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THE DEMAND FOR AND SUPPLY OF INTERNATIONAL
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DEMAND FOR AND SUPPLY OF INTERNATIONAL RESERVES:
A SIMULTANEOUS APPROACH

By

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To my wife, Negar

ABSTRACT

THE DEMAND FOR AND SUPPLY OF INTERNATIONAL RESERVES: A SIMULTANEOUS APPROACH

By Mohsen Bahmani-Oskooee

Empirical studies of demand for international liquidity have generally concentrated on the formulation and estimation of demand functions. Supply relationships have typically been handled by assumption, the usual practice being to assume that the supply of international reserves is elastic enough to meet the demand.

The main purpose of this thesis is to develop a model of demand for and supply of international reserves. Our model differs from previous studies in several ways. First, we have tried to eliminate the assumption of elastic supply by specifying a supply function. Second, incorporated into the model is the gold price, which allows us to look at the proposal for which provisions were made in the International Monetary Fund articles; these suggest that one possible method of dealing with the shortage of liquidity is gold revaluation.

Using two-stage least-squares demand functions were estimated for the period 1972-1977, using quarterly data for 19 developed countries and 21 less developed countries.

The demand for international reserves is found to be elastic with respect to the official price of gold. However, it is found to be inelastic with respect to the market price of gold (dollar price of gold in London).

Considerable evidence is also found that the assumption of elastic supply is valid for less-developed countries.

Third, in order to introduce the possibility of disequilibrium behavior into the model, an adjustment mechanism was used which led us to estimate the speed of adjustment . Estimates of the speed of adjustment are found to be in the range of almost 3-30 percent, which is in sharp contrast to what previous studies have found.

The main conclusion from the study is that any model of demand for international reserves that does not take the supply side into account is biased. Furthermore, the gold price exerts a negative effect on the demand for international reserves.

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CHAPTER ONE

INTRODUCTION

In the last decade, countries have preferred to move to a system of managed floating that is intermediate between the extremes of fixed rates and a clean float. Since managing the float requires international reserves, it is clear that the study of these reserves is as relevant today as it has been in the past.

If we could measure the need for reserves, we might be able to predict their growth rate. Quantitative methods may answer important questions pertaining to international liquidity. These methods concentrate on the purely statistical examination of time series data of international reserves and attempt to assess the relative adequacy of reserves by relating present stock to past performance. Studies using varying degrees of statistical sophistication have adopted this approach, and it shall be adopted here. However, all previous studies have generally concentrated on the formulation and estimation of demand functions. Supply functions have typically been handled by assumption, the usual practice being to assume that the supply of international reserves is elastic enough to meet demand.

The main purpose of this thesis is to develop a model of demand for and supply of international reserves. Our model differs from previous studies in several ways. First, we have tried to eliminate the assumption of elastic supply by specifying a supply function. Second, we incorporate into our model the gold price, which allows us to look at the proposal for which provisions were made in the International Monetary Fund articles; these suggest that one possible method of dealing with the shortage of liquidity is gold revaluation. Third, in order to introduce the possibility of disequilibrium behavior into our model, an adjustment mechanism is used which leads us to estimate the speed of adjustment.

Chapter Two presents an extensive review of the literature on the demand for international reserves. In Chapter Three, we develop the model of demand for and supply of international reserves. The specific questions to be analyzed in that chapter are:

- (1) Can the demand for international reserves be described as a function of a limited number of variables?
- (2) Can the supply of international reserves be described as a function of a limited number of variables?
- (3) How is the gold price related to the demand for and supply of reserves?
- (4) How would the model change if we introduced the possibility of disequilibrium behavior into the model?

Chapter Three attempts to provide answers to these questions.

Chapters Four and Five concentrate on empirical aspects. Specifically, in Chapter Four, the demand function is estimated for 19 developed and 21 less developed countries. In Chapter Five, further attempts are made to investigate the behavior of less developed countries. Considerable evidence has been found that the assumption of elastic supply is valid for the less developed countries. In the last part of Chapter Five, our conclusions are presented.

