regression equation similar to Equation (2.2.6), found that the income elasticity of demand for reserves is stable across the exchange rate regimes and

insignificantly different from the expected value of 0.5. He claimed that real income is a more inclusive measure of the desired volume of transactions and it is also less likely to be subject to the simultaneity bias due to correlation between the value of transactions and the error term of the reserves equation, as in the case for imports. Edwards (1983, 1984, 1985) showed this scale variable is in most years between 1964 and 1972 significantly different from zero for LDCs. The significantly positive relationships between real national income and the reserve demand was also found by Bahmani (1987, 1988). He found that the elasticity of reserve demand with respect to real income is much higher for developed countries (0.806) than for LDCs (0.448).

The third variable which the literature suggests to be relevant to the reserve demand is the propensity to import. The rationale for the use of this variable stems from an application of the Keynesian model of the foreign trade multiplier. It has generally been argued that it is the marginal propensity that is theoretically relevant, but Frenkel (1978) derived the relationship using the average propensity to import, *API*, or relative size of the foreign trade sector, $m = IM/Y$. This has in fact invariably been used in empirical work. It has been included in their cross-section and time-series regressions by Kelly (1970), Iyoha (1976), Heller and Khan (1978), Frenkel (1974, 1978, 1980),

Levy (1983), Edwards (1983, 1984, 1985) and Landell-Mills (1989). The empirical results from these studies are mixed.

According to the Keynesian model of the foreign trade multiplier, an external disequilibrium that is induced by a decline in export earnings could be corrected by a decline in output proportional to the multiplier. The cost of output adjustment could be saved if the monetary authorities are able to run down their stock of international reserves, therefore enabling them to finance the external deficit. Since the foreign trade multiplier is inversely related to the marginal propensity to import, *MPI*, it is argued by Heller (1966) that the cost of not having reserves, and hence the demand for reserves, is inversely related to the *MPI*. Kelly (1970) tested the validity of Heller's argument. He used *API* as a proxy for *MPI* and found that the coefficient for the *API* is significantly positive. His explanation was that *API* is not representative of the *MPI*, or the marginal propensity has a positive influence on reserves because there are income fluctuations due to internal exogenous shifts in demand as well as external shifts. Frenkel (1974) and Iyoha (1976), argued that the *API* should rather be interpreted as a proxy for "openness" of the economy, thus measuring the extent to which the economy is vulnerable to external disruptions. Accordingly, the positive coefficient on the *API* reflects the fact that the reserve demand is a positive function of external

vulnerability. Moreover, a positive sign could also be taken as evidence that expenditure-switching policies play a more important role than expenditure-reducing policies in effecting adjustment.

Edwards (1984), in his estimation of a multivariate dynamic equation for 23 developing countries for the period 1965-72, found that the coefficient of the openness variable (*API*) is insignificant at 5 percent level, though the sign on that coefficient is positive. He concluded that while the country's scale is important for determining the amount of desired reserves, the degree of openness and payments variability plays a secondary role.

Contrary to the results in most of other studies, in which the *API* frequently turned out to be positive, Landell-Mills (1989) found that the sign on the coefficient of the average propensity to import (a proxy for *MPI* in her test) is consistently negative and the variable itself is consistently significant for the entire sample of 24 countries for 1978-82. Landell-Mills theorizes that reserves fall when the marginal propensity to import rises because this reduces the cost of deflation in terms of output of home goods.

The **fourth** variable to have been widely tested is the opportunity cost of reserve holdings. To find an adequate

measure for the opportunity cost of holding reserves is one of the most difficult problems in the empirical analysis of international reserves behavior. Various proxies for this variable have been tried. Kelly (1970) used income *per capita* as a proxy and found that its regression coefficient has the "wrong" (positive) sign. Iyoha (1976) applied a domestic discount rate as a proxy of the opportunity cost of holding reserves. He again found a significant positive sign on the estimated coefficient. Frenkel and Jovanovic (1981) used the domestic interest rate (government bond yield) as a proxy. They found a marginally significant negative elasticity of the demand for reserves with respect to its opportunity cost. The regression equation estimated by Frenkel and Jovanovic is as follows

$$\ln R = \alpha_0 + \alpha_1 \ln\sigma + \alpha_2 \ln r + \mu. \quad (2.2.7)$$

It was run on a sample of 22 developed countries over the period 1971-75 and 1963-72. OLS estimates for the interest elasticities of reserve demand, r, are constantly negative and significantly different from zero.

Edwards (1985) argued that the reason for the poor empirical support for the validity of the opportunity cost of holding reserves as a determinant in the reserve demand function is that the variable has been measured incorrectly. He argued that since international reserves are usually held

in the form of short-term interest bearing assets, the appropriate opportunity cost of holding them is *a net* cost, *r*, given by *gross* income forgone by holding reserves *minus* the return obtained from holding them. The *gross* forgone income was approximated by the interest rate at which a particular country could borrow in the international capital market and the return obtained on reserve holdings was approximated by the London Interbanks Offered Rate (LIBOR). Consequently, in the estimations of the reserve demand function the spread charged over LIBOR has been used as a proxy for the *net* opportunity cost of holding reserves. The regression equation has the following form

$$\log R_n = \alpha_0 + \alpha_1 \log Y_n + \alpha_2 \log m_n + \alpha_3 \log \sigma_n$$

$$+ \alpha_4 \log r_n + \mu. \quad (2.2.8)$$

Considering that the spread between the cost of borrowing and LIBOR will be affected by the international reserves to *GNP* ratio, the regression was conducted using two-stages least squares for each year. The empirical results obtained using data for a group of 17 developing countries for 1976-80 indicate that when this *net* opportunity cost is used in the analysis, a significantly negative coefficient is found.

Based on Edwards' work, Landell-Mills (1989) provided a further validity on the significant impact of the interest

rate on the demand for international reserves. It is argued that the reserve holdings of countries that also borrow on international capital markets are significantly affected by the cost of holding these assets. If a country's reserve holdings are assessed in terms of its international borrowing rate, international reserves are not only costly to hold, but also vulnerable to changes in international financial markets. In her study, the variable of the interest rate was defined as individual country spreads over the six-month LIBOR on syndicated loans to the sample countries, denominated in US dollars, plus the six-month LIBOR rate and less the three-month US Treasury bill rate. A sample of 24 countries were subdivided into a small industrial country group, a set of non-debt-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 sample period 1978-82 and 1978-86. Different equations were tested. In all cases, the opportunity cost of holding reserves has a consistently negative effect on reserve holdings. Moreover, reserves in countries that were to develop debt problems are more strongly affected by the interest rate variable than by any other variable.

A fifth variable used in some studies is the domestic money supply. The rationale for using domestic money supply as a determinant in reserve demand function lies on the

monetary approach to the balance of payments.[3] Early studies by Machlup (1966) and by Courchene and Youssef (1967) provided the evidence that there is a significant relationship between reserve demand and domestic money supply, though Worrell (1976) found that the coefficient is insignificant in his regression analysis. Frenkel (1978) suggested the integration of the demand for international reserves theory and the monetary approach to the balance of payments. von Furstenberg (1982) introduced monetary variables in his estimates of the demand for reserves. Levy (1983) attempted to combine the demand for international reserves with monetary equilibrium considerations.

Edwards (1984) estimated a dynamic equation that explicitly allows reserves movements to reflect the monetary authority's excess demand for international reserves, and the public's excess demand for money. It was hypothesized that if there is a stable demand for international reserves, domestic credit cannot be exogenous. Therefore, changes in domestic credit will partially depend on the relationship between actual and desired reserves. In a fixed exchange rate system, with other things given, if actual reserves are below their desired level, there will be a tendency to reduce domestic credit in order to increase actual holdings of international reserves.

3. For details of the monetary approach to the balance of payments, refer to Mundell (1968, 1971), Johnson (1972), Frenkel (1971) and Dornbush (1971).

Using data for 23 fixed exchange rate developing countries, a two-step testing procedure was conducted by Edwards. In the first step, a demand for money equation

$$\log M_{nt} = \alpha_0 + \alpha_1 \log Y_{nt} - \alpha_2 \log \pi_{nt}$$

$$+ \alpha_3 \log M_{nt-1} + \epsilon_t \quad (2.2.9)$$

was estimated for these countries using least squares on pooled cross-section and time-series for the period 1965-72. M_{nt} is real money demanded in country n in period t, Y_{nt} is real income, and π_{nt} is the actual inflation in country n during period t, and is used as a proxy for expected inflation. In the second step, the fitted values from this demand for money equation were used as a proxy for the money market disequilibrium. These values were then used in the estimation of the demand for reserves-cum-monetary disequilibrium equation

$$\log R_{nt} = \beta_0 + \beta_1 \log Y_{nt} + \beta_2 \log API_{nt} + \beta_3 \log \sigma_{nt}$$

$$+ \beta_4 \log R_{nt-1} + \beta_5 [\log M^*_{nt} - \log M_{nt-1}]. \quad (2.2.10)$$

The results from the multivariate log-linear equation showed that the positive coefficient of money market disequilibrium (0.299) is significant at 10 percent level, suggesting that

in these countries money market disequilibrium have had an important role in determining the movement of reserves through time, and therefore that domestic credit cannot be considered to be completely exogenous.

Other variables such as the lagged variable of reserve holdings, expected export receipts, LDC debt, changes in terms of trade, gold price and the effective exchange rate are occasionally used in the empirical studies. Iyoha (1976) introduced expected export receipts as an explanatory variable into a lagged adjustment model. The regression equation is as follows

$$R = \alpha_0 + \alpha_1 X^e + \alpha_2 \sigma^2 + \alpha_3 r + \alpha_4 p + \alpha_5 R_{-1}$$

$$+ \alpha_6 R_{-2} + \epsilon, \quad (2.2.11)$$

where expected export receipts, X^e, were estimated for each LDC for the period 1950-69, and the disturbance variance of the estimated equation was used as the variability of export receipts, σ. The opportunity cost of holding reserves, r, was proxied by the domestic discount rate. R_{-1} and R_{-2} are lagged variables of reserve demand. Equation (2.2.11) was tested using cross-section data from 29 LDCs in 1970 and performed very well.

Eaton and Gersovitz (1980) analyzed LDC borrowing and reserve holding behavior as part of a general equilibrium portfolio problem. Estimates of LDC debt and reserve demand and credit supply from a joint maximum likelihood estimation support that debt, along with reserves, serves a transaction role and that borrowing from both public and private sources has diminished the demand for international reserves.

von Furstenberg (1982) used changes in the terms of trade into a regression equation. It is assumed that countries' reserve holdings may be affected strongly by changes in the terms of trade over the two preceding years. Any deterioration in the terms of trade may reduce countries' reserve-imports ratio. A significantly positive relationship was found between the reserve-import ratio and the terms of trade for both industrial countries excluding US and oil exporting countries.

Bahmani (1984) introduced the gold price into the reserve demand function

$$\log R = \alpha_0 + \alpha_1 \log M + \alpha_2 \log \sigma + \alpha_3 \log PG + \mu, \quad (2.2.12)$$

where PG denotes the market price of gold. It was argued that a higher price of gold revalues the gold component of total reserves belonging to a country, making the authority feel wealthy, thus leading to a lower demand for

international reserves. By pooling cross-section and time-series data for 19 industrial countries over the period 1973-81, equation (2.2.12) was estimated. Bahmani found that the price of gold exerts a significantly negative effect on the demand for international reserves.

In a recent study, Bahmani (1988) investigated the supposition that a change in the exchange rate lowers the demand for international reserves by incorporating the real effective exchange rate into a reserve demand equation. The model was estimated for a sample of 13 industrial countries for which the effective exchange rate was available, using pooled quarterly data over the period 1973-85. The empirical results revealed that a change in the exchange rate indeed reduces the demand for reserves thus supporting the theoretical arguments of the previous studies.

(2.2.2) The stability analysis of the demand for international reserves.

If the early studies on the demand for international reserves emphasize the determination of reserve demand, then the recent work seems to have paid attention to the issues of structural changes in the demand for international reserves. The analysis is focused on the instability of reserve demand to the changes in the exchange rate regime,

to the oil price shocks, and to the other institutional changes in the economy.

Most statistical tests of stability have concentrated primarily on testing whether there was a change in the demand for international reserves in 1973, the year in which the international monetary system changed from a fixed exchange rate regime to a relatively more flexible exchange rate regime. One set of tests, undertaken initially by Williamson (1974), considered various measures of reserve use in the periods before and after that date. While Williamson found no strong evidence of any difference between reserve use in the two periods, later tests based on his methodology did indicate that adoption of a floating exchange rate system led to some reduction in the use of reserves (Suss, 1976). These tests, however, have the problem that by dealing only with the behavior of reserves, they implicitly invoke the *ceteris paribus* assumption that factors affecting reserves are constant. Clearly, variables such as the level of imports and the variability of balance of payments have not remained constant in the two periods. A different, more general test of the stability of the demand for international reserves was conducted by Frenkel (1978).

Frenkel (1978) analyzed the role of international reserves under a regime of pegged exchange rates and under a regime of managed floating. It is argued that in a system of

floating exchange rates a country's demand for international reserves will be substantially reduced. A demand function was explicitly specified (Refer to equation 2.2.5) and estimated for the periods up to the adoption of floating and thereafter. The sample of 22 developed countries and 33 developing countries was divided into two periods: the pegged exchange rate period (1963-72) and the flexible exchange rate period (1973-75). Statistical tests were then performed to determine if the functions were different in the relative weights assigned to the various explanatory variables. Two methods of stability analysis were tried. One method for analyzing the stability of regression coefficients over time is the dummy variable method, according to which two separate regressions may be pooled if the coefficients of the two regressions do not differ significantly from each other. Using this method, Frenkel found that the hypothesis that the cross-sectional regression coe ficients have remained stable over time cannot be rejected at the 5 percent level; for the LDCs, the annual regression coefficients seem to have been stable during the periods 1963-72 and 1973-75, but not between these two periods. The limitation of the dummy variable method rests on the fact that the comparison of regression equations takes into account only the relationship among individual coefficients.

A more formal analysis of structural change following the method proposed by Quandt (1960) was conducted by Frenkel. Both Quandt's log-likelihood ratio technique and the Chow test led to rejection of the hypothesis that regression coefficients remained stable before and after 1972. These tests allowed Frenkel to conclude that while there was some evidence of structural change in 1972, the extent of the structural change (in particular with reference to the behavior of the developed countries) has not been as large as might have been expected and the estimates for the managed float period indicated that " the patterns of country holdings and usages of reserves resemble to some extent the behavior prescribed for a regime of pegged exchange rates" (Frenkel, 1978, p. 111).

In a later study, Frenkel (1983) confirmed his previous findings. He also found that the behavior of developed countries with respect to reserve holdings underwent a more drastic structural change than that of developing countries when the exchange rate regime changed. Frenkel's interpretation of the relative stability of the patterns of reserve holdings is that "economic behavior seems to have been more stable than legal arrangements" (Frenkel, 1983, pp. 81).

Heller and Khan (1978) examined the question of whether there was a shift in reserve demand functions in 1973, and

if so, in which direction. Their estimating equation was similar to that of Frenkel (1978), but with different country groupings. i.e., the world; the world, excluding oil exporting countries; the world, excluding oil exporting countries and the United States; industrial countries; industrial countries, excluding the United States; and the LDCs. A two-stage testing procedure was conducted. In the first stage, they utilized the time-series methodology of Box and Jenkins (1970) and estimated autoregressive integrated moving average (ARIMA) models for reserves of the six country groupings. More specifically, after transforming the level of reserves R_t into a stationary series R^*_t, where $R^*_t = \log R_t - \log R_{t-1}$, they fitted the ARIMA model described as:

$$\phi(L)R^*_t = \theta(L)v_t, \quad (2.2.13)$$

where $\phi(L)$ and $\theta(L)$ are polynomial functions of the lag operator, L, and v_t are serially uncorrelated, white noise errors. The residual, $\hat{v}_t$, is obtained after estimating equation (2.2.13), and the squared values, $\hat{v}^2_t$, are interpreted as a measure of the variability of reserves.

In the second stage, they estimated the following equation with a polynomial lag function imposed on $\hat{v}^2_t$:

$$\log R_t = \alpha_0 + \alpha_1 \log m_t + \alpha_2 \log IM_t$$

$$+ \alpha_3 \sum_{i=c}^{k} \alpha_i \log v^2_{t-1} + \mu_t. \quad (2.2.14)$$

The α_i are the weights attached to the current and lagged values of $\hat{v}^2_t$, and k represents the number of lag periods to be considered. The model was tested for six different country groups using quarterly data over the period 1960-76. By the use of the Quandt's log-likelihood ratio test, Heller and Khan pinpointed the timing of the occurrence of any structural change. They then estimated the reserves equation through 1972 and used it to predict the level of reserves for the period 1973-76. These predictions are compared with both the actual values of reserves in the subperiods and forecasts obtained from the ARIMA model fitted up to the end of 1972. A comparison between the ARIMA forecasts and the actual values should indicate whether the change in the exchange rate system has resulted in an increase or a decrease in the level of reserves relative to the level indicated from their past patterns of behavior.

The result of Heller and Khan's stability test indicated that there was clearly a shift in the demand for international reserves by industrial countries when the move to the floating rate system occurred. However, the change was not sudden and appeared to have taken place toward the end of 1973, rather than in the earlier part of the year when the actual change to floating occurred. Insofar as non-

oil developing countries were concerned, the move toward more flexibility in exchange rates did not appear to affect their behavior in any significant manner. This group of countries seems to have had a shift in their demand function in the period 1971-72 rather than at the time of the inception of managed floating. Heller and Khan suggested on that non-oil developing countries did not change their basic behavior pattern in a statistically significant manner may be attributed to the fact that for most of them the exchange rate regime did not change, as they continued generally to follow a policy of pegging their currency to another major currency. Moreover, Heller and Khan found that after the structural change in 1973, the functions explaining reserves behavior for both industrial and developing countries continued to be stable in the period of managed floating.

Finally, it was observed that there was some empirical evidence supporting the hypothesis that the demand for international reserves should be reduced as exchange rates become more flexible in the case of industrial countries. Surprisingly, the reverse seemed to hold true for non-oil developing countries. Their holdings of reserves during the floating rate period have tended to be higher than the levels that would have been implied by their behavior during the fixed rate period. Heller and Khan suggested that the greater degree of uncertainty and variability in these

countries' balance of payments resulted from being pegged to a floating currency. This may be the explanation.

Saidi (1981) presented quarterly evidence on the demand for international reserves under alternative exchange rate regimes by drawing on Canadian experience over the period 1950-76. He found that the evidence points to a structural change in the demand for reserves occurring during 1961-62 rather than 1972-73 as far as the Canadian experience was concerned. In particular, the flexible exchange rates period ended in the third quarter of 1961 and was followed by a transitional period, while the fixed exchange rates period began in the third quarter of 1962. Saidi indicated that the structural change took the form of a relatively larger responsiveness of reserves holdings under fixed exchange rates to a measure of payment variability in transactions. It was shown that the demand for reserves is characterized by economies of scale with respect to the volume of transactions that are invariant to the exchange rate regime. Finally, the evidence that there is a structural change in the demand for reserves occurring around the period 1972-73 was not found.

In a recent study by Bahmani (1988), the relationships between the oil price shocks and the stability of the demand for international reserves has been examined. It is argued that the changes in the exchange rate regime in 1973 which

coincided with a sharp increase in the price of oil could have resulted in a jump in the value of imports and the variability of the balance of payments. These would alter the reserve holding behavior of oil importing countries and therefore cause a structural shift in the reserve demand function.

Using Quandt's log-likelihood ratio technique, Bahmani first detected the switching point and then used the Chow test along with a dummy variable procedure to provide evidence of a structural shift in the reserve demand function. The regression equation, similar to those used by Heller and Khan (1978) and Frenkel (1978), was estimated for a sample of 19 developed countries and 17 LDCs, using pooled time series and cross-sectional quarterly data from the period 1973-85 (a period in which there was no change in the exchange rate regime, but an oil price shock occurred). Bahmani found the evidence that the reserve demand by developed countries (LDCs) experienced a structural shift toward the end of the first quarter of 1980 (1981). He then suggested that the structural shift in 1973 could have also been caused by the 1973 oil price shock.

Edwards (1983) argued that the demand for international reserves will be different in countries that rely exclusively on expenditure-reducing policies, and in countries that are willing to use expenditure-switching

policies to solve temporary payments problems. In general, the countries that are willing to use the exchange rate as a tool for correcting transitory payments imbalances would hold less reserves as a buffer stock to finance those payments problems.