CHAPTER TWO

SURVEY OF THE DEMAND FOR INTERNATIONAL RESERVE LITERATURE

2.1 - Introduction

There are at least five reviews of the literature relevant to this study: Clower and Lipsey [1968], Niehans [1970], Salant [1970], Grubel [1971], and Williamson [1973]. The justification for writing this review is that since completion of the last survey, several papers have appeared which contribute to the stock of knowledge in this field. This review will consist of two parts: the first will include a brief summary of the literature previous to the last survey, and the second part will be devoted to the expanded description of the literature since the last survey. At the end, a table will be provided containing the features of major demand for reserve studies.

2.2 - Pre-Floating Rate System Literature

The oldest approach to the demand for reserves that is relevant for a gold-standard world is that there is a direct relationship between desired reserves and the domestic money supply. The base money is gold held by

central banks, and similar to today's fractional banking system, the domestic supply of money can be increased if high-powered money reserves in the form of gold increases. By 1943, there was general recognition that reserves were relevant for international purposes rather than for backing the domestic money supply. Triffin (1947) argued that the demand for reserves could be expected to grow in line with trade, so that the reserve imports ratio could be taken as a measure of reserve adequacy. This measure was used by Harrod (1953), the I.M.F. (1953, 1958, 1970), Stamp (1958), Triffin (1960), Grubel (1965), Machlup (1966), and Heller (1968).

Besides imports, two other classes of scale variables are sometimes used. The first consists of variables such as domestic money supplies and liquid liabilities to foreigners. The theoretical justification for the use of these variables is provided by Johnson (1958) and Scitovsky (1958). Their empirical relevance has been tested by Machlup (1966).

The second class consists of variables such as net external balance, or reserve losses. As Grubel (1971) interprets them, they reflect the instability of countries' balance of payments in the past. The theoretical justification for the use of these variables is provided by the IMF Reports (1958 and 1970) and Machlup (1966).

Most of these studies have predicted that demand for reserve will increase by some percentage. For example,

the studies published after a 1970 IMF conference projected annual increases in reserve demand within a range of three to four percent. Triffin's projections (1960) led him to predict severe reserve shortages in the 1960s. Among these studies, one of them deserves special notice; the Machlup study (1966) appears designed to discredit the use of ratios in the analysis of the demand for reserves. He shows the difficulties involved in establishing theoretical justifications for why any of the ratios he examined (that is, reserves to imports, reserves to largest annual reserve losses, reserves to domestic money and quasi-money, and reserves to liabilities of central banks) should be constant across countries or through time. His statistical analysis showed that all ratios are different for the countries and periods under examination. Machlup was unwilling to make any forecasts of demand and judgments about adequacy, and he concluded that the demand for reserves is not a function of any identifiable variables. Rather, it is determined by the desire of countries to have their reserves grow. This has become known as "the Mrs. Machlup's wardrobe Theory of Monetary Reserves."

Distinction between reserves for transaction purposes, which are assets of a country's commercial banks, and reserves for precautionary purposes, which are assets of central banks, leads us to distinguish between two studies, one by Heller (1968) and the other by Olivera (1969).

Heller (1968) used the reserves-imports ratio in applying Baumol's square-root law to transactions involving balances of international reserves. His contribution was to calculate the ratio of commercial banks' foreign exchange to the square root of imports, which he used as a measure of the adequacy of international reserves for transaction purposes.

In a purely theoretical paper, Olivera (1969) contributed an important insight to the meaning of observed change in the ratios of reserves to imports. He argued that precautionary demand for reserves should be a function of the variance of changes in the level of imports; he showed mathematically that under some assumptions about economic behavior, this variance of import changes increases more slowly than the level of the underlying economic transactions. More precisely, he showed that the elasticity of precautionary demand with respect to volume of transactions is .5. In a simple Baumol-Tobin model, therefore, the level of precautionary demand is equal to the square root of the level of transactions. An elasticity of .5 implies that the rate of growth of the demand for cash is equal to that of the square root of transactions, rather than to that of transactions themselves. For this reason, this result is called, "the square-root law." Both the Heller and Olivera theories assume that an increase in the volume of transactions takes the form of an expansion in the number of transactions,

with no increase in the size of individual transactions. But as Baltensperger (1974) points out, a constant number of individual transactions but an increase in their size (due, say, to inflation) will result in the predicted elasticity becoming unity rather than .5; this applies to both theories.