In his study, Edwards analyzed the demand for international reserves by LDCs over the period 1964-72, 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, where the 23 "fixed rate countries" were defined as those that adjusted their parities less than 1 percent a year and the 18 "devaluation countries" were defined as those that had devaluations of at least 10 percent. The results obtained from a regression equation (similar to that used by Frenkel (1978)) using a dummy variable indicate that both groups of countries have different demand functions for international reserves, with devaluation countries holding, on average, less reserves. Furthermore, the results indicate that the reserve demand function for those LDCs that have maintained a fixed exchange rate is very similar to estimates previously obtained by Frenkel (1980) for developed countries.

(2.2.3) Studies on the dynamics of adjustment in reserve demand.

While most studies have identified the key variables which determine the demand for international reserves, some work on the dynamics of adjustment has found that the speed at which actual reserves adjust toward desired or target reserves is very slow and is often not significantly different from zero (Clark, 1970a, Iyoha, 1976).[4] If correct, these findings cast some doubt on the usefulness of the cross-sectional studies for analyzing the adequacy of international reserves, since evidence of a stable long-run demand function is of little value if it cannot be used to show that discrepancies between actual and desired stocks are eliminated over time.

Frenkel (1983) drew a distinction between short-run and long-run demand functions and examined the speed of adjustment of reserves to their long-run desired levels. He constructed a framework which allows the dynamic adjustment of international reserves to reflect both the central bank's excess demand for reserves and the public's excess demand for money. The general form of the reserve-adjustment equation is as follows:

$$\ln R_{it} = \alpha(\ln R^*_{it} - \ln R_{it-1})$$

4. The speed of adjustment is typically obtained by estimates of the coefficients on lagged dependent variables in these studies.

$$+ \beta(\ln M^*_{it} - \ln M_{it-1}) + \mu_{it}, \quad (2.2.15)$$

where R^*_{it} and M^*_{it} denote, respectively, the desired levels of reserves and money for country i at period t, and where α and β denote the speed of adjustment of reserves to disequilibrium in holdings of reserves and money, respectively.

The target levels of reserves and cash balances are estimated from equations (2.2.16) and (2.2.17).

$$\ln R_{i.} = \beta_0 + \beta_1 \ln \sigma_{i.} + \beta_2 \ln Y_{i.} + \beta_3 \ln m_{i.} + \mu i \quad (2.2.16)$$

$$\ln (M/P)_{i.} = \tau_0 + \tau_1 \ln Y_{i.} - \tau_2 r_{i.} + \epsilon_{i.} \quad (2.2.17)$$

A two-stage estimation procedure was conducted. The first stage of the estimation procedure involves estimating equations (2.2.16) and (2.2.17) from the sample averages of the time-series and cross-sectional data of 22 developed countries. In the second stage, the estimated parameters obtained from stage one are used to construct estimates of the target levels of reserves and money for country i at period t. These magnitudes are estimated as

$$\ln R^*_{it} = \beta_0 + \beta_1 \ln \sigma_{it} + \beta_2 \ln Y_{it} + \beta_3 \ln m_{it} + \mu_i \quad (2.2.18)$$

$$\ln M^*_{it} = \tau_0 + \tau_1 \ln Y_{it} - \tau_2 \ln r_{it} + \ln P_{it} + \epsilon_i \quad (2.2.19)$$

where the coefficients β_i (i = 0, ..., 3) and τ_i (i = 0, ..., 2) are the estimates of the corresponding coefficients in equation (2.2.16) and (2.2.17). Using equations (2.2.18) and (2.2.19) to construct the target levels of reserves and cash balances, the estimates of the speed of adjustment in equation (2.2.15) are reported to support the specification in the adjustment equation ((2.2.15). It is demonstrated that the actual changes in reserves are influenced by both the central bank's excess demand for reserves and the private sector's excess demand for money. The speed of adjustment is found higher than obtained by estimates of the coefficients on lagged dependent variables. Somewhat surprisingly, the estimated speed of adjustment is higher during the flexible exchange rate regime than during the pegged-rate regime.

(2.2.4) Comments on the empirical studies of the Demand for International Reserves.

The review of the empirical literature on the demand for international reserves has shown that a country's reserve demand is not only determined by a set of variables but also affected by the structural changes occurring in the economy. In the past, various authors have tried to justify the inclusion of different variables in the reserve demand functions. These variables are: (1) variability measure of

the balance of payments; (2) scaling variables such as the level of imports or the level of national income; (3) average (or marginal) propensity to import; (4) opportunity cost of holding reserves; (5) domestic money supply or money market disequilibrium; (6) other variables such as the lagged variable of reserve holdings, expected export receipts, LDC debt, terms of trade, gold price and the effective exchange rate. Elements of time and the speed of adjustment have also been introduced into the analysis.

Regression techniques for estimating the reserve demand have been extensively applied in almost all the studies we have investigated. The applicability of the techniques are widely recognized. Among them, ordinary least-squares (OLS) is used most frequently. Others like generalized least-squares (GLS), two-stage least-squares (2SLS), and integrated autoregressive-moving average (ARIMA) methods have also been used. Dummy variables are applied to take account of the cases of country specificity and of the introduction of some institutional or policy parameters into the regression analysis. Pooled cross-section and time-series data have been employed in the studies. The monthly, quarterly, or yearly data are available in International Financial Statistics or other publications. The tests have been conducted with respect to different country groups such as industrialized and developing countries. The sample periods range from 1950 to 1986.

Empirical results obtained have shown that the impact of various explanatory variables upon the demand for international reserves and their statistical significance in explaining reserve demand are, to a certain extent, mixed and inconclusive. Table 2.1 gives a summary of the features of major empirical studies (using regression techniques) on reserve demand reviewed here. The results of these studies are also indicated.

The stock of reserves (including a country's foreign exchange holdings, reserve positions in the Fund, SDRs, and gold or the total reserve minus gold) is constantly used as a dependent variable with few exceptions. The use of the stock of reserves rather than the level of reserve adequacy as a measure of countries' reserve demand is because the concept of reserve adequacy is now difficult to define. First, the exchange rate system is less precise and so the need for reserves for intervention purposes is less determinate. Second, the substantial growth in international capital movements both adds to potential exchange rate pressure (implying a greater need for reserves) and offers an alternative way of financing current account deficits (implying a lesser need). Finally, some countries have substantial capacity to borrow reserves in the international banking and capital market. This will affect countries' behavior towards reserve holdings.

Table 2.1 Features of Major Studies on Demand for Reserves[1]

Study	Main Regression	Dependent Variable	Relevant Explanatory Variables (Results in Parentheses)[2]	Countries[3]	Frequency	Time Period
Kenen & Yudin (1965)	Cross-section	Reserves	Proxies of reserve instability: 1-p (+,S) 2-ϵ (+,S) 3-σ_ϵ (+,S)	14 DCs	Monthly	1957-62
Thorn (1967)	Cross-section	Reserves	1-Imports (+,S) 2-Reserve-Imports ratio in 1960 (+,S)	14 DCs	Annually	1954 1957 1962 1967
Kelly (1970)	Cross-section & time-series	Reserves	1-Standard deviation of exports (+,S) 2-*API* (+,S) 3-Opportunity cost of funds (+,S)	46 DCs & LDCs	Annually	1953-65
Clark (1970)	Cross-section	Reserves	1-Time (+,S) 2-Reserves at t-1 (+,S)	38 DCs & LDCs	Monthly	1958-67
Archibald & Richmond (1971)	Time-series	Reserves	1-Time (M,S) 2-Reserves at t-1 (+,S)	14 DCs	Monthly	1961-67
Frenkel (1974)	Cross-section Cross-section & time-series Pooled	Reserves	1-*API* (+,S) 2-σ (+,S) 3-Imports (+,S)	22 DCs & 33 LDCs	Annually	1963-67
Officer (1976)	Time-series	Reserves	1-Value of international transaction (M,S*)	25 DCs & LDCs	Annually	1959-70
		Commercial bank's Foreign exchange	1-Value of international transaction (+,S*)			

Table 2.1 (Cont.)

Iyoha (1976)	Time-series	Reserves	1-Expected export receipts (+,S) 2-Variability of export receipts (+,S) 3-Interest rate on foreign exchange holdings (+,S) 4-*API* (+,S) 5-Reserves at t-1 (-,NS) 6-Reserves at t-2 (+,S)	29 LDCs	Annually	1970
Worrell (1976)	Time-series	Reserves	1-Change in money supply (+,NS) 2-Export earnings (+,NS) 3-Capital inflow from abroad (+,NS) 4-Reserves at t-1 (+,S)	Jamaica	Monthly	1968-71
Frenkel (1978)	Cross-section & time-series	Reserves	1-σ (+,S) 2-Imports (+,S) 3-*API*(M,S)	22 DCs & 32 LDCs	Annually	1963-75
Heller & Khan (1978)	Time-series	Reserves	1-*API* (-,S) 2-Imports (+,S) 3-σ (+,S*)	Six country groupings	Quarterly	1960-76
Frenkel (1980)	Cross-section Cross-section & time-series Pooled	Reserves	1-σ (+,M) 2-Imports (:,S*) 3-*API* (+,M)	22 DCs & 32 LDCs	Annually	1963-77
Frenkel & Jovanovic (1981)	Cross-section & time-series Pooled	Reserves	1-σ (+,S) 2-Opportunity cost of holding reserves (gov't bond yield) (-,S)	22 DCs	Annually	1971-75 1967-72

Table 2.1 (Cont.)

Saidi (1981)	Time-series	Real reserves	1-Real income (+,S) 2-σ (+,S)	Canada	Quarterly	1950-76
von Furstenberg (1982)	Time-series Cross-section & time-series	Reserve-imports ratio	1-imports (M,S) 2-terms of trade (+,S) 3-Exchange rate (+,NS) 4-Gold reserve percentage (M,S) 5-M2 growth (+,S) 6-US unemployment rate (M,S)	Three country groupings	Quarterly	1973-81
Edwards (1983)	Cross-section	Reserves	1-*GNP* (+,S) 2-*API* (+,S) 3-σ (+,S) 1-*GNP* (+,S) 2-*API* (+,NS) 3-σ (+,NS)	23 Fixed-rate LDCs 18 Devaluation devaluation LDCs	Annually	1964-72
Frenkel (1983)	Cross-section & time-series Pooled	Reserves	1-σ (+,S) 2-*GNP* (+,S) 3-*API* (+,S)	22 DCs & 32 LDCs	Annually	1963-79
Levy (1983)	Time-series	Reserves	1-σ (+,S) 2-Imports (+,S) 3-*API* (-,S) 4-Reserves at t-1 (+,S)	Turkey	Quarterly	1973-77
Bahmani (1984)	Cross-section & time-series Pooled	Reserves	1-Imports (+,S) 2-σ (+,S) 3-Market price of gold (-,S)	19 DCs	Quarterly	1973-81
Edwards (1984)	Cross-section & time-series Pooled	Reserves	1-*GNP* (+,S) 2-*API* (+,NS) 3-σ (+,NS) 4-Reserves at t-1 (+,S) 5-Money market disequilibrium (+,S)	23 LDCs	Annually	1965-72

Table 2.1 (Cont.)

Edwards (1985)	Cross-section	Reserves	1-*GNP* (+,S) 2-*API* (M,NS) 3-σ (+,NS) 4-Net opportunity cost of holding reserves (-,S)	17 LDCs	Annually	1976-80
Bahmani (1987)	Cross-section & time-series Pooled	Real Reserves	1-Real *GNP* (+,S) 2-σ (+,S) 3-Reserves at t-1 (+,S)	17 DCs & 15 LDCs	Quarterly	1973-80
Bahmani (1988)	Cross-section & time-series Pooled	Real Reserves	1-Real *GNP* (+,S) 2-σ (+,NS) 3-Real exchange rate of domestic currency (-,S)	13 DCs	Quarterly	1973-85
Landell-Mills (1989)	Cross-section & time-series Pooled	Reserves	1-Variability of reserves (M,M) 2-*API* (-,S) 3-Imports (+,S) 4-Net rate (-,S)	24 DCs & LDCs	Quarterly	1978-82 1978-86

1. All these studies were conducted by using regression techniques.
2. The results of estimated coefficients are indicated by the symbols in parentheses, where: + = positive; - = negative; S = significant; NS = non-significant; S^* = vary few cases are non-significant; M = mixed result.
   API = Average propensity to import;
   σ = Variability measure of balance of payments;
   GNP = Gross national product.
3. DCs = Developed countries; LDCs = Less developed countries.

As to the explanatory variables, in most of the studies, there is a general agreement that ıe level of imports or the level of real *GNP*, the variability measure of the balance of payments, and average propensity to import are the three major determinants in the reserve demand functions. Latter studies have also shown the importance of the opportunity cost of holding reserves and the domestic monetary conditions in the reserve demand equation.

GNP and the level of imports have been shown consistently to exert a significantly positive effect on the demand for international reserves in almost all studies, as the theory predicted.

While a significantly positive relationship between the variability measure of the balance of payments and the reserve demand has been found in most of the studies, a recent study by Landell-Mills (1989) showed an inverse relationship in which reserves decline as reserve variability rises. Using the actual changes in reserves as a measure of variability incurs a major drawback. This is because the actual changes in reserves need not provide the exact measure of the variability since countries may use some other policies. In a time-series study, the effect of national policies on this variable cannot be ignored. Further effort can be devoted to adding theoretical and

statistical refinement of the measures of payments variability.

The effect of propensity to import on reserve demand is mixed. Different results have different interpretations. A positive coefficient of *API* with respect to reserve demand was explained by taking *API* as a proxy of "openness" of the economy (Frenkel, 1974, 1983, Iyoha, 1976, and others). On the contrary, studies using *API* as a proxy of marginal propensity to import suggested a negative sign on the regression coefficient of *API*. This has been found by Heller and Khan (1978), Levy (1983) and most recently, Landell-Mills (1989). Moreover, the significance of *API* in the determination of reserve demand varies with the different country groups. While the regression coefficient of *API* is found significant in most of the reserve demand functions for developed countries, it is found insignificant in those functions for LDCs (Edwards, 1983, 1984, 1985). Further studies are needed before any conclusion can be made.

The cpportunity cost of holding reserves as a determinant of a reserve demand function has received empirical support from the studies in the 1980's (Frenkel and Jovanovic, 1981, Edwards, 1985, Landell-Mills, 1989), though the early studies failed to provide a support (Kelly, 1970, Iyoha, 1976). This is due in large part to the improvement in the technical specification of the

opportunity cost of holding reserves. The monetary approach and its international application had not been extensively tested empirically until the works of Frenkel (1983) and Edwards (1984). A significantly positive coefficient of money market disequilibrium in a dynamic reserve demand function for 23 LDCs may suggest that money market disequilibra have had an important role in determining the movement of reserves through time. The soaring price of gold in the 1970's has been one of the most important features of the international financial market. Bahmani's (1984) findings that the market price of gold exerts a significantly negative effect on the reserve demand adds to the literature. The last issue worth mentioning concerns the LDC debt. Eaton and Gersovitz (1980) provided the evidence that there is a significant relationship between the LDC debt and their reserve demand. As the debt crisis in LDCs has continued, the relationship between the debt accumulation and individual countries' reserve demand behavior needs to be further studied. Other variables such as the lagged variables of reserve holdings, changes in the terms of trade, external rate of domestic currency have received some empirical support.

Empirical results obtained from the past indicate that the impacts of some explanatory variables upon reserve demand are quite different with respect to different country groups. Frenkel (1974) found that the demand for reserves in

LDCs is much less sensitive to the variability measure of the balance of payments than is the demand in developed countries. Later, Frenkel (1980) showed an insignificant parameter estimate for the same variable. This was confirmed by Edwards (1983, 1984). *API* as an explanatory variable was shown to be consistently significant in the reserve demand functions for developed countries. However, it turned out to be insignificant in a reserve demand function for LDCs (Edwards, 1983). These differences may be a reflection of the institutional differences as well as policy differences between these two country groups. The reserves needed to finance the payments deficits will depend not just on the historic pattern of disturbances in a country's exchange market but also on the automatic adjustment mechanisms restoring equilibrium when the external balance is upset. The demand for reserves also depends on policies chosen to eliminate a payments imbalance and the speed of adjustments. Further empirical investigations should be directed towards these issues.

The empirical results from the stability analysis on the demand for international reserves receive some support. After structural shifts in the conditions of reserve markets such as the advent of flexible exchange rates and the financial market disturbance of the early 1970's, it was widely expected that countries would make a large adjustment in the level of their reserve holdings. Heller and Khan

(1978) provided some evidence that there was a shift in the demand for international reserves by industrial countries when the move to the flexible exchange rate system occurred. However, they found that the move towards more flexibilities in exchange rates did not appear to affect non-oil developing countries' reserve demand behavior in any significant manner. Other studies show a relatively stable long-run demand for reserves since the 1960's (Frenkel, 1978, Saidi, 1981). The stable demand for reserves indicates that although the termination of the obligation to defend fixed exchange rates has changed the rationale for holding international reserves, it does not bring about a substantial decline in the overall demand for reserves, as countries with flexible exchange rate systems have continued to intervene in foreign exchange markets. Other countries have managed their exchange rates or have pegged their currencies to another currency or to a currency basket. In addition, the demand for reserves continues as many countries attempt to protect themselves from the uncertainties arising from larger payments disequilibrium and exchange rate fluctuations, and to demonstrate their creditworthiness so as to preserve access to financial markets.

Finally, the analysis of the dynamics of adjustment to disequilibrium reserve holdings shows that changes in the holdings of international reserves reflect both the central

bank's excess demand for reserves and the public's excess demand for money.

Insofar as the mixed empirical results on the reserve demand are concerned, several issues from the previous studies arise. The first is the empirical difficulties of the reserve demand functions. All these studies have generally concentrated on the formulation and estimation of reserve demand functions. The supply of international reserves has been typically dealt with by assuming that it is always elastic enough to meet the demand. However, when one attempts to estimate the demand side without taking into account the supply equation, the results may embody a simultaneous equation bias. This problem has been dealt with by building a simultaneous equation model of demand for reserves and supply of reserves where the level of reserves and the price of gold were treated as endogenous variables (Bahmani, 1985b).[5] The second problem is that these studies have used pooled cross-section and time-series data. By employing the ordinary least squares method to estimate the reserve demand equation, these studies have assumed that the error terms are homoscedastic across countries and serially

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5. The reserve demand equation was estimated using two-stage least squares (2SLS) and ordinary least squares (OLS) methods on a group of developed countries. It was concluded that OLS provided highly significant coefficients which were absent when the 2SLS method was used. This findings supported the argument put forward by Crockett (1978, p. 14) who concluded that "... it is not too misleading to say that the supply of reserve currencies responds to changes in the demand to hold them with something approaching perfect elasticity."

uncorrelated within each country. To the extent that these two assumptions are not satisfied, the results of regression estimation would be biased. Therefore, a comparative study using different equations and testing procedures and testing for different country groupings is needed. Also, previous studies have not fully taken into account the new developments in the international financial markets. On the one hand, the rapid development of the international banking system increases the international liquidity which provides an alternative for individual countries to finance their external imbalances. On the other hand, the huge accumulations of developing countries' foreign debts and their worsening debt-service abilities have generated an additional need for international reserves in these countries. The impact of these new developments on the countries' reserve demand requires further studies and empirical investigation. Finally, the issue of demand for international reserves in centrally planned economies (CPEs) has been given little attention and no empirical work with respect to these economies has been undertaken. As CPEs are transferring to market economies or undergoing structural reforms, the analysis of their reserve demand behavior and the impact of this transition on the world demand for international reserves is of particular interest.

(2.3) Summary.

This chapter reviewed the theories and empirical studies of the demand for international reserves with particular emphasis on discussions of the empirical evidence on reserve demand. It has been shown that the traditional theories of the optimizing analysis based on the cost-benefit approach are applicable to studies of the demand for international reserves. Empirical studies on the identification of the determinants in reserve demand functions, the stability of countries' reserve demand, and the dynamics of adjustment to disequilibrium reserve holdings have provided some support to the theories, although the empirical results are mixed.

Generally speaking, the literature on the demand for international reserves is relatively new and open to further study. The following chapters attempt to integrate and extend the insights of the previous work surveyed here by conducting a comparative study on the demand for international reserves, and by analyzing these issues in the context of the new developments over the past three decades.

Chapter 3. A Comparative Approach to the Demand for International Reserves

Reserve demand behavior among developed, developing, and centrally planned economies is quite different due to the structural and institutional characteristics of these economies. In this chapter, a theory of reserve demand using a comparative approach will be presented and empirically investigated. Section (3.1) will present the theory of demand for international reserves in a comparative framework. The model, testing procedure, and empirical results are provided in Section (3.2). Finally, Section (3.3) summarizes the empirical evidence supporting the theory of demand for international reserves.