Officer (1976) argues that, in the real world, it is reasonable to expect changes in the volume of international transactions to take the form of changes both in number and size. Then the theoretically predicted elasticities of demand with respect to the volume of international transactions would be between .5 and unity for both the Heller and Olivera theories.

Officer has tested both of these theories, using a comprehensive measure of the volume of international transactions instead of the conventional merchandise-import flow. His measure, for a given country in a given year, is the sum of all gross flows (total credits or total debits) in the country's balance of payments. Using annual data for the period 1959-1970, Officer has used the following model for developed countries:

$$(1) \quad \log R = a + b \log T + u \quad \text{where } u_t = \rho u_{t-1} + w$$

$$(2) \quad \log E = c + d \log T + v \quad \text{where } v_t = \rho v_{t-1} + \varepsilon$$

Equation (1) tests the Olivera theory, and equation (2) tests the Heller theory. If these theories are to be accepted, then b and d , which are elasticity coefficients,

must be positive, significant, and lie between .5 and 1.

The Olivera hypothesis, which predicts a transaction elasticity of demand for reserves within the interval .5 to 1 and requires the use of official reserves (held by central banks) for R in equation (1), is satisfied for most countries in his sample. However, the Heller hypothesis, which predicts the same elasticity range and requires the use of reserves held by commercial banks for E in equation (2), is rejected by his evidence. Nearly all countries in his sample exhibit elasticities substantially above unity.

Makin (1974) has looked at the effect of exchange rate flexibility on the demand for international reserves, specially, the elasticity of demand with respect to a change in trade volume. He showed that the elasticity of demand for precautionary reserves with respect to an increase in exchange rate flexibility (defined as a widening of bands about parity) is estimated to lie between minus one-third and minus two-thirds. This result, of course, gives some idea as to the extent to which increases in exchange rate flexibility can be expected to counteract the impact of an increased volume of world trade upon the demand for reserves by central banks.

Even for the United States as a major supplier of the dollar component of the reserves, the degree of exchange rate flexibility should carry a special significance. Increased exchange rate flexibility, if available

to the United States, can reduce that country's dependence upon its reserve currency role in view of its relatively vulnerable reserve position.

2.3 - Pre-Floating Rate System Literature Using Econometric Techniques

During the 1960s, as computer technology was developing, many economists thought of using econometric methods, mainly regression techniques. The reason, as Grubel (1971) points out, may be due to the ready availability of computers, programs, and sufficiently long time series of observations needed in the calculations. The first study to use regression techniques was by Kenen and Yudin (1965), who mainly attempted to introduce a new version of the demand for reserve function. They claimed that the imports-reserves ratio does not tell us very much. It shows how long a country could finance its imports if it were suddenly deprived of all its foreign exchange earnings, and they theorized that reserves should be compared to the variations in payments and receipts that countries actually expect to experience. After inspection of major countries' statistics, they suggested that while reserve changes are basically stochastic and approximately normally distributed, they are also serially dependent. Therefore, the Markov process of

$$(3) \quad \Delta R_t = \rho \Delta R_{t-1} + \epsilon_t$$

in which $0 < \rho < 1$ and $\varepsilon_t \sim N(\bar{\varepsilon}, \delta_\varepsilon^2)$, could be used to describe a country's stochastic balance of payment.

Kenen and Yudin (1965) computed the least-squares estimates of $\Delta R_t = \bar{\varepsilon} + P\Delta R_{t-1}$, where $\bar{\varepsilon}$ approximates $\bar{\varepsilon}$ (average size of country's reserve losses), P is an estimate of ρ (the carry-forward or duration of a series of losses), and δ_e is an estimate of δ_ε (the standard error of reserve losses) in equation (3). They estimated these proxies for 14 industrialized countries using monthly data during the period 1958-1962 and then used them in cross-country regressions. The selected years were 1957 and 1962, they found the level of reserve holdings to be an increasing function of all three proxies of reserve instability. In the 1957 regression, only the coefficient of δ_e was significant; however, in the 1962 regression, all coefficients were significant. They also took account of two other variables which may affect the reserve holding behavior of countries: the opportunity cost of holding reserves and the level of "liquid" liabilities that governments regard as claims on their reserves. As a proxy for opportunity cost of holding reserves, they supposed that reserve accumulation is usually accomplished at the expense of capital formation and that the "social marginal product" of capital varies inversely with per capita income. Therefore, per capita income was used as a proxy for opportunity cost. The following equation was employed:

$$(5) \quad R_{it} = \beta_0 + \beta_1 p_i + \beta_2 \delta_{ei} + \beta_3 \left(\frac{Y}{P} \right)_{it} + \beta_4 L_{it} + \epsilon_{it}$$

where $\left(\frac{Y}{P} \right)_i$ represents per capita income in the i th country, and L_{it} represents that country's liabilities. Since β_3 and β_4 turned out to be insignificant, the inclusion of per capita income and liabilities did not improve the overall fit.

Thorn (1967) criticizes Kenen and Yudin's chain. As he puts it:

"It shall be shown that their "disturbance hypothesis" tells us no more, and perhaps less, than the hypothesis they discarded and that their statistical results are inconclusive."

Thorn develops the theoretical argument that countries have a desired ratio of reserves to imports that they attempt to maintain as imports grow. He formulates that a country's demand for international reserves (R_t) is determined by a policy parameter, the target ratio of reserves to imports (r_0), and the actual level of imports (I_t):

$$(6) \quad R_{it} = I_{it} r_0$$

Then he considers the 1960 reserve-to-import ratio for each country as its reserve target and estimates the following equation for the same 14 industrialized countries studied by Kenen and Yudin (1965) for the years 1954, 1957, 1962, and 1964:

$$(7) \quad \log R_{it} = a_0 + a_1 \log I_{it} + a_2 \log r_{i \ 1960}$$

where $i = 1, \dots, 14$.

In none of the equations were a_1 and a_2 significantly different from unity, nor was the constant term significantly different from zero. Thorn also gets higher $\bar{R}^2$'s compared to R^{-2} of Kenen and Yudin. Based on this result, he concluded that there is insufficient evidence to reject the "import-target ratio hypothesis." The import-target reserve ratio hypothesis yields results as good as the "disturbance hypothesis" in terms of the Kenen-Yudin criterion, even with the crude method of determining the target ratios employed above.

In their reply, Kenen and Yudin (1967) brought out the weakness of Thorn's paper, stating that he had used an economic model that totters on the brink of tautology. They showed that since $R_{it} = R_{i0} e^{b_{1i}t}$ and $I_{it} = R_{i0} e^{b_{2i}t}$ (b_{1i} and b_{2i} are the rates of growth of i th country reserves and imports between the base date for r_{i0} and the current period to which equation (6) applies), then the definition of r_{i0} yields the tautology: $R_{it} = I_{it} r_{i0} e^{(b_{1i}-b_{2i})t}$ or, logarithmically:

$$(8) \quad \log R_{it} = (b_{1i} - b_{2i}) t + \log I_{it} + \log r_{i0}$$

This is identical to Thorn's equation (7), with $a_0 = (b_{1i}-b_{2i})t$ and $a_1 = a_2 = 1$. No wonder, then, that a_1 and a_2 in equation (7) are never significantly different from unity.

Courchene and Youssef (1967), rather than estimating cross-section equations, estimated two time-series equations for 9 countries using quarterly data over the period 1958-1964.

In the first equation, a country's reserve holdings have been related to imports (M) and to the long-term interest rate (r), which is taken to be a proxy for the opportunity cost of holding reserves. In the second equation, again, a country's reserve holdings have been related to the money supply and long-term interest rates (r). To justify the use of imports, reference has been made to the quantity theory of money and its international implications. The use of domestic money supply is defended with the help of Johnson's monetary model of the balance of payments (1958) and Scitovsky's (1958) theoretical considerations on the relationship between the domestic money supply and foreign payments imbalances. Assuming the existence of a stable demand function over time, their empirical results support the idea that demand by individual countries for reserves can be represented as a function of the money supply and the long-term interest rate.