(3.1) The Demand for International Reserves: A Comparative Approach.

A country's optimum reserve demand is determined where the marginal cost of holding reserves equals the marginal benefits from reserve holdings, which is a tradeoff between the financing and adjustment of the balance of payments deficit. This section first discusses the relationships between adjustment, financing, and reserve demand in Section (3.1.1). Section (3.1.2) will provide a comparative framework of the theory of demand for international reserves.

(3.1.1) Adjustment, financing, and the reserve demand.

In principle, a payments deficit may initially be financed by running down a country's reserve holdings and by international borrowing or be corrected through the pursuit of adjustment policies, or be repressed by controls. The economic theory underlying the choice between various combinations of financing and adjustment speed has been developed in the literature (see Chapter 2).

It is generally agreed that international reserves permit a country to pursue domestic policy goals in the face of a temporary balance of payments deficit, and they also allow the country to "buy time" in order to adopt appropriate policies if the payments must be either financed or eliminated by adjustments within the economy. The mechanism by which the availability of reserves affects governments' policies is through changing the perceived relative costs of different means of responding to balance of payments disturbances. A decision fixing the level of reserves necessarily entails a specific rate of adjustment. These two are interdependent. Assume that a country wishes to maintain a given probability of running out of reserves, and that it can accomplish this goal with different combinations of reserve levels and rates of adjustment. These two policy instruments entail a cost for the country

of a different kind: larger reserves reduce the level of income, whereas a higher speed of adjustment increases the variability of income. By assuming that the welfare of the country is a function of both the expected value and the variability of income, the government maximizes its utility (welfare) subject to the tradeoff between lower income levels implicit in larger reserve holdings and greater income fluctuations generated by exogenous external disturbances when reserve holdings are small. The optimum speed of adjustment and the optimum level of reserves as well as the various determinants of reserve demand are therefore derived in this cost-benefit framework.[6]

The optimum combination of financing and adjustment is achieved where the marginal rate of substitution between income level and income variability equals their marginal rate of transformation. Given a deficit of similar size, however, this may not lead to the same combination of policies in a less developed or a centrally planned economy as it would in a developed one.

There are a number of different actions which can be undertaken to achieve the desired change in the level of reserves. These can be divided into expenditure-switching and expenditure-changing policies. The former category

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6. Refer to the Clark (1970), Kelly (1970) and Grubel (1977) models in Chapter 2.

redirects current spending away from foreign-produced goods and toward domestically-produced goods primarily by means of a change in relative prices. The main policy instruments in this category are devaluation, tariffs, quotas, and exchange control. The latter category involves policy instruments such as changes in tax rates, government expenditures and interest rates. 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.

A country's utility maximization behavior is constrained by its own institutions. This includes the basic economic structure, the policy effectiveness, the exchange rate arrangement, the characteristics of the financial systems and the financial organizations, etc. Countries' optimizing solution to the demand for international reserves may be different due to their structural conditions and institutional arrangements.

Several characteristics of less developed countries (LDCs) and centrally planned economies (CPEs) are relevant to our analysis. First, LDCs encounter relatively high financing costs. They are encouraged to make relatively greater use of adjustment. Since the capacity for short-term adjustment is relatively lower in these economies than in

developed countries and the cost of adjustment higher, it might be expected that for these reasons LDCs will be more inclined to try to finance a deficit than correct it. However, these economies may be precluded from using the theoretically optimum combination of financing and adjustment by the constrained availability of finance, thus they may be forced to adjust more rapidly than they would wish. Furthermore, the rudimentary nature of financial systems and the large perceived uncertainty in most of these countries do not facilitate the use of monetary policy as a means of inducing capital inflows to offset current account deficits. The required level of reserve holdings for LDCs is therefore higher.

Secondly, the foreign trade of LDCs, on average, has not been greater in proportion to *GNP* than that of the DCs. However, the instability in export earnings of LDCs as a group has been much greater than that of the developed countries. Export instability is a result of fluctuations in the prices of, the demand for and supply of, primary commodities, and the level of export concentration in these products. Many primary products are subject to a high degree of instability, and a feature of LDCs is their high degree of export concentration in a few primary products. Furthermore, the terms of trade of LDCs have been subject to a long run deterioration since most LDCs are essentially exporters of primary products and importers of manufactured

final goods, and that the primary products' prices have fallen relative to those of manufactured goods. Since most LDCs exert little control over either the demand or supply determinants of their commodity terms of trade these become a largely exogenous variable in the short run.[7] These structural factors are the major causes of the balance of payments disequilibrium in LDCs, increasing their demand for reserves.

Thirdly, CPEs share many of the features of LDCs. Moreover, in the past, all the CPEs practiced over-full-employment planning which means that planned demand exceeds available supplies. Under these circumstances, as with inflationary pressures in industrial countries, domestic producers and consumers compete for exportables and demand more imports, and in the process create pressures which cause deterioration in the balance of payments. The situation can be demonstrated diagrammatically as in Figure 3.1. Assume a nation on an actual transformation curve T_a, with domestic output at Y_a, and an after-trade equivalent absorption A_a. Assume that this country planned to be on T_p with before-trade goal of Y_p and after-trade goal of A_p. If the country actually ends up at A_a instead of the planned A_p, it will experience excess demand equal to *BD* of exportables + *CE* of importables. Plans may be fulfilled by either unhoarding the country's international reserves or

7. See MacBean (1966), Letiche (1973) and Bird (1988).

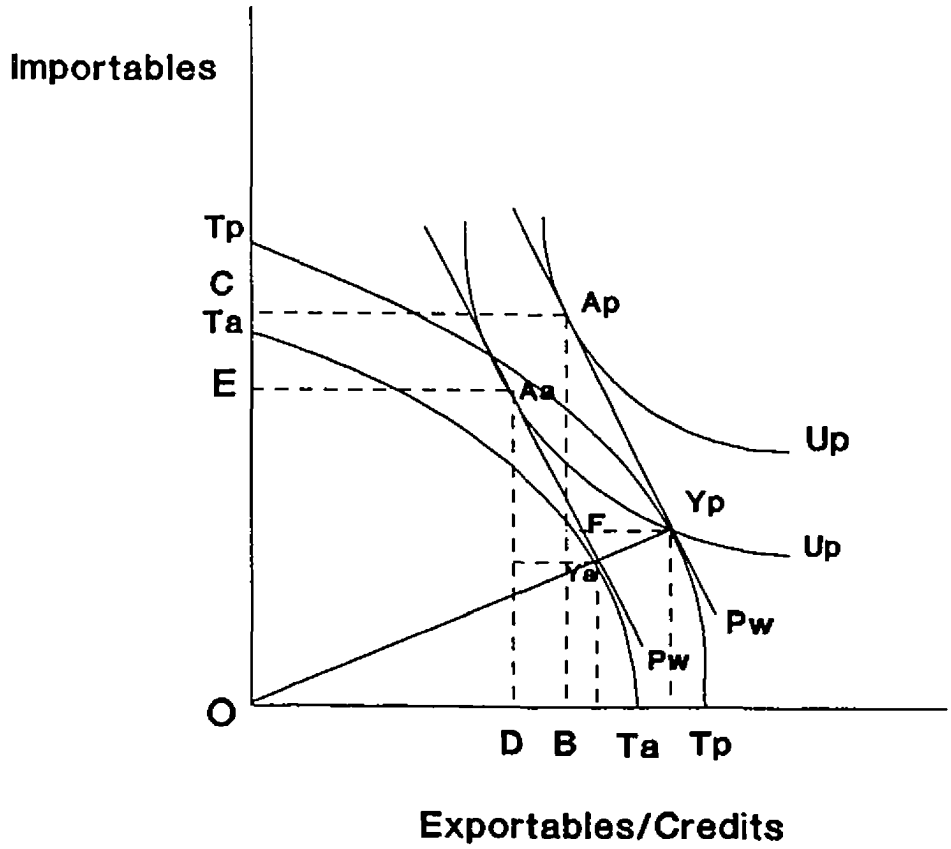

Fig. 3.1

obtaining credits of an amount measured as FY_p of exportables. Considering the lack of accessibility to international capital markets by the CPEs, the use of international reserves becomes the primary source of financing the balance of payments deficit and therefore increasing the demand for reserves.

The high cost of financing and the lesser accessibility to international capital markets combined with the high cost of adjustment as a result of the institutional and structural characteristics in LDCs and CPEs, lead to the expectation of a higher demand for international reserves by these economies.

(3.1.2) A comparative framework for the theory of reserve demand.

Basic Model. Generally speaking, a country desires to maintain a target level of reserves, R^*. Its monetary authority is assumed to adjust its current stock of reserves in proportion to the discrepancy between actual and desired reserves. Assume a small country whose balance of payments is in temporary disequilibrium. Random disturbances, generated outside the economy, cause variations in the level of reserves. The country is committed to keep its exchange

rate within a certain range.[8] The dynamic adjustment equation can be written as

$$R_t - R_{t-1} = \delta(R^* - R_{t-1}) + \mu_t, \ \mu \sim N(0, \sigma^2_\mu) \quad (3.1.1)$$

where $0 \leq \delta \leq 1$, and μ_t is a random disturbance. The coefficient δ is called the "adjustment coefficient" since it indicates the rate of adjustment of R to R^*. Both the speed of adjustment of reserves δ and the optimal level towards which they adjust, R^*, are chosen in order to maximize a utility function depending on the mean and variance of the income.

Figure 3.2 is an adapted version of the Clark (1970) and Kelly (1970) models. Consider first the opportunity cost associated with holding a larger stock of reserves. This

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8. It was generally expected that the adoption of floating exchange rates would reduce the demand for reserves by allowing greater reliance on adjustment via changes in the exchange rate. However, actual experience under floating rates has seen no apparent reduction in reserve use and the empirical studies reviewed before found only minor changes in reserve demand. Countries with flexible exchange rate systems have continued to intervene in foreign exchange markets or have pegged their currencies to another currency or to a currency basket. The demand for reserves continues as many countries, especially LDCs, attempt to protect themselves from the uncertainties arising from larger payments disequilibrium and exchange rate fluctuations, and to demonstrate their creditworthiness so as to preserve access to financial markets. In fact, a large majority of Fund members either still peg their currencies or have adopted heavily managed floating systems and thus are not making much use of the greater flexibility allowed. This is because the floating system is workable only when certain conditions are met. The country must have well-developed financial and foreign exchange markets, and both trade and capital movements must be largely liberalized. Presumably, these conditions are not met in a large majority of countries. For these reasons and for the simplicity of the analysis, the adjustment mechanism discussed here is mainly related to the expenditure-changing policy.

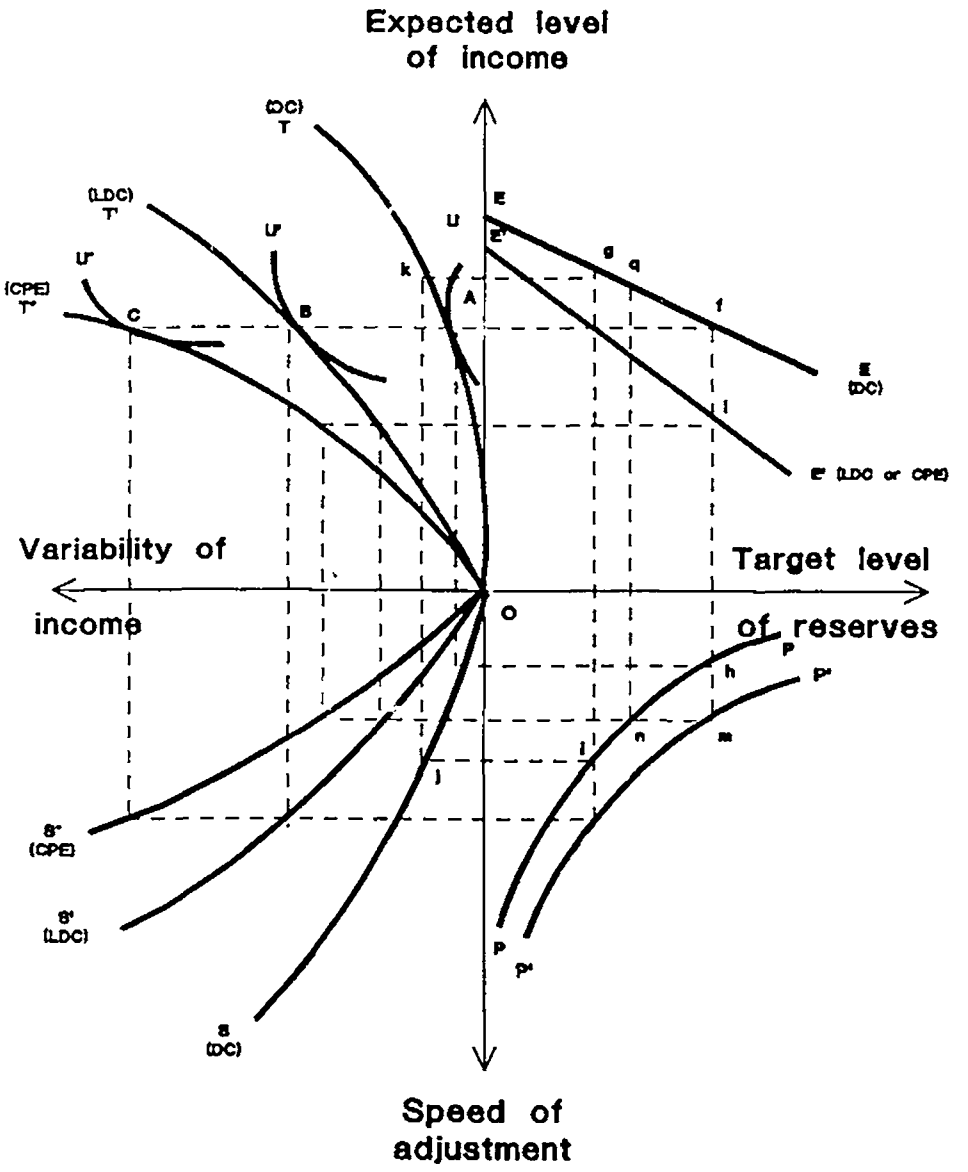

Fig. 3.2

relationship is described in the N.E. quadrant of Figure 3.2. The stock of reserve assets represents the allocation of scarce resources away from domestic uses. If reserves are invested in foreign assets which have a positive yield, then they entail a net opportunity cost, r, equal to the difference between this yield and alternative capital investment. The mean income is thus reduced by an amount equal to rR^*. This relationship is given by equation (3.1.2):

$$E_y = Y_0 - rR^*. \quad (3.1.2)$$

The equation is graphed as the straight line in the N.E. quadrant of Figure 3.2. Mean income declines along EE due to the opportunity cost of holding larger reserves. The slope and intercept of the line depend on the cost of financing and the level of income. The higher the cost of financing and the lower the level of income, the steeper is the slope.

In the S.E. quadrant, the level of reserves is obtained by using equation (3.1.1) and adding R_{t-1} to both sides

$$R_t = \delta R^* + (1 - \delta)R_{t-1} + \mu_t. \quad (3.1.3)$$

For $\mu_t \sim N(0, \sigma^2_\mu)$, the variance of the reserve holdings is

$$\sigma^2_R = \sigma^2_\mu/\delta(2-\delta). \quad (3.1.4)$$

The probability of running out of reserves is determined as

$$P = p(R^*, \delta, \sigma^2_\mu), \quad (3.1.5)$$

where $dp/dR^* < 0$, $dp/d\delta < 0$, and $dp/d\sigma^2_\mu > 0$.

Chebychev's Inequality is then introduced to relate the probability of not running out of reserves $P(R \geq 0)$ to the speed of adjustment and the desired level of reserves. This gives the equation (3.1.6):

$$P(R \geq 0) = \sigma^2_R / 2R^{*2}. \quad (3.1.6)$$

A constant probability of not exhausting reserves along the PP curve can be maintained either by means of rapid adjustment or by means of large reserve holdings. It follows that given the speed of adjustment, an increase in the variance of reserves and/or a decrease in the desired level of reserves will lead to the PP curve being shifted outward, and *vice versa*.

The S.W. quadrant of Figure 3.2 shows the relationship between variability in income and the speed of adjustment. This is given by equation (3.1.7):

$$\sigma^2_y = (\delta^2 \sigma^2_R)/m^2 = (\delta \sigma^2_\mu)/[(2-\delta)m^2], \quad (3.1.7)$$

where m is the marginal propensity to import. Since the derivative is always positive, the variance of income is a non-linearly increasing function of the speed of adjustment, depicted as curve OS.

These three curves then combine to produce the tradeoff OT between mean income and the variability of income in the N.W. quadrant. This technical tradeoff between E_y and σ^2_y represents the transformation curve or feasibility locus which faces the country. It has the form:

$$E_y = f(\sigma^2_y), \quad (3.1.8)$$

which specifies the maximum attainable average level of income associated with a given degree of variability.

Assume that a country has the a utility function of the form:

$$U = f(E_y, \sigma_y, P), \quad (3.1.9)$$

where $dU/dE_y > 0$, $dU/d\sigma_y < 0$, and $dU/dP < 0$. The optimum values of E_y, σ_y and P would be determined by the point of tangency of the feasibility surface with the highest possible indifference surface and the implied values of R^* and δ could then be derived. It follows that there exists a

positive relationship between R^* and σ_μ or Y, and a negative relationship between R^* and MPI or r (Details of the derivation are in Appendix A).

Extensions. The structural and institutional differences among the different economies can lead to variations in these countries' reserve demand behavior. Consider first the opportunity cost of holding reserves illustrated in the N.E. quadrant of Figure 3.2 by the slope of the tradeoff between the level of income and the desired level of reserve holdings. Assume that in general the level of national income in LDCs and CPEs is lower than that in DCs and the cost of financing is higher. The opportunity cost of holding reserves is thus higher in these economies than in DCs. The slope is drawn steeper and to the left as depicted by E'E'.

In the S.E. quadrant of Figure 3.2, the locus of combinations of reserve level and adjustment speed is shown consistent with the maintenance of a constant probability of reserve depletion. It is assumed that both LDCs and CPEs exhibit greater uncertainty and instabilities with regard to the effectiveness and timing of their macroeconomic policies because of smaller monetised sectors, inadequacy of financial intermediaries and less effective monetary and fiscal policies. It follows from this that LDCs and CPEs will have to hold larger reserves and adjust more rapidly

than DCs in order to achieve the same probability of reserve depletion. This is reflected by the outward shift of the PP curve to P'P' which represents both LDCs and CPEs.

The S.W. quadrant of Figure 3.2 reflects the costs of adjustment in terms of the variability of income. Given equation (3.1.7), the faster the speed of adjustment the greater is the variance in income, since a reserve deficiency implies deflation so as to cut imports and this must be more severe the greater the chosen speed of adjustment. The costs of adjustment will depend on both the openness of the economy measured by the marginal propensity to import, m, and the size of the random component in the balance of payments, σ^2_R. The less open is the economy and more variable is the balance of payments the larger will be the costs associated with any given adjustment speed. In the S.W. quadrant, curve OS'' is depicted for CPEs where the balance of payments are particularly volatile as a result of a relatively less open economy. Curve OS is depicted for DCs where the economies are relatively open and domestic adjustments exert less effect on domestic income variations. Curve OS' is depicted for LDCs.

Interaction between the relationship in the N.E., S.E, and S.W. quadrants of Figure 3.2 serves to trace out the tradeoff between income level and its variability depicted in the N.W. quadrant. Just as the transformation curve

relating income levels and the degree of stability is different as among DCs, LDCs and CPEs so the indifference curves between income level and stability which illustrate the preferences of the monetary authorities are different, since authorities in LDCs and especially in CPEs are likely to have a stronger preference for income level than for income stability.[9] These are depicted as different transformation curves (OT, OT', and OT'' for DCs, LDCs, and CPEs respectively). Optimal solutions (A, B, and C) for each economy are found at the points of tangency of the indifference curves (U, U', and U'') and the transformation locus respectively. If a country, say a developed country, desires to maintain a lower level of R^* by instead increasing the speed of adjustment δ, i.e. R^* is reduced from f to g, the δ will have to be increased from h to i, which will in turn bring about a combination of a higher level of income k, and a greater variability of income j. The tradeoff between the level of income and the variability of income in LDCs and CPEs follows the same pattern. Furthermore, given the level of R^* (f or l), LDCs or CPEs in general require a higher speed of adjustment (m compared to h). On the other hand, given the speed of adjustment, DCs require less R^* (q compared to l).

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9. In a centrally planned economy, the government has a target level of economic growth rate in its five-year or ten-year plan. To realize this target level of income growth is the first priority of all economic activities and the government economic policy. Sometimes, this is done at the expense of income stability.

A country's accessibility to international capital markets may alter the above scenario. Consider a developed economy with a high credibility in borrowing in international capital markets. It can finance its balance of payments deficit via short-term borrowing. Thus, given the level of income, this country's desired reserve holdings can be reduced to a lower level. In other words, the opportunity cost of holding reserves in terms of the foregone income is relatively lower. The opportunity cost line EE depicted for DCs in the N.E. quadrant of Figure 3.2 will thus be flatter. The locus of combinations of the reserve level and the adjustment, PP, shown in the S.E. quadrant will be shifted further towards the origin. Assuming that adjustment takes the form of demand management policy, the S.W. quadrant reflects the costs of adjustment in terms of the variability of domestic income. The slower the speed of adjustment the smaller is the variance in income. Finally, in the N.W. quadrant, the curve between the level and the variability of national income will be steeper reflecting a higher level of income given the same degree of variability of income. A country's borrowing capability enables it to have a slower speed of adjustment at a given level of reserve holdings. On the other hand, given the greater difficulties that LDCs and CPEs encounter in borrowing short term capital, they need to maintain a lower probability of reserve depletion than DCs, and therefore have a high demand for international reserves.

In such a case the curves for LDCs or CPEs shift in the opposite direction.

It is therefore hypothesized that: (1) A country's demand for international reserves is determined by an optimum combination of the desired level of reserve holdings and the speed of adjustment. The desired reserve holdings are determined by the country's payments variability, level of imports, the marginal propensity to import, and the opportunity cost of holding reserves in terms of the foregone assets yield. Both payments variability and level of import will exert a positive impact on the reserve demand, while the marginal propensity to import and opportunity cost of holding reserves have a negative impact on the reserve demand.

(2) The structural and institutional differences between different economies, such as the differences in the economic system, financial system and organizations, the efficacy of monetary and fiscal policies, and the accessibility to international capital markets, may lead to variations in these countries' reserve demand behavior. The resulting high cost of financing, lack of accessibility to external borrowing, the rudimentary nature of the financial system and rigid economic planning, together with lack of competitiveness in the foreign trade sector, may force LDCs and CPEs to require larger holdings of international

reserves and/or need a more rapid adjustment to a balance of payments deficit. These hypotheses will be empirically tested and the empirical evidence presented in the following section.

(3.2) Model, Testing Procedure, and Empirical Results.

In this section, an empirical examination on the theory of demand for international reserves will be conducted. Section (3.2.1) presents the model and empirical specification. The testing procedure and empirical results are reported in Section (3.2.2). We will first analyze reserve demand behavior with respect to the different country groupings. A test of dynamic adjustment will also be conducted. These tests serve the purpose of identifying the reserve demand equation for each economy and the most significant explanatory variables which consistently perform well in the reserve demand functions.

(3.2.1) Model and empirical specification.

Following the theory on the subject, the demand for international reserves, R, can be related to four major variables: (1) a measure of variability of the balance of payments, σ^2, reflecting the role of reserves as a buffer stock accommodating fluctuations in external transactions; (2) the level of imports, IM, as a measure of scale

reflecting the value of international transactions; (3) the ratio of imports to *GNP* or a proxy for the marginal propensity to import, *m*, reflecting the economy's degree of openness or the amount of domestic adjustment; and (4) the opportunity cost of holding reserves, *r*. The reserve demand has the following form:

$$R = f(\sigma^2, IM, m, r). \quad (3.2.1)$$

In this formulation the dependent variable is defined as total reserves including monetary authorities' holdings of foreign exchange, SDRs, and its reserve positions in the Fund but excluding gold. The choice of the level of total reserves minus gold as a dependent variable is simply following convention. While other measures, such as "net reserves" - reserve holdings adjusted for net foreign assets or liabilities - may be more relevant in assessing the "true" liquidity position of a country, the total reserves concept is better because we want to explain the level of reserves that a country "demands." If it borrows in order to add to its stock, then that is taken to imply that the accumulation is a reflection of increased demand.

The variability measure of the balance of payments is entered into the reserve demand function to reflect the theoretical concepts of risk and uncertainty. Greater variability in the balance of payments, by creating greater

uncertainty, is expected to increase the demand for reserves. The effect of the scale variable is obvious - an increase in imports or *GNP* will result in an increased demand for reserves. The relationship between the demand for reserves and the ratio of imports to *GNP* is ambiguous in nature. However, if the ratio is a proxy for the *MPI*, and therefore its inverse is an indication of the amount of domestic adjustment required to produce a particular level of reserves, then the relationship would be negative. The opportunity cost of holding reserves is expected to have a negative effect on the reserve demand.

In summary then, we expect that the partial derivatives of equation (3.2.1) would have the following pattern of signs:

$$dR/d\sigma^2 > 0;\ dR/dIM > 0;\ dR/dm < 0;\ dR/dr < 0.$$

A country's demand for international reserves will vary positively with the instability of the balance of payments and wealth, and negatively with the *MPI* and the opportunity cost of holding reserves.

Assuming that the true functional form is linear in the logarithms,[10] the desired reserve function can be written as

10. The Box-Cox transformation technique was used for testing nonlinearity of the functional form. In most cases, the lambdas were very close to zero (eg. 0.02, -0.10, -0.39, 0.04, and -0.17 for five

$$R^*_t = \alpha_0 + \alpha_1 \sigma^2_t + \alpha_2 IM_t + \alpha_3 m_t + \alpha_4 r_t + \mu_t, \quad (3.2.2)$$

where, R_t = total reserves minus gold;

σ^2_t = variance of the balance of payments measured as the variance of exports over the previous 10 years;[11]

IM_t = level of imports;

m_t = the proxy for marginal propensity to import, measured as the ratio of imports to *GNP* or *GDP*;

r_t = the opportunity cost of holding reserves;[12]

α_i = parameters;

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country groupings). We thus assume that the functional form is Cobb-Douglas in nature.

11. Kelly (1970), Edwards (1983) and Bahmani (1988) used similar proxies in their regression analyses. Using variance of exports as a measure of payments variability has the advantage of reducing the simultaneity problem posed by the fact that some parts of the payments balance - e.g., imports - are influenced by adjustment policies rather than being exogenous as supposed in the theory, though this advantage is assumed at the cost of ignoring other causes of instability.

12. Since, in practice, international reserves are typically held in interest-earning liquid assets, *r* should be viewed as the difference between what could have been earned and what is actually earned; i.e. *r* measures the penalty rate that is incurred by investing reserves in liquid short-term assets. It was shown (Edwards, 1985 and Landell-Mills, 1989) that individual countries' spreads over LIBOR on syndicated loans plus LIBOR rate and less the US Treasury bill rate might be a good proxy for the opportunity cost of holding reserves. This proxy will be applied where the relevant data are available.

μ_t = random error term.

The specification in logarithms assumes reserves react proportionally to changes in the explanatory variables.

Assume that the monetary authority adjusts its current stock of reserves in proportion to the discrepancy between actual and desired reserves. In the log-linear form, the dynamic adjustment equation can be written as

$$R_t - R_{t-1} = \delta_0 + \delta(R^*_t - R_{t-1}), \quad (3.2.3)$$

where δ is the coefficient of adjustment. Substituting equation (3.2.2) into (3.2.3) yields

$$R_t = (\delta_0 + \delta\alpha_0) + \delta(\alpha_1\sigma^2_t + \alpha_2 IM_t + \alpha_3 m_t + \alpha_4 r) + (1 - \delta)R_{t-1} + \delta\mu_t. \quad (3.2.4)$$

Equation (3.2.4) can be rewritten as

$$R_t = \beta_0 + \beta_1\sigma^2_t + \beta_2 IM_t + \beta_3 m_t + \beta_4 r_t + \beta_5 R_{t-1} + \epsilon_t, \quad (3.2.5)$$

where $\beta_0 = \delta_0 + \delta\alpha_0$, $\beta_i = \delta\alpha_i$, $i = 1, \ldots, 4$, $\beta_5 = 1 - \delta$, and $\epsilon_t = \delta\mu_t$. The actual stock of reserve holdings is a

function of the proposed explanatory variables as well as its lagged value.

In this model the supply of international reserves is assumed to be elastic enough to meet the demand. This simply follows the convention (Refer to the discussions in Section 2.2.4). The quantity of reserves adjusts to the demand for them: reserves are demand-determined. Certainly balance of payments surpluses can reflect the demand for additional reserves in the countries running them; reserve currency countries such as US and Germany may then meet this demand by financing the related deficits through the creation of extra externally held liabilities. The supply of reserves then increases. Furthermore, even reserve creation made through the IMF responds, in an indirect way, to the demand for reserves. What is perhaps more true is that the quantity of international liquidity is demand-determined. With a high degree of international capital mobility, countries short of reserves may be able to borrow in the international financial markets and thereby sustain expenditure above levels that would otherwise be possible.

(3.2.2) Testing procedure and empirical results.

This section presents empirical estimates of the demand for international reserves by different economies obtained

from a set of tests.[13] The reserve demand by CPEs will be dealt with separately in Chapter 4 and therefore is not included here.

Recall that two approaches have been employed in the literature to estimate reserve demand: the first is so-called equilibrium models which assume that adjustment to determinate desired reserve levels occurs in the estimating period (Heller and Khan, 1978 and Frenkel, 1974, 1983); the disequilibrium versions of the demand for international reserves are based on stock adjustment models which allow for a gradual adjustment of actual to desired reserve holdings (Frenkel, 1983 and Edwards, 1984). The determinants of reserve demand were very similar in each approach. Both approaches have yielded significant results.

This study first applies the equilibrium approach and estimates the long-run demand function to identify the determinants of the desired level of reserve holdings. The level of reserves rather than the rate of change was estimated, on the principle that reserve demand is a demand for a stock rather than a flow. The different reserve demand behaviors between different country groupings will be empirically examined. We then conduct a test on the speed of adjustment with respect to developed and developing

13. All tests are conducted using the "Shazam Econometrics Computer Program" (White, et al., 1988) unless otherwise stated.

countries using a stock adjustment model. Finally, we attempt to explain what causes actual reserves to deviate from desired reserves in the first place and how the dynamic adjustment process depends on the nature and persistence of such causes, recognizing that the nature of the disturbances and reactions differs systematically between groups of countries.

Test 1. The identification of the determinants of reserve demand.

The empirical analysis includes annual data from five country groupings and covers the period from 1961 to 1986. The classification of countries as world, industrial, oil-exporting, non-oil developing, and 15 heavily indebted is based on that of the International Monetary Fund (Refer to Appendix B). Countries are grouped by predominant exports and by financial criteria. The choice of the period of analysis was determined by the availability of continuous series of data. As indicated before, the empirical definition of international reserves used below consists of foreign exchange, SDRs and countries' reserve positions at the IMF. The end-of-year data for reserves is divided by the consumer price index from each country grouping to obtain real reserves, R/P. The demand function was assumed to depend on three variables: (a) a measure of variability of international receipts and payments denoted by σ^2. The value

of σ^2 for each year was estimated by computing the variance of exports over the previous 10 years; (b) a scaling variable, measuring the size of international transactions, represented by the level of real imports *IM/P*; and (c) the marginal propensity to import, *m*, proxied by the ratio of imports to *GDP*. The data are obtained from *International Financial Statistics*. The fourth variable, the opportunity cost of holding reserves, was initially included in the regression equation. Available proxies for this variable such as the central bank discount rate and the government bond rate were used. In all cases, it failed to provide a significant coefficient. This may be due to the poor proxies for the variable as was found by previous studies. We therefore dropped the variable in this test.

The long-run, or equilibrium, demand for reserve has the functional form in logarithms:

$$(R/P)_{it} = \alpha_0 + \alpha_1\sigma^2_{it} + \alpha_2(IM/P)_{it}$$

$$+ \alpha_4 m_{it} + \mu_{it}, \quad (3.2.6)$$

where $(R/P)_t$ and $(IM/P)_t$ are real reserves and real imports in constant US dollars, and μ denotes a random error term.

A simple ordinary least-squares regression was first run using annual observations for the period 1961-1986. The

regression results showed the presence of a positive serial correlation. The presence of a positive serial correlation may come from the cumulative effects of the omitted variables in the regression model. Specifically, countries' demand for reserves may be affected by the other variables such as the opportunity cost of holding reserves. A standard method is to apply the Cochrane-Orcutt iterative procedure. Table 3.1 presents estimates of the reserve demand by different country groupings with the application of the Cochrane-Orcutt procedure. In all cases, the coefficients of the variability measure σ^2 and the level of real imports *IM/P* have the expected positive signs, and in most cases, these coefficients are statistically significant at the 5 percent significance level. These findings are consistent with previous studies. While Kelly (1970), Frenkel (1980), and Edwards (1984) found a positive relationship between the propensity to import and reserve demand, this study shows the coefficient of the marginal propensity to import *m* is significantly negative in all cases, which is consistent with our theoretical predictions and the results obtained by Heller and Khan (1978) and Landell-Mills (1989). It should be noted that the overall fit of the regressions reported in Table 3.1 (as measured by the coefficients of determination R^2) is very satisfactory. This result is consistent with those obtained by Bahmani (1988) and Landell-Mills (1989). The descriptive statistics for each variable are reported in Table 3.2.

Table 3.1 Demand For International Reserves, 1961-1986[1]
(Estimated generalized least-squares results)

$$\log(R/p)_t=\alpha_0+\alpha_1\log\sigma^2{}_t+\alpha_2\log(IM/p)_t+\alpha_3\log m_t$$

Country Grouping	α_0	α_1	α_2	α_3	SEE	R^2	D-W	RHO
All Countries	0.029 (0.05)	0.088 (5.29)	1.277 (8.65)	-0.853 (3.26)	0.066	0.98	1.74	-.46
Industrial Countries	-0.467 (0.58)	0.146 (4.82)	0.622 (2.45)	-0.587 (1.57)	0.082	0.98	1.96	-.44
Oil-export Countries[2]	-2.488 (3.09)	0.184 (4.68)	0.367 (1.84)	-0.588 (2.23)	0.148	0.97	2.10	-.38
Non-oil Developing Countries	1.242 (2.53)	0.198 (8.06)	1.053 (18.93)	-1.129 (5.99)	0.069	0.98	1.90	-.61
15 Heavily Indebted Countries	1.461 (1.16)	0.062 (0.99)	0.969 (8.22)	-1.220 (2.86)	0.168	0.98	1.52	-.41

1. t-values in parentheses.
2. Sample period is from 1964 to 1986.

Table 3.2 Descriptive Statistics for the Variables[1]

Country Grouping	Variables	Mean	Variance	Minimum	Maximum
All Countries	LR	-0.703	0.300	-1.501	-0.030
	LV	3.740	7.512	-0.088	6.811
	LM	0.872	0.166	0.241	1.507
	LMPI	2.550	0.062	2.241	2.901
Industrial Countries	LR	-0.970	0.324	-1.798	-0.300
	LV	3.385	6.726	-0.212	6.284
	LM	0.754	0.269	-0.128	1.463
	LMPI	2.492	0.060	2.163	2.845
Oil-export Countries	LR	-2.463	0.934	-4.039	-1.331
	LV	2.038	11.422	-3.056	5.222
	LM	-1.900	0.435	-2.904	-1.030
	LMPI	2.932	0.032	2.701	3.440
Non-oil Developing Countries	LR	-3.283	0.373	-4.949	-2.535
	LV	1.447	5.348	-1.482	4.075
	LM	-1.691	0.421	-3.521	-1.107
	LMPI	2.689	0.068	2.351	3.020
15 Heavily Indebted Countries	LR	-5.299	2.254	-9.064	-3.880
	LV	0.592	7.008	-2.571	4.314
	LM	-4.046	2.870	-8.208	-2.343
	LMPI	2.395	0.027	1.974	2.646

1. LR = log of real reserves; LM = log of real imports;
LV = log of variance of the balance of payments;
LMPI = log of marginal propensity to import.

In order to see if there was a shift in reserve demand in 1973 when the international monetary system changed from fixed exchange rate to flexible exchange rate. We tried to include a dummy variable to account for this change. However, all five dummies for the five country groupings failed to pass a significant test at the 5 per cent level, indicating there was no significant shift in reserve demand in that year. We therefore dropped this variable in the test.

Considering the results obtained form the different country groupings, we observe that in all cases but one the estimated elasticities are significantly different from zero at the 5 percent level. It was as expected that the coefficient of the variability of payments elasticity in the regression equation for industrial countries would be relatively low at 0.146, compared with those obtained for the oil-exporting and non-oil developing countries (0.184 and 0.198 respectively). This result supports the hypothesis that in general, developing countries demand more reserves than developed countries since developed countries have greater access to world capital markets and swap arrangements. Thus increased variability in their balance of payments has less of an effect on their stock demand for international reserves. Unexpected shocks can be met by borrowing from other central banks or from the markets. Surprisingly, the elasticity of variability measure of the

balance of payments in the regression equation for 15 heavily indebted countries is quite low (0.062). The variable is insignificant in the EGLS regression.

The elasticities of reserve demand with respect to real imports for industrial and oil-exporting countries are 0.622 and 0.367 respectively, while those for non-oil developing and heavily indebted countries are 1.053 and 0.969 respectively. While the estimates for industrial and oil-exporting countries suggest a certain degree of economies of scale in the demand for reserves as was found by Frenkel (1974, 1978), a close-to-unity elasticity of reserve demand with respect to imports for the latter two groups indicates that in these economies the reserves apparently grow in proportion to trade with not much evidence of economies of scale. This result tends to support the judgment of Polak (1970) that this particular elasticity would lie in the region of 0.8-1.0, and also does not reject the hypothesis made by Olivera (1971) that the elasticity should be between 0.5 and 1.0. More importantly, the higher elasticity of reserve demand with respect to imports for LDCs indicates that for a given level of imports, *ceteris paribus*, these countries demand more reserves. The differences in the import elasticity of the demand for reserves reflect differences in the characteristics of the financial systems. The sophisticated financial system in DCs entails possibilities for increasing returns to scale which make

possible a rise in the import velocity of reserves. On the other hand, the financial structure of LDCs entails a much lower degree of these economies of scale. These findings further support our model's prediction that in general LDCs tend to require a larger holding of reserves.

The ratio of imports to income consistently exerts a negative effect on the reserve demand, implying a more "Keynesian" role for this variable. However, the effect of the import-*GDP* ratio on the reserve demand with respect to different country groupings is mixed. It appears from our results that for industrial and oil-exporting countries the effect of this ratio is relatively small. The fairly large elasticities obtained from the regression equations for non-oil developing countries and 15 heavily indebted countries are unexpected. This may be due to the fact that the increasing borrowing activities during the late 1970's and the early 1980's enable these countries to mitigate the burden of internal adjustment.

In general, the results obtained have supported our hypotheses. The variability measure of the balance of payments, countries' level of real imports, and the marginal propensity to import are the three determinants in the reserve demand function. While the variability measure of the balance of payments and the level of real imports have a positive impact on the countries' real demand for

international reserves, the *MPI* consistently exerts a negative effect on the reserve demand. In terms of the relative importance of the three determinants for the level of current reserves, the beta coefficients in the regressions for the five country groupings have shown that the level of real imports has the strongest impact on reserve holdings. It is also shown in general that LDCs require larger holding of international reserves than developed countries.

Test 2. The difference in the reserve demand behavior between different economies.

To see whether there is a difference in the reserve demand behavior between different economies, we have conducted a cross-sectional and time-series estimate of demand for international reserves with the introduction of country-grouping-specific dummy variables.

The use of dummy variables serves two purposes. That is to account for the different structural and institutional conditions among the different economies and to formally analyze if the long-run demands for reserves for each group of countries is significantly different. Although 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 country groupings or over time - it seems unreasonable to expect the intercept to remain constant among country groupings because these will have different demands for reserves as a result of different policy priorities and structural conditions (Pindyck and Rubinfeld, 1981, pp. 254-55). For these reasons a set of individual country grouping's dummy variables (denoted as CGD_{it}, i = 1, 2, and 3, representing the three country groupings of oil-exporting, non-oil developing, and 15 heavily indebted countries) is introduced to represent the influence of different economic conditions on the reserve demand. Thus, the oil-exporting country grouping's dummy variable takes on the value 1 when the observations are from this grouping and 0 otherwise; the non-oil developing country grouping's dummy variable takes on the value 1 when the observations are from this grouping and 0 otherwise; and so on. The log-linear equation is estimated using generalized least-squares on the entire data set. The results from pooled cross-section and time-series regression are stated as follows with the t statistics in parentheses:

$$(R/P)_{it} = \underset{}{0.606} + \underset{(1.93)}{.147\sigma^2_{it}} + \underset{(12.28)}{.939(IM/P)_{it}} - \underset{(24.69)}{1.11m_{it}} - \underset{(8.20)}{}$$

$$+ \underset{(8.54)}{1.72CGD_{1t}} + \underset{(3.34)}{0.475CGD_{2t}} + \underset{(2.56)}{0.418CGD_{3t}} \quad (3.2.7)$$

Adjusted R^2 = .97, SEE = 0.875.