Kelly (1970) has introduced a new variable into the demand functions; he has replaced the measure of variability of balance of payment introduced by Kenen and Yudin (1965) with the standard deviation of exports. This has the advantage of reducing the simultaneity problem posed by the fact that some parts of the payments balance, for example, imports, are influenced by adjustment policies rather than being exogenous, as supposed in the theory. This advantage is bought at the cost of ignoring other causes of instability. Kelly (1970) pooled annual data for the period 1953-1965 for

46 countries (46 countries X 13 years = 598 observations). Using dummy variables for each country, he estimated the following equations:

$$(9) \quad \log R = a_1 \log S(X) + a_2 \log \frac{M}{y} + a_3 \log \frac{y}{P} + \epsilon$$

$$(10) \quad \log R = b_1 \log S(X) + b_2 \log \frac{M}{y} + b_3 \log A + b_4 \log L \\ + u$$

where $S(X)$ = standard deviation of exports;

$\frac{M}{y}$ = average propensity to import;

$\frac{y}{P}$ = per capita income as a proxy for opportunity cost;

A = foreign assets
 L = liabilities } again proxy for opportunity cost

His results are very good. All of the independent variables were significant, and all but the import propensity and foreign liabilities variables had the expected sign.

Kelly was expecting to get a negative sign for $\frac{M}{y}$, but he got a positive one. This is the case for most of the other studies examined here, a point discussed in later pages. However, the positive sign of $\frac{M}{y}$ simply indicates that $\frac{M}{y}$ reflects the degree of openness of the economy rather than the average propensity to import.

Kelly also used equation (9) in estimating cross-section equations for each year (1953-1965). He concluded that:

"The constancy of the coefficients for the annual cross-sections over a 13-year period provides a strong base on which to predict the growth in demand for reserves. If export variance and foreign assets and liabilities continue to grow at the same rates (5.8, 10.4, and 9.8 percent respectively) and the same import responsiveness is maintained, then the demand for reserves will increase at an average annual rate of 5.9 percent."

Clark (1970) assumed that policy makers have some desire to maintain a given target level of reserves, and as long as reserves depart from the desired level, the country will attempt to induce a balance-of-payment surplus (or deficit), S_t^* . This is given by

$$(11) \quad S_t^* = \gamma(R^* - R_{t-1}), \quad 0 \leq \gamma \leq 1$$

where R^* is the average stock of reserves (desired reserves). Clark argues that the actual balance of payment surplus or deficit (S_t) is equal to the desired change in reserves (S_t^*), plus a random term which measures the net capital account:

$$(12) \quad S_t = S_t^* + \varepsilon_t$$

Combining (11) and (12), he obtained:

$$(13) \quad R_t = \gamma R^* + (1-\gamma) R_{t-1} + \varepsilon_t$$

With the assumption that the target level of reserves can be represented by a linear time trend, that is,

$R_t^* = R_0^* + kt$, Clark got the following equation:

$$(14) \quad R_t = \gamma R_0^* + \gamma kt + (1-\gamma) R_{t-1} + \varepsilon_t$$

or

$$(15) \quad R_t = a + bt + cR_{t-1} + e_t$$

Clark employed equation (15) using monthly data for 38 countries over the period 1958-1967. His results were satisfactory, the speed of adjustment, γ , was in the expected range (between zero and one in all cases but one). His estimate of δ_e was then used in a cross-country regression analysis to explain average reserves and proved highly significant, even after the data were deflated by the value of trade to prevent correlation due to size. The independent variables used in cross-country regressions did not differ from those used in previous studies.

Archibald and Richmond (1971) also used equation (15) originally employed by Clark (1970). Their empirical finding is that the variance of the disturbances around their time trend increased during the period 1961-1967, which supports the assumption made by Clark (1970) in formulating equation (15). The refined measure of instability is used not in the estimation of an equation of the demand for reserves, as was done by others, but primarily in estimating the likelihood that countries will run out of reserves.