The signs of the estimated regression coefficients are all theoretically correct and statistically significant at the 5 percent level. Both σ^2 and *IM/P* exert a positive effect on the demand for reserves. The negative coefficient for *m* implies that the increased *MPI* reduces the country's demand for reserves. The dummy variables for country-grouping-specificity and the regression intercept are significantly different from zero at the 5 percent level, suggesting that the variations in economic structure and other institutional arrangements in different country groupings play a significant role in the determination of the countries' reserve demand behavior. The regression analysis explains 97 percent of the variation in countries' reserve demand.

If the reserve-import ratio is used as a measure of countries' reserve-adequacy, our empirical results are accentuated by the fact that, on average, LDCs have maintained a higher reserve-import ratio than DCs. Table 3.3 shows the five country groupings' ratios of non-gold reserves to imports over 1960-86 period. An indication of how reserves behaved can be seen from examining these ratios. Overall, the industrial country grouping has maintained a relatively stable reserve-import ratio. The

Table 3.3 Ratio of Non-Gold Reserves to Imports, 1960-86

Year	World	Industrial Countries	Oil-Exporting Countries	Non-oil Developing Countries	Heavily Indebted Countries
1960	0.18	0.18	0.31	0.15	0.19
1961	0.18	0.19	0.26	0.13	0.15
1962	0.17	0.18	0.26	0.14	0.13
1963	0.18	0.18	0.36	0.16	0.16
1964	0.17	0.17	0.32	0.14	0.16
1965	0.16	0.15	0.32	0.17	0.20
1966	0.16	0.15	0.37	0.17	0.18
1967	0.17	0.16	0.36	0.18	0.18
1968	0.17	0.16	0.33	0.18	0.19
1969	0.15	0.13	0.33	0.19	0.21
1970	0.19	0.17	0.40	0.20	0.24
1971	0.28	0.28	0.63	0.22	0.28
1972	0.30	0.29	0.69	0.30	0.43
1973	0.26	0.23	0.66	0.30	0.51
1974	0.22	0.16	1.41	0.20	0.47
1975	0.22	0.17	1.08	0.18	0.40
1976	0.23	0.16	1.01	0.23	0.47
1977	0.26	0.19	0.88	0.27	0.44
1978	0.26	0.21	0.62	0.29	0.45
1979	0.23	0.18	0.74	0.26	0.47
1980	0.21	0.17	0.66	0.20	0.37
1981	0.20	0.17	0.51	0.18	0.28
1982	0.20	0.17	0.44	0.19	0.21
1983	0.22	0.18	0.48	0.22	0.29
1984	0.21	0.17	0.53	0.24	0.45
1985	0.24	0.18	0.70	0.24	0.47
1986	0.25	0.20	0.66	0.24	0.37

Source: *International Financial Statistics*, various issues.

average reserve-import ratio of the industrial country grouping was at 0.165 in the 1960's. It was up to 0.204 in the 1970's and down to 0.177 in the first half of the 1980's. During the same periods, the average reserve-import ratios for non-oil developing countries were 0.161, 0.245 and 0.215 respectively. The reserve-import ratios for oil-exporting and heavily indebted countries were quite volatile. Both countries' average reserve-import ratios jumped to 0.812 and 0.416 in the 1970's from 0.322 and 0.175 in the 1960's. These ratios were lower in the first half of the 1980's but were still as high as 0.568 and 0.348 respectively.

Test 3. The dynamics of adjustment of international reserves.

The dynamics of adjustment of international reserves have been examined with respect to developed and developing countries, in an attempt to find empirical evidence supporting our hypothesis that in general LDCs adjust more quickly than DCs if there is a balance of payments deficit. We have applied our data set to equation (3.2.5) but excluding the interest rate variable. Equation (3.2.5) can be called the short-run demand function for reserves since in the short-run the existing stock of reserves may not necessarily be equal to its long-run level. Estimation of equation (3.2.5) poses some problems. As the equation

contains a lagged endogenous variable R_{t-1}, simply estimating the equation using OLS may lead to biased parameter estimates and inconsistency if the error term is serially correlated. For example, when the error term follows the pattern $\epsilon_t = \mu_t - w\mu_{t-1}$, the OLS estimators become inconsistent and biased. The problem arises because ϵ_t and R_{t-1} are correlated and the correlation does not disappear as the sample size gets larger. However, in the partial adjustment model, according to Gujarati (1988), if μ_t of equation (3.2.2) satisfies the assumptions of the classical linear regression model, so will $\delta\mu_t$ of equation (3.2.4). Although R_{t-1} depends on μ_{t-1} and all the previous disturbance terms, it is not related to the current error term μ_t. Therefore, OLS estimation of the partial adjustment model will yield consistent estimators although they tend to be biased (in finite samples).[14] Dhrymes (1981) showed that, by assuming the error term of the model is a first order Markov process, the estimators of the parameters of a geometric lag structure model are consistent, asymptotically unbiased and efficient.[15]

The results obtained from estimating the equation (3.2.5) with respect to industrial and developing countries

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14. Using a set of lagged exogenous variables as instrumental variables to test for the model in a two-stage least-squares estimation process (2SLS) yielded unsatisfactory results. This may be due to the poor proxies for the original dependent variable.
15. For details refer to Dhrymes' Theorem 7.1 (1981, pp. 199-208).

are stated in the equation (3.2.8) and (3.2.9) with the t statistics in parentheses.

$$(R/P)_t = \underset{}{.443} + \underset{(.56)}{.159\sigma^2_t} + \underset{(7.51)}{.379(IM/P)_t} - \underset{(1.81)}{.761m_t} + \underset{(2.25)}{.297(R/P)_{t-1}}, \quad (3.2.8)$$

Adjusted R^2 = .98, SEE = 0.071, D-H = -0.047.

$$(R/P)_t = \underset{}{-1.91} + \underset{(1.51)}{.126\sigma^2_t} + \underset{(1.56)}{.928(IM/P)_t} + \underset{(22.31)}{.128m_t} + \underset{(.27)}{.072(R/P)_{t-1}}, \quad (3.2.9)$$

Adjusted R^2 = .99, SEE = 0.097, D-H = 1.47.

Considering the results obtained from both country groupings, we observe that all but one of the estimated coefficients have the expected signs and all but two of the estimated coefficients of explanatory variables are significantly different from zero at the 5 per cent level. Although the sign of the elasticity of reserve demand with respect to the marginal propensity to import for developing

countries turned out to be wrong (positive), it is statistically insignificant. The estimated dynamic adjustment coefficient for the industrial countries is statistically significant at the 5 per cent level. The coefficient of 0.703 (= 1 - 0.297) suggests that 70 per cent of the disequilibrium between desired and actual reserves will be eliminated in one year. The coefficient of adjustment for developing countries is statistically significant at the 10 per cent level. Compared with that of the industrial countries, the speed of adjustment is much faster in developing countries at 0.928 (1 - 0.072), suggesting that more than 90 per cent of the disequilibrium between desired and actual reserves is eliminated in one year. These results support our hypotheses that in general developing countries will adjust more quickly to a balance of payments disequilibrium. The high speeds of adjustment obtained from our tests are consistent with the theoretical predictions made by Frenkel (1983, p. 82). However, by introducing monetary adjustment into the dynamic equations of reserve demand, Frenkel's model only explains between 13 to 25 per cent of the variation of the reserve demand by developed countries over periods of 1963-72 and 1973-79. A similar monetary variable in Edwards (1984) failed to pass a significance test at the 5 per cent level. Our regressions explain more than 98 per cent of the variations in reserve demand for each grouping of countries.

To see if there exists any serial correlation in the error term appearing in the model, we applied the Durbin *h* Test. The calculated Durbin *h*-statistics for both industrial and developing country groupings (-0.047 and 1.47 respectively) are within the range of between -1.96 and +1.96. The null hypothesis that there is no first-order (positive or negative) autocorrelation cannot be rejected. Therefore, it was assumed that there is no serial correlation in the error term.

Test 4. The identification of the disturbance factors in reserve demand.

So far we have derived estimates of the demand for international reserves from commonly used models involving specification of (1) desired reserves as a function of the variability of international receipts and payments, the marginal propensity to import, and a measure of scale such as real imports; and (2) the process by which deviations of actual from desired reserves tend to be eliminated over time. This approach can be used to derive the level of reserves normally desired but it does not explain what causes actual reserves to deviate from desired reserves in the first place and how the dynamic adjustment process depends on the nature and persistence of such causes with respect to different country groupings. An alternative procedure is to estimate the demand for reserves directly by

including identifiable disturbance factors that may cause actual and desired reserves to differ for varying durations. The latter procedure is followed here.

Assume that countries choose a non-gold reserve-import ratio as the level of reserve adequacy. This test tried to identify disturbances and the direction of disturbances directly rather than having them affect variances constructed over lengthy periods. All estimates are prepared for three groupings of countries for the available data. These are the industrial countries excluding the US, oil-exporting countries, and non-oil developing countries. The estimation period is from the fourth quarter of 1981 through the first quarter of 1988.

In estimating the demand for reserves as per cent of imports, an attempt is first made to account for worldwide cyclical disturbances to this ratio by introducing the US unemployment rate. While lagging the business cycle in the US, this rate has been roughly coincident with the rate of production for industrial countries as a whole. Rising unemployment in the US and slackening demand will tend to lower the reserves of other countries from the trade side.

The reserve holdings of industrial countries excluding the US are further influenced by pressures on the dollar exchange rate as the monetary authorities of other countries

intervene by "leaning against the wind." Any excess of US money (M2) growth over that of all other industrial countries will add to the pressure on those countries to take excess dollars off the market. Thus, a decline in the SDR value of the US dollar and relatively faster US money growth will tend to raise their reserves, *ceteris paribus*. The same may hold for other country groupings, since a depreciating dollar is likely to be associated with low real interest rates in the US and in Eurodollar markets, thereby lowering interest burdens and encouraging external foreign borrowing. On the other hand, the reserve-import ratio may rise in oil-exporting and non-oil developing countries when lower money growth in the US dampens the rise in the price of their imports and encourages them to hold foreign assets in liquid form.

The effect of the market price of gold reserves on the non-gold reserve-import ratio is mixed. Countries may have a demand for total reserves including gold, but not for non-gold reserves *per se*, to buffer their economies against variations in international receipts and payments. An increase in the average market price of gold reserves may tend to reduce the residual demand for non-gold reserves to meet their stabilization objectives. Alternatively, the official holders may sell off part of the appreciated gold and thereby raise the non-gold reserve-import ratio.

Furthermore, a net rate, calculated as the average spreads over the LIBOR on syndicated credits to the sample country groupings plus the three-month LIBOR rate and less the three-month US Treasury bill rate, was introduced as an opportunity cost of holding reserves. The increased spreads over LIBOR for the LDCs also reflect their lower credit-worthiness as a result of the worsening debt service ability. A high net rate will tend to induce a lower level of reserve holdings and therefore a lower reserve-import ratio.

Finally, to account for the effect of rapidly developing international banking credits, we have introduced a variable, CIBC, defined as the growth rate of the Eurocurrency international banking credits, into the regression equation. An increase in the international banking credits tends to reduce countries' holdings of international reserves. The regression techniques were applied to each country grouping separately. Serial correlation was dealt with by applying the Cochrane-Orcutt iterative procedure. The EGLS regression results are presented in Table 3.4.

For all three country groupings, the changes in the SDR price of the US dollar, CER, have a significantly negative effect on the non-gold reserve-import ratio, as predicted. The effect on the reserves of oil-exporting and non-oil

Table 3.4 Demand For International Reserves, 1981:IV-1988:I[1] (Estimated generalized least-squares results for each of the three groupings of countries). Dependent variable: Log of non-gold reserve-import ratio.[2]

Independent variable	Industrial countries excluding the US	Oil exporting countries	Non-oil developing countries
Regression number:	(1)	(2)	(3)
Intercept	-2.654	-0.777	-0.712
	(4.75)	(0.76)	(2.37)
CER (Change in exchange rate)	-0.253	-1.050	-0.470
	(1.74)	(2.45)	(2.32)
UNEM (Unemployment rate in US)	-0.045	-0.068	-0.041
	(5.02)	(1.67)	(2.71)
MG (M2 growth in US)	-	-0.005	-0.001
		(1.49)	(0.48)
MGD (Difference in M2 growth)	0.007	-	-
	(3.06)		
Rate (Spread plus LIBOR minus TB rate)	-0.023	-0.009	-0.027
	(2.04)	(0.78)	(3.69)
GP (Market price of gold)	0.263	0.279	-0.049
	(2.72)	(1.84)	(0.80)
CIBC (Changes in International banking credits)	-0.363	-0.343	-0.591
	(2.06)	(0.82)	(3.13)
Regression statistic			
Adjusted R^2	0.878	0.847	0.781
SEE	0.045	0.064	0.041
Durbin-Watson	2.17	1.06	2.13
RHO	-0.352	0.884	-0.439

1. t-values in parentheses.

2. In the construction of the dependent variable, non-gold reserves at the end of any quarter were divided by the average annual US dollar values of imports, before taking the logarithm. CER is the percentage change in the end-of-quarter SDR price of the US dollar from four quarters ago to the current quarter. UNEM is the average quarterly unemployment rate in the US, seasonally adjusted. MG is the seasonally adjusted US M2 growth rate converted to period averages and expressed as index numbers (1980=100). MGD is the difference between the US M2 growth rate and those of industrial countries converted to period averages and expressed as index numbers (1980=100). Rate is the average spreads over the LIBOR on syndicated credits (excluding fixed rate issues) to the sample groupings plus the three-month LIBOR rate and less the three-month US Treasury bill rate. GP is the average of that and the previous end-of-quarter's US dollar gold price registered in the London market, before taking the logarithm. CIBC is the percentage change in the end-of-quarter Eurocurrency international banking credits from two quarters ago to the current quarter. The data for generating the variables Non-gold reserve-import ratio, CER, MG, MGD, Rate, GP were collected from *International financial statistics* and its supplements. The average spreads over the LIBOR on syndicated credits were provided by World Economy and Finance Division at Bank of England. UNEM were collected from US *Federal Reserve Bulletin*. CIBC were collected from Morgan Guaranty Trust Company's *World Financial Markets*.

developing countries is even larger. Since most of the LDCs lack capacity in foreign exchange market intervention, this may be attributable to the increased ease and lower cost of international borrowing rather than to intervention associated with a falling dollar. Reductions in worldwide economic activity proxied by a rise in the US unemployment rate, UNEM, have the same effects, as they tend to be associated with a lower non-gold reserve-import ratios in these countries as predicted. If the US money supply is growing faster than those in other industrial countries, the non-gold reserve-import ratio for other industrial countries will be raised. Specifically, if the US M2 rose by 1 percentage point while money growth in other industrial countries remained constant, the non-gold reserve would be 0.7 per cent higher in industrial countries excluding the US. However, they would be 0.5 and 0.1 per cent lower in oil-exporting and non-oil developing countries respectively, perhaps because more inflationary US policies induce accelerated diversification of their non-gold reserves into other international assets, including gold. The market price of gold exerts a significantly positive effect on the reserve-import ratio for industrial and oil-exporting countries. The regression coefficient for non-oil developing countries is negative. However, it is statistically insignificant.

Our attempts to include the opportunity cost of holding reserves into the reserve demand equation generate some mixed results. Although the signs of regression coefficients for each country groupings are consistently negative as predicted, they are statistically significant only for industrial and non-oil developing country groupings. The insignificant coefficient parameter for oil-exporting countries suggests that for these countries the difference between borrowing and lending rates does not play a significant role in the determination of the reserve-import ratio.

The same applies to the demand elasticities of Eurocurrency international banking credits. The growth in the international banking credits has reduced the demand for reserves by both industrial countries excluding the US and non-oil developing countries. The higher elasticity of demand for reserves with respect to international banking credits for non-oil developing countries suggests these countries' reserve demand behaviors are very sensitive to external borrowing. Although it is generally agreed that LDCs lack accessibility to the international capital markets, the rapid increases in the international banking credits provide countries with additional international liquidity and consequently lower demand for reserves. These findings are accentuated by the fact that developing countries accumulated debt in the early 1980's was at a rate

exceeding 20 per cent per year. This huge increase in indebtedness was made possible by the liberal way in which the international financial community and in particular the banks, provided funds to these countries.

Overall, the regression results are satisfactory with the exception of those for oil-exporting countries. The regressions explain at least 78 per cent of the variations in the logarithms of reserves in per cent of imports for each grouping of countries. The standard errors of estimate are less than 6 per cent for each of the groupings. Durbin-Watson statistics for both industrial countries excluding the US and non-oil developing countries are in the range of accepting the null hypothesis that there is no serial correlation in the error term, after correction.

(3.3) Summary.

In this chapter, a comparative approach to the theory of demand for international reserves has been developed and empirically investigated. To conduct a comparative study on the countries' reserve demand behavior in a systematic way is a new effort. The study has been conducted in both long-term and short-term perspectives.

Previous studies tested the reserve demand functions between different countries and provided mixed results. This

study, via a set of empirical tests, shows consistent evidence in support of the hypotheses derived from the theoretical model. It has been shown that countries' demand for international reserves is not only determined by economic variables, but is also affected by institutional as well as the structural conditions in the economy.

The identified determinants in the reserve demand functions include: (1) real factors such as the level of real imports; (2) disturbance factors which are associated with the variance of international receipts and payments such as the changes in the US dollar exchange rate, the money supply, the business cycle, the market price of gold, the difference between the borrowing and the lending rate, and the size of international banking credits; and (3) structural factors such as the level of imports in per cent of the national income.

The level of real imports exerts a significantly positive effect on the demand for reserves. While the variance of international receipts and payments is positively associated with reserve demand, there is a negative relationship between countries' marginal propensities to import and the demand for international reserves. The impact of the opportunity cost of holding reserves on the countries' reserve demand behavior is basically consistent with findings from previous studies.

The inverse relationship between these two is significant for industrial and non-oil developing countries and insignificant for the oil-exporting countries.

Other factors such as changes in the SDR price of the US dollar, US money supply as compared to the rest of the industrial countries, the US unemployment rate, the market price of gold, and the growth of international banking credits have a significant effect on countries' reserve holdings in per cent of imports. Among the disturbance factors, the changes in international banking credits and in the SDR price of US dollars, and the market price of gold, are relatively more important in the determination of reserve holdings by industrial countries. While changes in the US dollar exchange rate and the market price of gold are the two major determinants in the reserve demand equation for oil-exporting countries, the later variable has no significant role in the reserve demand equation for non-oil developing countries. Instead, the size of international banking credits has the major impact on non-oil developing countries' reserve holdings.

It is the first time in the literature that a study has found empirically a significant impact of the growing international bank lending on countries' demand for reserves in percentage of imports. International borrowing has apparently provided countries with additional funding

sources to finance disequilibrium in the international receipts and payments. Therefore, the analysis of the determination of reserve adequacy should take into account the size of the international borrowing. This in turn suggests that control the growth of international reserves and a coherent management of aggregate international liquidity can play an important role in avoiding potential global excesses or deficiencies in liquidity.

This study has revealed that, in general, less developed countries require higher reserve holdings and a greater use of adjustment as compared to those required by developed countries. The structural and institutional differences between different economies, such as the differences in the economic system, the financial system and organizations, the efficacy of monetary and fiscal policies, and accessibility to the international capital markets contribute to the influence of the explanatory variables upon different country groupings' demand for international reserves. The policy implications of these findings are that for LDCs, optimal reserve holdings depends on the progress of these economies in making structural changes and financial reforms such as the increasing degree of financial deepening. The same will apply to centrally planned economies. The demand for reserves by CPEs will be studied in the next chapter.

Chapter 4. China's Demand for International Reserves, A Case Study for a Centrally Planned Economy

The reserve demand behavior in a centrally planned economy has its own unique pattern, although the general principle of holding reserves developed in Section (3.1) applies. In this chapter, China's demand for international reserves will be theoretically analyzed and empirically examined. Section (4.1) describes a brief history of China's external economy and reserve developments. A theory of reserve demand by CPEs will be developed in Section (4.2). Section (4.3) presents empirical estimations of China's demand for reserves. The chapter ends with a summary in Section (4.4).

(4.1) China's Demand for International Reserves, Past and Present.

China's external economic relations have experienced dramatic changes since the economic reforms were initiated in 1979. Reserve demand management in China became increasingly important as a result of China's open door policy and its rapid increases in foreign trade and international borrowing activities. Section (4.1.1) first gives a brief history of China's external economy. The relationships between foreign trade, investment, money and China's reserve demand are discussed in Section (4.1.2).

(4.1.1) A brief history of China's external economy.

China's demand for international reserves has experienced dramatic changes during the past four decades. For a long time after the founding of the People's Republic, the annual foreign exchange receipts or payments stayed under 10 billion US dollars. This was due to the fact that foreign trade, the main source of foreign exchange earnings, was done on a limited scale. During this period, capital flows were insubstantial. The foreign trade payments were based on the principle of "making imports contingent on exports, suiting expenditure to income, and striking a balance between the two while allowing a little surplus" (Liu, 1987, p. 510). Under these circumstances, there was no significant demand for international reserves. This changed when economic reforms began. The change in reserve demand behavior has been closely related to the rapid development of foreign trade and capital flows.

The principal objectives of the economic reforms initiated in 1979 were greater efficiency of resource allocation, technological modernization, and the establishment of a firm basis for sustained growth and a rising material standard of living for the Chinese people. The institutional and procedural details of the new system, described as "socialism with Chinese characteristics," are

being defined through a cautious process of trial and error, rather than in accordance with a clear and well-defined blueprint. Nevertheless, several broad guidelines, emerging from the authorities' analysis of the underlying causes of the inefficiencies in the pre-reform system, have set the directions for reform. Specifically, the reforms are moving the system toward greater decentralization of microeconomic decision-making; increased reliance on markets and material incentives; and an opening of the economy to foreign trade, investment, and technology.

The reform in external economic relations is of particular significance. For one thing, it implies a fundamental change in China's development strategy, from self-reliance in a relatively closed economy to interaction and integration with the world market in a relatively open economy. For another, the management of the external sector will be an important determinant of the prospects for success in China's modernization.

The open door policy apropos the external sector, in its various manifestations, has led to changes in objective and priorities in several spheres since the late 1970's. The role of foreign trade is no longer limited and passive; it is large and active as China pushes for an expansion of trade to exploit its comparative advantage in an interdependent world economy. The stress on indigenous

technological development has given way to imports of technology on a large scale from the industrial countries. The reliance on domestic resources alone to finance development has been diluted by a conscious effort to induce foreign capital inflows and, in particular, attract direct foreign investment.

For a long time, the function of external trade in China was to provide a residual balance. Imports were necessary either to meet shortfalls in domestic production and fill the gaps in material balances, or to provide necessities that could not be produced within the domestic economy in sufficient quantity, if at all. Exports, in turn, were necessary to finance such imports. In such a system, domestic prices are insulated from world prices, and the exchange rate does not relate to the structure of internal and external prices. Hence, the pricing of foreign trade transactions in the domestic market is quite independent of what it would be in the world market, which is in keeping with objectives of maintaining domestic price stability and protecting domestic industries. As a rule, exports are purchased in the home market at domestic prices and sold in the world market at international prices, whereas imports are purchased in the world market at international prices and sold in the home market at domestic prices. Until the early 1980's, the exchange rate prevalent in China meant that, in terms of the local currency, the domestic prices of

exportables and importables were higher than the corresponding world prices. Consequently, most exports received an implicit subsidy in the form of an accounting loss, while most imports paid an implicit tax in the form of an accounting profit. Such profits and losses, over a period of time, have compensated for each other in the centralized foreign trade system that was a state monopoly.

There was a qualitative change in the role assigned to foreign trade at the end of the 1970's, which was associated with the reform in external economic relations and the open door policy. The foreign trade sector had a strategic function to perform in the quest for the Four Modernizations (i.e. Modernization in industry, agriculture, science, and defence). At one level, China moved from a system where the size of foreign trade was determined not so much by import needs as by export possibilities. In a wider context, the role of foreign trade was no longer residual but became that of an important catalyst. Two perceptions emerged. First, a belief that participation in world trade and integration with the world market would facilitate modernization. Second, it was felt that closer proximity between domestic prices and world prices would not only yield larger gains from the international division of labour but also improve efficiency at home through the exploitation of comparative advantage.

Table 4.1 shows a rapid growth in both exports and imports in the last decade, which was pronounced and concentrated during a few years in the 1980's. The pace of change was slow initially but accelerated after 1983. Exports which had risen from 13.614 billion US dollars in 1979 to 22.177 billion dollars in 1983 went up to 27.327 in 1985 and 51.626 billion dollars in 1989. The growth in imports was more spectacular - from 15.621 billion dollars in 1979 to 42.526 billion dollars in 1985 and 58.282 billion dollars in 1989. To obtain an assessment in the wider context of the national economy, it is worth comparing the foreign trade sector with a macroeconomic aggregate such as national income. The share of foreign trade in China's national income was less than 6 per cent in 1970. However, this share rose from less than 10 per cent in 1977 to 21.1 per cent in 1985 and 31.4 per cent in 1989. This suggests that, in terms of the share of foreign trade in national income, the Chinese economy is now more open than that of Japan, United States or India (the shares of foreign trade in national income are 21.3, 18.3 and 12.4 per cent in 1989 respectively), though these values do not reflect domestic prices which are far below the world prices in China.

Table 4.1 China's International Reserves, Foreign Trade, and Reserve-Import Ratio (%), 1977-1989 (Billions of US dollars, End of year)

Year	Total Reserves[1]	Non-Gold Reserves	Imports	Exports	Reserves -Import Ratio	Non-Gold Reserve -Import Ratio
1977	2.889	2.345	7.148	7.520	40.4	32.8
1978	2.141	1.557	11.131	9.955	19.2	14.0
1979	2.744	2.154	15.621	13.614	17.6	13.8
1980	3.117	2.545	19.941	18.099	15.6	12.8
1981	5.575	5.058	21.635	21.465	25.8	23.4
1982	11.839	11.349	18.900	21.872	62.6	60.0
1983	15.452	14.987	21.336	22.177	72.4	70.2
1984	17.802	17.366	25.950	24.831	68.6	66.9
1985	13.216	12.728	42.526	27.327	31.1	29.9
1986	11.997	11.453	43.172	31.147	27.8	26.5
1987	16.936	16.305	43.392	39.542	39.0	37.6
1988	19.140	18.541	55.278	47.540	34.6	33.5
1989	18.544	17.959	58.282	51.626	31.8	30.8

1. Gold is valued at SDR 35 per Ounce.
Source: *International Financial Statistics*, various issues.

It is worth noting that transactions on the capital account had become significant even before 1985 when a substantial need for foreign capitals arose. The smaller current account deficits in the late 1970's were financed mostly by short-term borrowing but long-term external borrowing also emerged at about the same time. It took several forms: credits and deferred payments to finance imports, borrowing in international capital markets, bilateral aid from the industrial countries and multilateral assistance from international financial institutions. The significance of long-term borrowing on the capital account increased much further in the 1980's while short-term borrowing receded in importance. Table 4.2 shows the foreign capital inflow since the end of 1970's. China's external borrowing had been increasing steadily from 1.513 billion US dollars in 1983 to 8.407 billions in 1986 and 9.813 billions in 1988, while direct foreign investment rose from negligible levels in the late 1970's to several billion US dollars per annum in the middle of 1980's. The total direct foreign investment amounted to 28.165 billion US dollars from 1979 to 1988, and the total amount of foreign borrowing was 46.549 billion dollars during the same period. Over the period of 1983 and 1988, debt-service was an average of more than one billion dollars a year.

The rapid increases in foreign trade and the flow of capital accentuate the importance of reserve management

Table 4.2 China's Foreign Borrowing and Debt Service, 1979-1988, (Billions of US dollars)

	Foreign Borrowing	Foreign Direct Investment	Other Foreign Investment	Debt-service[1]
1979-88	46.549	28.165	3.799	-
1979-82	13.549	6.010	0.989	-
1983	1.513	1.732	0.185	1.846
1984	1.916	2.651	0.224	0.813
1985	3.534	5.932	0.401	1.018
1986	8.407	2.834	0.496	0.927
1987	7.817	3.709	0.610	1.394
1988	9.813	5.297	0.894	1.146

1. Current interest and amortization payments on public and publicly guaranteed external debt.
Sources: *Zhong Guo Tong Ji Nian Jian* (Statistical Yearbook of China), Various issues.

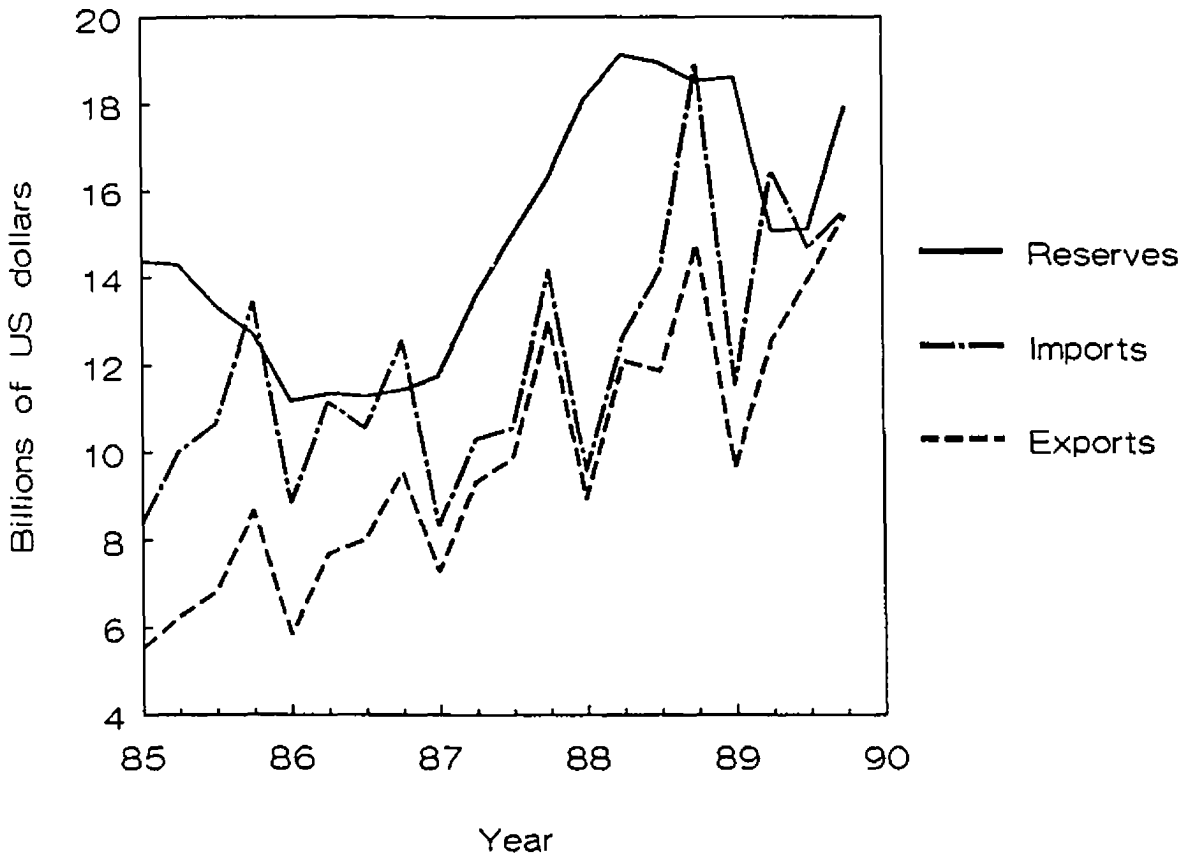
in China. There is a general tendency that the transaction and precautionary demand for international reserves in China have substantially increased during the last decade. While China's total reserves (Gold was valued at SDR 35 per Ounce) were increased from 2.889 billion US dollars in 1977 to 11.839 billion in 1982 and 18.544 billion in 1989, the non-gold reserves were increased from 2.345 billion to 11.349 and 17.959 billion during the same period (see Table 4.1). Meantime the country's gold reserves were kept at a nearly constant level of 12.7 million ounces per annum. Although the non-gold reserve-import ratios were fluctuating between 10 to 70 per cent in the first half of the 1980's, it was relatively stable at a level of more than 30 per cent in the second half of the 1980's.

(4.1.2) Trade, investment, money, and China's demand for international reserves.

Figure 4.1 shows the movement of China's stock of non-gold reserve holdings, commodity exports and imports over the 20-quarter period from 1985 to 1989. Several trends can be observed.

First, consider the cyclical pattern of China's non-gold reserve holdings. Although the general level of China's non-gold reserve holdings was rising over the 20-quarter period, there were cyclical variations during this period.

Fig. 4.1 China's Non-Gold Reserves, Imports and Exports



Source: International Financial Statistics, various issues.

China's non-gold reserve holdings experienced a decline between the second quarter of 1985 and the third quarter of 1986. It was followed by a steady increase for four quarters. Another cycle started at the beginning of 1988.

The cyclical variation of China's stock of non-gold reserve holdings was closely associated with the change in the trade balance. A decline in the country's non-gold reserve holdings from 14.376 billion to 11.453 billion US dollars over the period from the first quarter of 1985 to the fourth quarter of 1986 was accompanied by an average quarterly trade deficit of 3.4 billion US dollars (see Table 4.3). Throughout the period from the first quarter of 1987 to the second quarter of 1988, the average trade deficit was reduced to one billion US dollars, meanwhile the country's non-gold reserve holdings increased from 11.784 billion to 19.143 billion US dollars. A new cycle was observed starting from the third quarter of 1988.

The second obvious feature observed from Figure 4.1 is the seasonal variation of foreign trade activities. Commodity imports and exports rose in the fourth quarter and fell in the first quarter of the year. This pattern of seasonal variation was also observed with respect to the trade balance. From 1985 through 1988, the average trade deficit was 1.87 billion US dollars in the first quarter and

Table 4.3 China's Balance of Trade and Reserve demand 1985:I-1989:IV (Billions of US Dollars, End of period)

	Imports	Exports	Balance[1] of Trade	Non-gold Reserves
1985:1	8.36	5.54	-2.82	14.376
2	10.04	6.27	-3.77	14.298
3	10.67	6.84	-3.83	13.366
4	13.45	8.68	-4.77	12.728
1986:1	8.85	5.85	-3.00	11.199
2	11.17	7.71	-3.46	11.362
3	10.57	8.04	-2.53	11.295
4	12.58	9.56	-3.02	11.453
1987:1	8.32	7.28	-1.04	11.784
2	10.32	9.35	-0.97	13.551
3	10.58	9.88	-0.70	14.949
4	14.18	13.03	-1.15	16.305
1988:1	9.56	8.93	-0.63	18.148
2	12.66	12.12	-0.54	19.143
3	14.17	11.88	-2.29	18.970
4	18.95	14.76	-4.19	18.541
1989:1	11.55	9.66	-1.89	18.637
2	16.49	12.58	-3.91	15.093
3	14.68	13.96	-0.72	15.108
4	15.57	15.43	-0.14	17.960

1. The difference between total exports and total imports of the economy; a negative sign indicates that imports exceed exports and *vice versa*.
Sources: *International Financial Statistics*, Various issues.

3.28 billions in the fourth quarter. The low trade deficit in the fourth quarter of 1989 was due in large part to the huge increase in the commodity exports following a major devaluation of the Chinese RMB Yuan exchange rate.

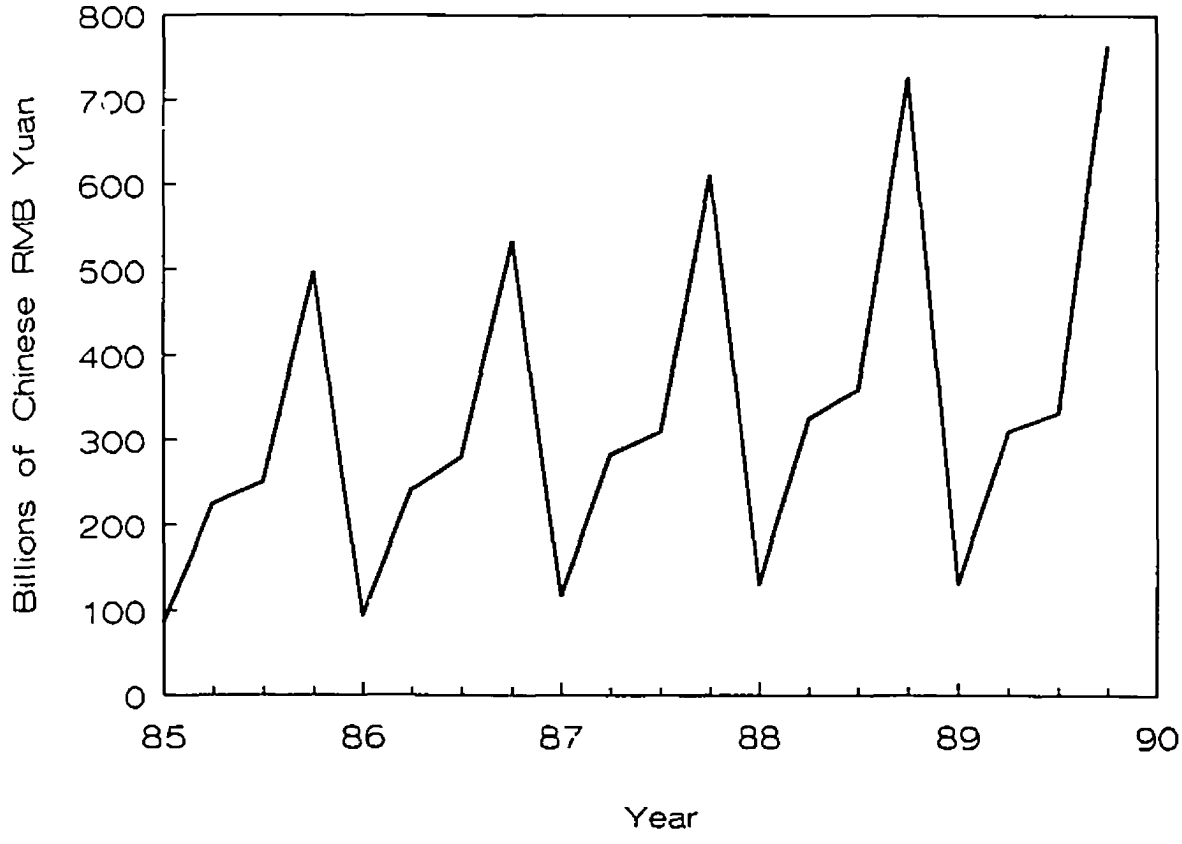
The seasonal variations in China's exports and imports as well as its trade balance are the results of fluctuations in China's capital investment. Table 4.4 shows the time series values for quarterly capital investment in China for 20 quarters from 1985 to 1989. The data in the first column of Table 4.4 are graphed in Figure 4.2 using a frequency polygon. The pattern presented in the data is quite evident. Apparently, the general level of capital investment was rising substantially over the 20-quarter period, but there were also marked seasonal fluctuations in investment. The fourth quarter had an especially high level of investment, while the first quarter was characterized by a low level of investment. While the average investment in the first quarter was 111.77 billion RMB Yuan over the five-year period, it was as high as 626.73 billion RMB Yuan in the fourth quarter over the same period. This pattern of capital investment is typical of CPEs where the fulfillment of annually planned investment expenditure is the first priority, although the data may be manufactured by the statistical bureau. The same pattern can be observed in terms of the investment-output and investment-expenditure ratios in China (see Table 4.4).