Flanders (1971) was the first and only person to use the ratio of reserves to imports as the dependent variable. She used as measures of payments instability some indices which had been developed by others for purposes of analyzing

the effects of commodity stabilization schemes. She also explored a large number of other independent variables, mainly foreign exchange holdings by private banks, official holdings of foreign exchange, rate of growth in GNP, the ratio of exchange rate to the cost of living index, per capita income, and indices of export instability. All these have been discussed as being theoretically relevant as influences on individual countries' reserve holdings.

Flanders reports that the "empirical results of the study were a dismal failure" (p. 43). What factors might account for this failure? Is it because the reserve-import ratio rather than the reserve itself is used as a dependent variable, or is cross-section analysis inappropriate because of the small number of countries (18, 26 and 57) in the sample, or is it the selection of so many independent variables? The important point is that Flanders has introduced new independent variables that should be explored in future studies.

As mentioned, the use of the reserve-import ratio as a dependent variable may not be appropriate. Except for Flanders, all other studies have used reserves rather than the reserve-import ratio. Reserves are demanded in order to finance the deficit, and the higher the imports of a country, the more reserves will be demanded by that country in order to finance the imports. It is generally accepted in the literature that there is a positive relation between reserves and imports, so if $R = A + bM + ck + \epsilon$ (where

k is vector of other dependent variables), then $R/M = a/M + b + c k/M + u$. But Flanders fails to do so. She just weights reserves by $1/M$ and not the right-hand side variables, and perhaps this is why her results are not satisfactory.

Tobin (1973) has used several definitions of payments imbalances as independent variables in the demand for free world reserves, such as payments imbalances on current account (I_1), in the liquidity concept (I_3), and in the basic balance sense (I_4) for different developed country groupings. His empirical results are not so satisfactory. In his first equation, in which reserves are regressed on I_1 , Tobin concludes, "such a result is, of course, theoretically absurd" (p. 536). In another case, when reserves were regressed on I_3 , it is understood that this measure of reserve demand has only limited usefulness. Finally, Tobin's least-squares regressions between reserves and I_4 yielded a statistically insignificant result, that is, a low t-statistic.

2.4 - Post-Floating Rate System Literature

Frenkel (1974-A) has reexamined the relation between reserve holdings and the openness of the economy within a price-adjustment model. In contrast with the Keynesian prediction that reserve holdings are inversely related to the average propensity to import (discussed in more detail in Chapter 3), he argues that there exists a positive

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association between reserve holdings and openness. This positive association is not explained by the standard priceless Keynesian model, but can be explained by the price-adjustment model. Frenkel's empirical results support the idea.

In another paper, Frenkel (1974-B) employed the following model:

$$\log R = a_0 + a_1 \log m + a_2 \log \delta + a_3 \log M + \varepsilon$$

He used it to compare the demand for reserves of developed countries with that of less developed countries. In that equation, M stands for imports, m represents the import-GNP ratio, and δ is the measure of the variability of international receipts and payments, which represents the trend-adjusted yearly disturbance in a country's stock of international reserves. The value of δ for each year was estimated by computing the standard deviation over the previous fifteen years of the trend-corrected annual observations of the level of reserves.

Frenkel's empirical results cover 22 developed countries and 33 less developed countries over the period 1963-1967. Cross-section equations were estimated for each year for both groups and then for all 55 countries together. These estimates were found to be stable over time, and it was found that the holdings of reserves are positively and significantly related to all three independent variables and had high R^2 . The results also suggest that the

behavior of the developed countries with respect to their holdings of reserves differs from that of the less developed; therefore, it is desirable to analyze these groups separately. Some explanations were offered for these differences, and it was suggested that emphasis should be given to the monetary aspects of the problem.

Iyoha (1973) has developed a model that assumes an optimal balance of payments strategy for less developed countries. His model is a welfare maximizing model with respect to the production possibility frontier of the economy, which produces two goods, importables and exportables. The question was how to determine the optimal balance of payments strategy for a developing country. With Iyoha's model, the problem was reduced to one of finding the optimal level of imports in any year - given the amount of reserves the country owns at the beginning of that year. One way to determine the optimal level of imports in each state was then developed. It was found that the optimal import level rises as a function of reserve holdings and depends on the social discount rate, the degree of self-sufficiency of the economy, the expected stream of export earnings, and the degree of instability of export receipts.