Table 4.4 China's Investment Growth and Credit,[1] 1985:I-1989:IV (Billions of RMB Yuan, End of period)

	Total Capital Investment	Total Industrial Output	Investment as % of Output	Investment[2] as % of Expenditure	Total Industrial Credits
1985:1	86.20	1,903.8	4.5	4.7	88.851
2	225.69	2,178.3	10.4	12.2	91.181
3	251.99	2,057.9	12.2	13.7	95.682
4	497.49	2,111.5	23.6	27.0	116.508
1986:1	94.36	1,987.2	4.7	4.0	121.132
2	242.34	2,294.0	10.6	10.4	134.753
3	281.23	2,230.0	12.6	12.1	143.475
4	534.56	2,446.4	21.9	22.9	163.351
1987:1	117.40	2,262.5	5.2	4.8	166.565
2	284.15	2,654.7	10.7	11.6	175.179
3	311.21	2,588.2	12.0	12.7	187.876
4	611.34	2,774.2	22.0	25.0	204.361
1988:1	130.06	2,644.9	4.9	4.9	178.986
2	325.96	3,122.4	10.4	12.2	186.807
3	360.70	3,055.9	11.8	13.5	197.958
4	726.57	3,297.0	22.0	27.2	208.509
1989:1	130.84	2,919.3	4.5	4.3	212.575
2	311.38	3,470.3	9.0	10.3	222.350
3	332.09	3,219.5	10.3	11.0	235.303
4	763.68	3,321.5	23.0	25.3	272.463

1. Total capital investment presents data on capital construction investment by administrative unit. Total output value of industry is at 1980 constant prices.
2. The ratio of total capital investment to the government expenditure, where the government expenditure is the average annual rate.
Sources: *Zhong Guo Tong Ji Yue Bo* (China's Statistics Monthly); *Zhong Gou Jin Ron* (China's Finance), Various issues.

Fig. 4.2 China's Capital Investment



Source: China's Statistics Monthly

The seasonal variations in capital investment were parallel to the seasonal variations in commodity exports and imports, and consequently those of the trade deficit. A surge in capital investment requires an increase in commodity imports, which in turn needs to be financed by an increase in exports of goods and services or foreign borrowing. For an economy such as a CPE, where exports are in large part exogenously determined and access to external borrowing is limited, the resulting trade deficit may be financed only by running down a country's international reserves or by imposing a major adjustment.

The cycle of expansion-imbalance-contraction-adjustment in a CPE such as China is a result of its rigid planning system and the inefficiency of its macroeconomic policy. There is a cyclical pattern in the policy implementation. Major steps forward have been followed by periods of some retrenchment or slow advance, as economic problems, especially excess demand and inflation, have appeared. For example, periodic fluctuations in monetary policy can be broadly attributed to the government's haphazard investment. From the end of 1983 to the fall of 1984, the preliminary liberalization of the banking system and relatively easy money policy stimulated the initiative of enterprises with an accompanying high growth rate. From the end of 1984 to the summer of 1985 excessive aggregate demand gradually rose. It became serious in the middle of 1985. The very

rapid increase in consumer incomes, and hence demand could be met only by allowing a substantial increase in imports. China's commodity imports jumped from 25.95 billion US dollars in 1984 to 42.526 billion in 1985, an increase by more than 63 per cent, while the exports were only increased from 24.831 to 27.327 billion US dollars. This led to a huge trade deficit of 15.199 billion US dollars. About two third of the deficit was financed by the service sector surplus and the capital inflow. The rest of it was financed by running down its international reserves. China's non-gold reserve holdings were decreased from 17.366 billion US dollars in 1984 to 12.728 billion in 1985 (see Table 4.1).

The central government tried to rely on indirect instruments of monetary control, especially lending by the People's Bank of China (PBC) - China's central bank - to banks. However, the PBC's ability to control money growth has been limited by local government pressure to expand credits. In the latter half of 1985, the very tight quantity rationing of the banking business was adopted and the excessive growth rate slowed down step by step within half a year. But at the beginning of 1986, while the aggregate money supply had not yet been tightened enough, the irrational sectoral structure of loans emerged. The big coastal cities and large-scale industries were seriously short of working capital. Some local growth rates became zero or negative, while the impact on small industries and

industry in the countryside, which are more dependent on private relations with loan agents, was relatively small. With a view to improving this sectoral structure and supporting the scale of the economy, another round of easy money policy came along.

Total industrial credits (see Table 4.4) reveal a continuing trend of expansionary monetary policy that had not shown any signs of reversal in the last few years up to the first quarter of 1988. The deficit financing of the state, through the issue of money, and the over-expansion of the money supply, which is caused by excessive investment, are the major causes of the acceleration of inflation in China in 1987. The high inflation in 1987 had forced the central leadership to adopt another stringent economic policy in the latter half of 1987.

It was believed that a prolonged relaxation of import curbs to rectify consumer markets would lead to an undesirable, and at any rate unsustainable, deterioration in the external balance. Periodic devaluations of China's currency became a major policy tool to cope with the issue. A major devaluation of China's RMB Yuan was introduced in the third quarter of 1986, together with the other measures of import restriction and export promotion. While the commodity exports continued to grow at an average of 20 per cent per annum between 1986 and 1987, the growth of China's

commodity imports was kept at as low as 1 per cent (a negative real growth) on average during the same period. At the end of 1987, China's trade deficit was reduced to 3.85 billion US dollars and the decline of China's non-gold reserve holdings was reversed. However, towards the end of 1989, another huge trade deficit and reduction of non-gold reserve holdings were registered. On December 16 of 1989, another devaluation of Chinese RMB Yuan was announced.

The fluctuations in China's capital investment, which is a result of China's rigid planning system and policy inefficiency, its role in the variations of China's foreign trade activities and consequently its reserve holdings, feature the unique pattern of China's international reserves movements. China's reserve demand behavior will be theoretically analyzed and empirically investigated in the following section.

(4.2) A Theory of Demand for Reserves by Centrally Planned Economies.

The reserve demand behavior in a CPE like China has some unique characteristics. The pattern of China's demand for international reserves is in part determined by its economic planning system. In this section, the basic characteristics of CPEs will be stated in Section (4.2.1).

Section (4.2.2) presents a theoretical model of reserve demand by CPEs.

(4.2.1) Basic characteristics of centrally planned economies.

The economic system that evolved and developed historically in China can be characterized by the general features of centrally planned economies (CPEs).[16] Among them are:

(1) State ownership of the means of production. The state administration gains a dominant role through a large share of state ownership.

(2) Detailed central plans for enterprise inputs and outputs and for foreign trade. The activity of economic units is directed by government administration using the directive elements of central planning - target setting and central allocation of resources - to coordinate enterprise activities with the national economic plan. Foreign trade and the balance of payments are also controlled by the planners through a system of direct controls.

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16. A number of authors have discussed the general characteristics of CPEs. Among them are Holzman (1968, 1979, 1981), Perkins (1973), Kornai (1980), Allen (1982) and Wolf (1985).

(3) The role of the monetary system is to finance the plan. The system requires price and income regulation that makes it possible to cover the costs incurred in implementing the plan. Plan fulfillment rather than profit is the main evaluative criterion for the enterprises.

(4) The incomes of citizens are derived from activities of centrally regulated organizations. Remuneration for enterprise management and employees, as well as financial incentives of an egalitarian nature, are defined in the plan.

There are many ancillary features associated with traditional central planning in addition to those four. Among the most important are: forced economic growth; strong uncontrolled state preferences that distort the pattern of resource allocation; the insulation of the economy from the noncontrolled external world economy; and stable prices over long periods.

The initiation of the economic reforms and the open-door policy in China since 1979 have brought about a process of decentralization of the economy and have, to a certain extent, broken the insulation between China's economy and that of the rest of the world. However, the basic economic infrastructure of China's socialist economy and its planning system in various economic sectors remain unchanged. The

unique adjustment process to internal and external balance and consequently reserve demand behavior under such a system are analyzed in the following sections.

(4.2.2) Investment, monetary policy cycles, and reserve demand.

In principle, a country's long-run demand for international reserves is determined by the variance of its balance of payments, the level of imports or the national income, the marginal propensity to import, and the opportunity cost of holding reserves. This applies to a CPE where the precautionary and transaction demand for reserves may be higher due to its structural and institutional characteristics (refer to Section (3.1)). Here, a country's long-run demand for reserves is also its desired level, or optimal level of reserves.

The stock of reserves is the reserves actually held by a country. Although the actual level of reserves tends to adjust to its desired level over time, there are discrepancies between the desired and actual level of reserves during certain period of time. In China, this adjustment process is affected by the investment and monetary policy cycles.

Major policy goals in a CPE typically have included rapid economic growth fueled by high rates of industrial capital accumulation. The main source of demand-side disturbances in CPEs is the investment cycles that develop from fundamental excess demand in an environment of perceived chronic shortage. It is therefore widely agreed that in a CPE the investment cycles are the primary cause of the changing degree of imbalance in the consumer and foreign trade sector.[17] This process is usually accompanied by a cycle of monetary policy with the alternative of tight and easy money.

In China, as in other CPEs, some of the domestic disturbances, and in particular the fluctuations in investment, were the result of complex and as yet inadequately understood interactions between the authorities themselves and lower-level decision-making units. A case can be made for the view that a policy response to such disturbances takes place in two analytically distinguishable steps.

In the first stage, which may run from several months to a longer period, authorities adhere to the basic investment goods priority that has characterized economic development. That is the continued importance of rapid

17. See Bauer (1978), Kornai (1982), Winiecki (1982), Tyson (1983), Wolf (1985) and Brada, Hewett and Wolf (1988).

economic growth as a goal of the planners, and the continuing implicit preference of the planners for investment goods. Enterprises may purposely understate their total investment requirement when "hooking on" to the plan. The result is a surge in the demand for investment goods that spills over into the foreign trade sector. Here, the enterprises' excess demand could be the result of policy mistakes, such as too lax a credit policy, and of subtle systemic features of the planned economies, such as implicit output maximization rather than profit maximization as the goal of enterprises, an inefficient price system, and the "soft budget constraint," by which the authorities accommodate the credit and subsidy demands of enterprises, thereby weakening financial discipline.[18]

The investment goods priority combined with price stability means that short- and medium-run adjustment will involve primarily quantity rather than price changes. These quantity responses will appear as growing excess demand pressures in the consumption sector while the growth in output of consumer goods fails to keep up with rising household incomes, as well as in a deterioration in the balance of trade. The latter may occur if the country initially has plentiful international reserves or easy access to foreign credit and if the diversion of resources into investment eats into exportable surpluses and, together

18. On the soft budget constraint see Kornai (1980).

with the emerging shortage of consumer goods, leads the authorities to step up imports. Thus, there would be a positive correlation between the share of investment in domestic spending and trade deficits in a CPE.

In the second stage, planners attempt to bring the external deficit under control and to restore some degree of balance to the market for consumption goods. Resources are diverted away from investment and imports and channelled into consumption and exports. Here real imports have borne the burden of adjustment in CPEs for two reasons. First, it is easier for the authorities to decree that real imports be reduced so as to induce domestic enterprises to increase the quantity of exportables to be supplied abroad, particularly in the context of domestic macroeconomic policies that continue to accommodate internal excess demand pressures. Second, these countries may have market access problems in exports and encounter quantitative restrictions. Consequently the expansion of real exports, without significant further deterioration in their terms of trade, has been relatively difficult. To the extent that CPEs are aware of their selling difficulties, they can tailor plan imports to amounts which can be financed through exports. However, the planners usually overestimate the amount of exports they can sell in the world market. When *ex ante* export plans are not fulfilled, the *ex ante* balanced trade plan becomes an *ex post* deficit (with unplanned drawing down

of reserves or unplanned credits) and/or import plans cannot be fulfilled. This adjustment stage may arrive slowly because of the inertia that characterizes economic management in planned economies and because of the relatively heavy reliance on quantity rather than price adjustments. Its advent may also be significantly delayed if external credit conditions are particularly favorable.

The gradual improvement in the external balance creates an environment conducive to a reemergence of excess demand for investment goods, and the cycle begins again.

Corresponding to the investment cycle, in China, the banking system characteristically generates a monetary policy cycle - cycling between tight and easy money policies. That is, when an easy money policy is carried out, the behavior of loan agents causes damage to the sectoral structure due to the distorted price signals. With the intention of improving the sectoral structure and giving play to enterprise initiatives, the bank is urged by governmental intervention to extend its easy money policy further. Once aggregate demand becomes seriously excessive, the Central Bank has to use a comprehensive shrinking policy through credit rationing and loan quotas without appropriately differentiating among individual transactions, which causes a slump and depresses many enterprises.

If investment fluctuations are an important determinant of changing levels of macroeconomic imbalance in centrally planned economies, we would expect increases in the growth rate of investment to be positively correlated with some measure of excess money supply, and negatively correlated with the overall trade balance. In other words, an excessive investment expenditure, fueled by an easy monetary policy, leads to a trade deficit. To finance the deficit by running down a country's stock of reserve holdings leads to the actual reserves being below its desired level. Imports, investment (as well as money supply or credit) are then tightened to restore reserves to the desired level. There is overshooting and too many reserves accumulate. This sets off easing of restrictions and higher investment, which in turn overshoot and deplete reserves. And so on. This unique reserve demand behavior will be empirically examined in the next section.

(4.3) Empirical Estimations of China's Demand for International Reserve.

Based on the theory of reserve demand in the comparative framework (Section 3.1) and the unique pattern of the reserve demand behavior identified in China (Section 4.2), this section includes empirical tests for the purpose of providing evidence regarding reserve demand in China. Section (4.3.1) outlines the model and empirical

specifications. A model of the dynamic adjustment of China's demand for reserves is developed. The testing procedure and empirical results are then presented and discussed in Section (4.3.2).

(4.3.1) Dynamic adjustment and China's demand for reserves.

Recall that equation (3.2.3) in Chapter 3 stated that the dynamic adjustment of reserve demand has the following form

$$R_t - R_{t-1} = \delta_0 + \delta(R^*_t - R_{t-1}), \quad (3.2.3)$$

where R_t refers to the actual level of international reserves held at period t, and R^*_t is the desired level of reserves. δ is the coefficient of adjustment.

It has also been assumed that the long-run demand for reserves can be related to four variables: (1) a measure of variability of the balance of payments, σ^2; (2) the level of imports, IM; (3) the marginal propensity to import, m; and (4) the opportunity cost of holding reserves, r. Thus, assuming that the true functional form is log-linear, the long-run demand for reserves function can be written as equation (3.2.2):

$$R^*_t = \alpha_0 + \alpha_1\sigma^2_t + \alpha_2 IM_t + \alpha_3 m_t + \alpha_4 r_t + \mu_t, \quad (3.2.2)$$

A country's demand for international reserves will vary positively with the instability of the balance of payments, ^{2}, and the level of imports, IM, and negatively with the marginal propensity to import, m, and the opportunity cost of holding reserves, r.

However, this formulation may be incomplete with respect to China's demand for reserves, since variations in China's investment expenditures may have an impact on the behavior of international reserves. For example, if a burst in investment (due to an excess supply of money or credit) is partially reflected in a reduction of reserves actually held, equation (3.2.3) will be unsatisfactory.

In order to capture the effect of the investment fluctuations on reserves movements, equation (3.2.3) can be rewritten as the following log-linear form, with the introduction of an investment disequilibrium term:

$$R_t - R_{t-1} = \delta_0 + \delta(R^*_t - R_{t-1}) + \tau(I^*_t - I_{t-1}). \quad (4.3.1)$$

This equation indicates that the actual change of international reserves will depend not only on the differences between the desired and actual reserves but also on the differences between the desired and actual investments. While the coefficient measures the speed at

which discrepancies between the actual and desired level of reserves will be corrected, measures what proportion of an investment disequilibrium will be translated, in the first period, into an accumulation or discumulation of reserves.

Substituting equation (3.2.2) into (4.3.1) yields

$$R_t = (\delta_0 + \delta\alpha_0) + \delta(\alpha_1\sigma^2{}_t + \alpha_2 IM_t + \alpha_3 m_t + \alpha_4 r_t) + (1 - \delta)R_{t-1} + \tau(I^*{}_t - I_{t-1}) + \delta\mu_t. \quad (4.3.2)$$

Equation (4.3.2) can be rewritten as

$$R_t = \beta_0 + \beta_1\sigma^2{}_t + \beta_2 IM_t + \beta_3 m_t + \beta_4 r_t + \beta_5 R_{t-1} + \tau(I^*{}_t - I_{t-1}) + \epsilon_t, \quad (4.3.3)$$

where $\beta_0 = \delta_0 + \delta\alpha_0$, $\beta_i = \delta\alpha_i$, $i = 1, \ldots, 4$, $\beta_5 = 1 - \delta$, and $\epsilon_t = \delta\mu_t$. The actual stock of reserves in China is a function of the proposed explanatory variables, its lagged variable, as well as the investment disequilibrium.

(4.3.2) Testing procedure and empirical results.

The empirical analysis includes quarterly data from China and covers the period from the first quarter of 1985 to the fourth quarter of 1989. The choice of the period of analysis was determined by the availability of a continuous series of data. Non-gold reserve holdings were chosen as the

empirical definition of international reserves, which consist of China's foreign exchange reserves, SDRs and reserve position at the IMF. The end-of-quarter data for reserves were divided into the corresponding US export unit values to obtain real reserves, R/P. The value of σ^2 for each quarter was estimated by computing the variance of exports over the previous 10 quarters; a scaling variable, measuring the size of international transactions, represented by the level of real imports, IM/P; and the marginal propensity to import, m, proxied by the ratio of imports to *GNP*. The opportunity cost of holding reserves, r, was proxied by the average spreads over the LIBOR on syndicated credits to the LDCs plus the three-month LIBOR rate and less the three-month US Treasury bill rate. The capital investment by administrative unit in China was used as the investment variable. In order to extract the seasonal component of this variable, we applied the seasonal index method to generate the seasonally adjusted series of investment in China.[20] It was then divided by China's consumer price index to get it in real terms.

The estimation of equation (4.3.3) poses two problems. First, as the equation contains a lagged endogenous variable R_{t-1}, simply estimating the equation using OLS may lead to biased parameter estimates and inconsistency if the error

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20. Details of the seasonal index method see Newbold (1988, pp. 688-93).

term is serially correlated. The problem arises because ϵ_t and R_{t-1} are correlated. However, as discussed in Section(3.2), in the partial adjustment model if μ_t of equation (3.2.2) satisfies the assumptions of the classical linear regression model, so will $\delta\mu_t$ of equation (4.3.2). Although R_{t-1} depends on μ_{t-1} and all the previous disturbance terms, it is not related to the current error term μ_t. The Durbin h Test was used to detect serial correlation. The second problem is to determine the desired level of investment, I^*. One can assume that the optimal (or desired) level of investment is the trend value of investment. Thus the differences between the actual and desired level of investment can be proxied by the deviations from the trend in investment. We regressed China's capital investment against a trend variable. The regression coefficients on the trend variable and the constant term are both statistically significant at the 5 per cent level. The differences between the actual and the predicted value of investment (*DFI*) are then used as a proxy for the investment disequilibrium term.

The following results were obtained from OLS estimation of equation (4.3.3) with the t statistics in parentheses.

$$R_t = -.848 + .064\sigma^2{}_t + .182IM_t - .226m_t - .030r_t$$
$$\quad (0.84) \quad (2.28) \quad (0.92) \quad (1.11) \quad (0.54)$$

$$+ .799R_{t-1} - .272DFI \quad (4.3.4)$$
$$\quad (5.44) \quad (4.17)$$

Adjusted R^2 = .77, SEE = 0.055, D-H = -0.28.

The results stated in equation (4.3.4) are interesting for several reasons. First, all the estimated coefficients have the expected signs. Second, the coefficients of $\sigma^2{}_t$, R_{t-1}, and *DFI* are statistically significant at the 5 per cent level. The regression explains 77 per cent of the variations in reserve demand in China.

The estimated partial adjustment coefficient is 0.201 (1 - 0.799), indicating that, with other things given, more than one fifth of the disequilibrium between the desired and actual reserves is eliminated in one quarter.

The significant coefficient of the deviations from the trend in real investment (*DFI*) suggests that variations in China's investment expenditures have had a significant impact on the country's reserve demand. Specifically, this result indicates that on average, with other things given, a 1 per cent increase in excessive investment will result in a 0.27 per cent reduction in the level of reserves held in China. A negative sign for this coefficient is consistent

with the model predictions that an excessive investment creates trade deficits and a reduction in reserve holdings, and *vise versa*.

To see if there exists any serial correlation in the error term appearing in the model, the Durbin *h* Test was applied. The calculated Durbin *h*-statistic (-0.28) is within the range of between -1.96 and +1.96. The null hypothesis that there is no first-order (positive or negative) auto correlation cannot be rejected. Therefore, we assumed that there is no serial correlation in the error term.

From the results stated in equation (4.3.4) it is possible to obtain the estimated long-run coefficients of China's demand for reserves. According to Gujarati (1988, p. 520), once we estimate the short-run demand function (equation (4.3.4)) and obtain the estimate of the adjustment coefficient, δ (from the estimated coefficient of R_{t-1}), we can derive the long-run demand function by simply dividing i by and omitting the lagged R term, which then gives the long-run coefficients of reserve demand. These coefficients are: $\alpha_1 = 0.320$, $\alpha_2 = 0.903$, $\alpha_3 = -1.123$, and $\alpha_4 = -0.150$. Considering the long-run coefficient of 0.320 for σ^2_t, it is much higher than those obtained for DCs and LDCs (see Table 3.1). A close to unity elasticity of reserve demand with respect to imports is similar to those obtained for non-oil developing countries and heavily indebted

countries. The nearly equal proportion increase in imports and reserve demand implies that there is not much evidence of economies of scale in China. The higher elasticities of reserve demand with respect to the variance of trade and the level of imports, together with the evidence of a much faster speed of adjustment in China's reserve demand, support the hypothesis that in general a CPE requires larger holdings of international reserves and it needs a more rapid adjustment to a balance of payments deficit.

Using China's reserve-import ratio as a measure of reserve-adequacy, the empirical results are accentuated by the fact that, on average, China has maintained a higher reserve-import ratio than DCs and LDCs. China's average non-gold reserve-import ratio was 34.8 per cent over the 1977-1989 period, while those for the industrial and developing country groupings were 18 and 30.1 per cent respectively. These findings further support our theoretical model's prediction that in general CPEs tend to require larger holding of reserves than other economies.[21]

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21. In a separate test (see Appendix C), we applied Equation (4.3.1) on annual data from former Yugoslavia over the period of 1960 and 1986. The regression results showed a greater than unity elasticity of reserve demand with respect to imports (1.113). This number is higher than those for industrial, oil-exporting, non-oil developing, and heavily indebted country groupings (0.622, 0.367, 0.969 and 1.053 respectively, see Test 1 of Section 3.2).

(4.4) Summary.

This chapter has examined the reserve demand behavior in a centrally planned economy. As a centrally planned economy, China's reserve demand behavior has been empirically estimated. It is the first time in the literature that the reserve demand in a CPE has been theoretically and empirically studied.

The general principle of the theory of demand for international reserves developed in Chapter 3 is quite applicable to CPEs. Among others, the identified determinants in China's reserve demand function are similar to those in DCs and LDCs. It is found that the variance of exports is the most important determinant in China's reserve demand function. The study shows China maintains a higher reserve-import ratio than those of other countries and has a much faster speed of adjustment in its reserve holdings. These findings support the basic theory of reserve demand and extensions developed in the previous chapter.

What makes this study different from previous ones is that it shows reserves movements in China respond both to discrepancies between the desired and actual reserves and between the desired and actual level of investment. The results obtained in this study suggest that, to the extent

that there is a well-defined demand for international reserves, domestic investment fluctuations cannot be considered to be completely exogenous. In fact, these results can be viewed as partial evidence that at least for China during the period from the first quarter of 1985 to the fourth quarter of 1989, variations in domestic capital investment partially responded to the existence of discrepancies between the actual and desired level of international reserves. After a burst of investment, reserves drop below the target level. Money, investment and imports are tightened to restore reserves to the desired level. There is overshooting and too many reserves accumulate. This sets off an easing of restrictions and higher investment, which in turn overshoot and deplete reserves. Such a reserves movement is in large part a result of China's rigid economic planning system and its inefficient macroeconomic policies.

There are two policy implications. Insofar as there is a significant relationship between China's reserve demand and the variance of its investment expenditure, the prediction of China's reserve demand should incorporate its investment disequilibrium considerations. This may apply to other CPEs. Further studies should be conducted when the relevant data from these economies become available.

On the other hand, the structural and institutional deficier ies inherent in a centrally planned system may prevent these economies from achieving the optimal level of reserve holdings. This is implied by the high demand for reserves and the rapid adjustment in CPEs, which is either a waste of its scarce real resources in terms of larger reserve holdings or at the expense of the domestic economy. For these countries the achievement of optimal reserve holdings depends on the progress of their economic reforms and their structural changes.

Chapter 5. Conclusions and Implications.

The preceding chapters have examined the reserve demand behavior among developed, less developed, and centrally planned economies. In order to explain different economies' demands for international reserves, a comparative approach to reserve demand was developed. The hypotheses have been tested and their empirical results reported.

Traditional studies on the demand for international reserves have revealed that a country's reserve demand is a function of certain variables and such a functional relationship is relatively stable over the long-term period. This functional relationship is found with respect to developed, less developed, and centrally planned economies. It is shown that a country's demand for international reserves is not only determined by economic variables but is also affected by the institutional as well as structural conditions in the economy. The reserve demand behavior between different economies is different due to the different institutional and structural conditions in these economy.

This concluding chapter summarizes in more detail the theoretical and empirical results on the demand for international reserves between different economies in

Section (5.1). Section (5.2) concludes with a discussion on the policy implications of this study.

(5.1) Concluding Remarks.

Based on the traditional cost-benefit approach to the demand for international reserve, this study has developed a comparative framework within which the reserve demand behavior between different economies is analyzed.

The study has presented two hypotheses about the behavior of countries' demand for international reserves. A country's desired reserve holdings are determined by its payments variability, the level of imports, the marginal propensity to import, and the opportunity cost of holding reserves. The structural and institutional differences between different economies may lead to variations in these countries' reserve demand behavior. In general, LDCs and CPEs require larger holdings of international reserves and need a more rapid adjustment to a balance of payments deficit.

Using ordinary least-squares or generalized least-squares estimation, these hypotheses were tested on the different country groups' reserve demand functions over the period from 1961 to 1989. The test was conducted in two parts. The first part investigated differences in the

reserve demand behavior between DCs and LDCs. The equilibrium approach was first applied to estimate the long-run demand function and to identify the determinants of the desired level of reserve holdings for DCs and LDCs (where LDCs were grouped as oil-exporting, non-oil developing and 15 heavily indebted countries). A test was then conducted on the speed of adjustment with respect to DCs and LDCs. Finally, a test was conducted to explain the causes of deviations between the actual and the desired level of reserves with particular emphasis on the nature and persistence of such causes with respect to different country groups. The second part examined China's reserves movements since the beginning of its economic reforms. The dynamics of adjustment of China's demand for international reserves were estimated and its long-run reserve demand behavior revealed.

In general, the results obtained have supported the hypotheses. The identified determinants in the reserve demand functions obtained from the first part of the test include: (1) real factors such as the level of real imports, and (2) the variability measure of the balance of payment such as the variance of export earnings. Other disturbance factors which are associated with the variance of international receipts and payments such as the changes in the US dollar exchange rate, the money supply, the business cycle, the market price of gold, the difference between the borrowing and the lending rate, and the size of

international banking credits; and (3) structural factors such as the level of imports in per cent of the national income.

The level of real imports is found to exert a significantly positive effect on the demand for international reserves. In terms of the relative importance of the determinants in the reserve demand function, the high elasticity of reserve demand with respect to imports shows that the level of real imports has the strongest impact on reserve demand.

While the variance of international receipts and payments is positively associated with reserve demand, there is a negative relationship between countries' marginal propensities to import and the demand for international reserves. The inverse relationship between the opportunity cost of holding reserves and reserve demand is significant for industrial and non-oil developing countries.

Other factors such as changes in the SDR price of the US dollar, US money supply as compared to the rest of the industrial countries, the US unemployment rate, the market price of gold, and the growth of international banking credits have a significant effect on countries' demand for international reserves. Among the disturbance factors, the changes in international banking credits and in the SDR

price of US dollars, and the market price of gold, are relatively important in the determination of reserve holdings by industrial countries. While changes in the US dollar exchange rate and the market price of gold are the two major determinants in the reserve demand equation for oil-exporting countries, the latter variable has no significant role in the reserve demand equation for non-oil developing countries. Instead, the size of international banking credits has a strong impact on non-oil developing countries' reserve demand.

The general principle of the theory of demand for international reserves is applicable to China, a typical centrally planned economy, although there are some unique characteristics in China's reserve demand behavior. The identified determinants in China's reserve demand function obtained from part two of the test are similar to those in DCs and LDCs. While the variability measure of the balance of payments and the level of real imports have a positive effect on China's reserve demand, the marginal propensity to import and the opportunity cost of holding reserves exert a negative effect. It is found that the variance of exports is the most important determinant in China's reserve demand function.

The study has shown that reserves movements in China respond both to discrepancies between the desired and actual

reserves and, to a lesser degree, between the desired and actual level of investment. The pattern of reserves movements in China is unique. After a burst of investment, reserves drop below the target level. Money, investment and imports are tightened to restore reserves to the desired level. There is overshooting and too many reserves accumulate. This sets off an easing of restrictions and higher investment, which in turn overshoot and deplete reserves. And so on. The empirical results obtained in this study suggest that, to the extent that there is a well-defined demand for international reserves, domestic investment fluctuations in China cannot be considered to be completely exogenous. Variations in domestic capital investment partially respond to the existence of discrepancies between the actual and desired level of international reserves.

This study has revealed that, in general, LDCs and CPEs require higher reserve holdings and a greater use of adjustment as compared to those required by DCs. This is reflected in the higher coefficients in these countries' reserve demand functions and in the faster speed of adjustment obtained from the test of the dynamics of adjustment in international reserves.

It is found that LDCs and CPEs have higher elasticities of reserve demand with respect to the variability measure of

the balance of payments and to the level of real imports. The lower coefficient for the variability measure of the balance of payments for DCs suggests that for these countries increased variability in their balance of payments has less of an effect on their demand for international reserves. Unexpected shocks can be met by borrowing from international financial markets. While the estimates for industrial countries suggest a degree of economies of scale in reserve demand, a close to unity elasticity of reserve demand with respect to imports for non-oil developing countries and CPEs like China and former Yugoslavia indicates that in these economies reserves grow in proportion to trade with not much evidence of economies of scale.

Using a country's reserve-import ratio as a measure of reserve-adequacy, the empirical results are accentuated by the fact that, on average, China has maintained the highest reserve-import ratio and CPEs (as represented by China) and LDCs have maintained a higher reserve-import ratio than DCs.

These findings provide strong empirical evidence for the theoretical model's predictions and are consistent with the hypotheses presented in this study.

(5.2) Policy Implications.

This study shows that the different reserve demand behavior between different economies is a result of the structural and institutional differences between these economies. This includes the difference in the economic system, the financial system and organizations, the efficacy of monetary and fiscal policies, and accessibility to the international capital markets.

It is shown theoretically and empirically that the high cost of financing, lack of accessibility to external borrowing, the rudimentary nature of the financial system, the inefficiency of macroeconomic policy, and lack of competitiveness in the foreign trade sector, may have forced CPEs or LDCs to maintain higher reserve holdings and to adjust more quickly to a balance of payments deficit. The reserves movements in CPEs would also be affected by their rigid centrally planned system, where cycles of investment and monetary policy contribute to the deviations of the actual reserves from the desired ones.

There are two policy implications of this study. Consider first the individual countries' reserve management. Since the structural and institutional deficiencies inherent in LDCs or CPEs may prevent these economies from achieving the optimal level of reserve holdings and the optimal speed

of adjustment, and the higher reserve holdings or the faster speed of adjustment imply either a waste of their scarce real resources or at the expense of domestic economy, the progress of their economic and financial reforms as well as the structural changes in these economies become crucial to these countries' reserve management.

As to LDCs, the stability of export earnings relies on improvement in trade competitiveness and the terms of trade. This in turn requires the restructuring of the economy. An effort can also be made to take steps towards increasing financial deepening in the economy. This includes the increasing function of the financial system as an intermediary in the economy. The sophisticated financial system entails possibilities for increasing returns to scale which make possible a rise in the import velocity of reserves and therefore a reduction of transaction demand for reserves.

The same applies to CPEs. In China, financial markets are still relatively underdeveloped, interest rates remain regulated, and the exchange rate is still influenced by administrative controls. Under strict central planning, the limited objective of fiscal policy is to allocate resources administratively, which creates the cycle of investment. Using periodic devaluations of Chinese RMB Yuan and the policies of export promotion and import restriction to

achieve a balance of international payments has already resulted in not only large fluctuations in reserve holdings but also instability in economic policy. The latter has also brought about negative repercussions from China's major trading partners. This implies that in China a sound reserve management relies on the elimination of these kind of market distortions.

With respect to the implications for international monetary reform, the empirical evidence presented in this study lends support to the idea that countries' reserve demand is rationally determined and is related to a set of variables common to all countries over a long-term period. If it is reasonably predictable on the basis of a few determinants and if these determinants themselves can be forecast with reasonable reliability, then the level of reserves needed in a given situation can be predicted. This in turn suggests that the institutional mechanisms such as the creation and distribution of SDRs and other lending facilities in the IMF may provide some assurances that the supply of reserves grows in step with demand.

More importantly, the issue of higher reserve demand required by LDCs and CPEs in their transition period can also be addressed in these mechanisms. On the one hand, the severe external shocks of recent years reduced incomes and output and gave rise to foreign exchange shortages in the

majority of LDCs. In addition to a deterioration in their terms of trade, a decline in their export volume and an increase in real interest rates on the external debt, there was a sharp decline in the flow of capital to many of these countries. Import volumes were forced to contract. The countries affected undertook major adjustments in response to these external events. There was a need to service the debt and restore foreign exchange reserves. Despite considerable efforts at restructuring and restraint, underlying rigidities were not immediately defeated.

The application of sheer macroeconomic restraint for the purpose of achieving medium-term external balance objectives implies very high longer-term costs. By implication, the provision of finance to permit a long period of structural adjustment is important. This may include the restructuring of international debt and an expansion of the lending activities of the IMF and the World Bank.

On the other hand, the scale of financial requirements for reconstruction in Eastern European countries and the post-USSR is now becoming more clear. With the virtual breakdown of the Comecon trading system, these countries' difficulties in meeting trade-related payments point to a further worsening in their current balances. The European Commission proposed increasing assistance to these countries

and the issue with respect to the Soviet Union was also considered at the London Summit. The Group of Seven (seven major industrialized countries) called for a thorough study (to be coordinated by the IMF) prior to any decision on collective financial assistance, but it did leave the way open for assistance from the IMF and the World Bank.

Finally, a significant impact of the growing international bank lending on countries' demand for reserves in per cent of imports obtained in this study suggests that international borrowing has apparently provided countries with additional funding sources to finance disequilibrium in the international receipts and payments. Particularly, increasing participation by LDCs in private international financial markets raises questions about the role of private capital markets in the international financial system. Debt may provide a means of financing reserves or borrowing itself may directly perform a transactions function, serving to smooth domestic absorption across periods in which export earnings vary. This has the implication that increased access to capital markets lowers the demand for reserves as reserves and debt may be substitutes or complements. Therefore, the analysis of the determination of reserve adequacy should take into account the size of international borrowing. This in turn suggests that control of the growth of international reserves and a coherent management of aggregate international liquidity can play an important role

in avoiding potential global excesses or deficiencies in liquidity. The latter requires coordination between individual countries' macroeconomic policies and international monetary reforms.

APPENDIX A

Optimal Reserves and the Speed of Adjustment

From equation (3.1.6), $P(R\geq 0) = \sigma^2_R/2R^{*2}$, substituting the expression for σ^2_R in equation (3.1.4) to obtain

$$P = \sigma^2_\mu/[2\delta(2-\delta)R^{*2}]. \quad (1)$$

Expressing δ as a function of the other parameters, we have

$$\delta(2-\delta) = \sigma^2_\mu/2PR^{*2}. \quad (2)$$

Solving the quadratic equation for δ and taking the negative root, we end up with

$$\delta = 1 - (1-[\sigma^2_\mu/2PR^{*2}])^{1/2}. \quad (3)$$

When R^* becomes very large, the speed of adjustment required to maintain a given P becomes very small, and when $R^*= \infty$, $d\delta/dR=0$.

The utility function that the authorities want to maximize is given by equation (3.1.9). Converting it into a linear functional form, we have:

$$U = \alpha_0 + \alpha_1 E_Y - \alpha_2 \sigma_Y - \alpha_3 P. \quad (4)$$

Substituting the expressions for E_Y, σ_Y and P from equations (3.1.8), (3.1.7) and (1) to obtain

$$U = \alpha_0 + \alpha_1(Y_0 - rR^*) - \alpha_2[(\delta^{1/2}\sigma_\mu)/(2-\delta)^{1/2}m]$$

$$- \alpha_3[\sigma^2{}_\mu/2\delta(2-\delta)R^{*2}]. \quad (5)$$

Differentiate this expression with respect to R^* and δ, the first-order condition for a maximum requires

$$U_{R^*} = - \alpha_1 r + \alpha_3\sigma^2{}_\mu/\delta(2-\delta)R^{*3} = 0; \quad (6) \text{ and}$$

$$U_\delta = [-\alpha_2\sigma_\mu(1-\delta)]/[\delta^{1/2}(2-\delta)^{1/2}(2-\delta)m]$$

$$+ [\alpha_3\sigma^2{}_\mu(1-\delta)]/[\delta^2(2-\delta)^2R^{*2}] = 0. \quad (7)$$

If we differentiate these equations with respect to σ_μ, we obtain

$$dU_{R^*}/d\sigma_\mu = (\partial U_{R^*}/\partial R^*)(dR^*/d\sigma_\mu) + (\partial U_{R^*}/\partial\delta)(d\delta/d\sigma_\mu)$$

$$+ (\partial U_{R^*}/\partial\sigma_\mu)(d\sigma_\mu/d\sigma_\mu) = 0; \quad (8) \text{ and}$$

$$dU_\delta/d\sigma_\mu = (\partial U_\delta/\partial U^*)(dR^*/d\sigma_\mu) + (\partial U_\delta/\partial\delta)(d\delta/d\sigma_\mu)$$

$$+ (\partial U_\delta/\partial\sigma_\mu)(d\sigma_\mu/d\sigma_\mu); \quad (9)$$

Thus all the partial derivatives in these two equations can be calculated from equations (6) and (7), and by using Cramer's rule one can obtain the signs of the derivatives as the ratio of two determinants:

$$dR^*/d\sigma_\mu = \frac{\begin{vmatrix} -\partial U_R^*/\partial\sigma_\mu & \partial U_R^*/\partial\delta \\ -\partial U\delta/\partial\sigma_\mu & \partial U_\delta/\partial\delta \end{vmatrix}}{\Delta} = \frac{\begin{vmatrix} - & - \\ + & - \end{vmatrix}}{\Delta} > 0. \quad (10)$$

Similar calculations yield the signs of the other derivatives as:

$$dR^*/dY_0 > 0,\ dR^*/dm < 0,\ \text{and}\ dR^*/dr < 0.$$

APPENDIX B

Classification of Countries

Based on the International Monetary Fund (*International Financial Statistics*' Supplement on International Liquidity (1987) and Supplement on Trade Statistics (1988)), countries are grouped by predominant exports and by financial criteria. Industrial Countries are the following countries:

Australia	Japan
Austria	the Netherlands
Belgium	New Zealand
Canada	Norway
Denmark	Portugal
Finland	South Africa
France	Spain
Germany	Sweden
Greece	Switzerland
Iceland	Turkey
Ireland	United Kingdom
Italy	United States

Oil Exporting Countries are the following countries:

Algeria	Nigeria
Indonesia	Oman

Iran,I.R. of	Qatar
Iraq	Saudi Arabia
Kuwait	United Arab Emirates
Libya	Venezuela

Non-Oil Developing Countries are the remaining Developing Countries.

Fifteen Heavily Indebted Countries are the following countries:

Argentina	Morocco
Bolivia	Nigeria
Brazil	Peru
Chile	Philippines
Colombia	Uruguay
Cote d'lvoire	Venezuela
Ecuador	Yugoslavia
Mexico	

APPENDIX C

Yugoslavia's Demand for International Reserves

Former Yugoslavia is a modified centrally planned economy. It resembles some of the structural and institutional characteristics in CPEs.

The long-run demand for reserves has been empirically examined by applying Equation (3.2.6) on the annual observations from Yugoslavia for the period 1960-1986. The estimated generalized least-squares results are presented as follows:

$$(R/P)_t = -5.706 + .240\sigma^2{}_t + 1.113(IM/P)_t - .045m_t$$
$$\qquad\qquad (3.75) \quad (1.75) \quad (4.31) \qquad\qquad (0.09)$$

Adjusted R^2 = .67, SEE = .592, D-W = 1.61, RHO = .41

All the coefficients of the explanatory variables have the expected signs. The variability measure of the balance of payments σ^2 and the level of real imports IM/P both exert a significantly positive effect on reserve demand. The estimated coefficients for σ^2 and (IM/P) are .24 and 1.113. They are higher than those obtained from DCs and LDCs. A greater than unity elasticity of reserve demand with respect to imports indicates that in Yugoslavia the demand for

international reserves faces diseconomies of scale. Yugoslavia has a high (precautionary and transactions) demand for international reserves.

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