In another paper, Iyoha (1976) used the findings from his 1973 article and concluded that the optimal level of reserves (R^P) depends mainly on expected export receipts (X^e), the variability of export earnings (δ^2), the interest

rate on foreign exchange holdings (r), and the degree of openness of the economy (ρ). Hence, the specification of the determinants of optimum reserve is:

$$R^P = f(X^e, \delta^2, r, \rho); \quad f_1, f_2, f_3, f_4 > 0$$

This specification has been used in a lagged adjustment model in order to specify the demand for reserves function.

The model is:

$$(16) \quad R = a_0 + a_1 x^e + a_2 \delta^2 + a_3 r + a_4 \rho + a_5 R_{-1} + a_6 R_{-2} + \epsilon$$

Following Adelman and Chenery (1966), expected export earnings were estimated for each LDC for 1950-1969, and the disturbance variance of the estimated equation was used as a measure of the variability of export receipts. Also, the discount rate was used as a proxy for the opportunity cost of holding reserves (r).

Equation (16) was tested using cross-country data from 29 less developed countries in 1970 and performed extremely well. Iyoha's most interesting result concerns the opportunity cost of holding reserves. Before his study, no cross-section study had obtained a significant result for the opportunity cost of the reserve holding variable. Finally, Iyoha's regression equation (16) explains more than 93 percent of the systematic variations in the reserve holding behavior of less developed countries in 1970.

Iyoha's significant coefficient of r in his model

(a_3) has been attacked by both Hipple (1979) and Shinkai (1979). They argue that Iyoha has misinterpreted his results. He makes no allowance in his regression for compositional differences in the reserve stocks of different countries. Not all components of reserves of a country can earn interest. There is an investable component (foreign exchange) and a sterile component (gold, SDRs, and the IMF position). Iyoha has entered only the yield rate in his equation for reserve demand and has made no adjustment for these compositional factors.

Another weakness of Iyoha's analysis is his selection of a statistical series for the yield rate in each country, which is an internal yield rate. This is incorrect, since the only meaningful yield rate for invested foreign exchange reserves must be an external yield rate. The bulk of international reserves is held in U.S. dollars. Since the dollar must have carried the same interest rate, it would appear that the effect of the interest rate could not have been captured by a cross-country analysis. Iyoha obtained a positive effect because he used country-specific interest data (discount rate of each country).

Shinkai suggests that if one is to capture an effect of the opportunity cost of holding reserves, one should have a variable such as $(r\$ - r_{\text{Country-Specific}})$ that measures the net gain (inverse cost) of holding reserves instead of investing the equivalent sum within the country.

In a cross-regression r_t is a constant, and one should obtain a negative coefficient on the country-specific interest rate.

Worrell (1976) has looked at both the costs and benefits of holding reserves in the long term. He argues that the consequences of holding a reserve stock last into the long term and may have implications for the country's rate of economic growth. His model gives a framework for evaluating these long-term consequences. There is no need to explain Worrell's model in great detail here. The only part which might be relevant for our purposes is the way in which he relates the reserve holding behavior of the authorities to the structure of the whole economy. He chose four variables to represent the structure of the economy: export earnings (X), capital inflows from abroad (K), changes in the money supply (dMs), and government expenditures (G). The model was tested for the Jamaican economy using monthly data between January 1968 and December 1971. The results were:

$$\begin{aligned}
 (17) \quad R_t = & 12.51 + 0.72 R_{t-1} + 0.01 dMS_t + .079 X_t \\
 & (2.52)^* (12.93) \quad (0.04) \quad (3.17) \\
 & + 0.36 K_t + 0.20 G_t + Z_t \\
 & (1.50) \quad (1.41)
 \end{aligned}$$

$$\bar{R}^2 = 0.948$$

The coefficients of individual variables are not always

significant and do not always have the signs and values we would expect, but because of good $\bar{R}^2$ the standard error of the error term ($\bar{Z}_t$) was used in constructing his model.

As mentioned, Worrell tried to relate the reserve holding behavior of the authorities to the structure of the whole economy. But do those four variables represent the structure of the whole economy? We believe they do not. There are other important variables that Worrell failed to include. For example, there is no doubt about the positive relation between the reserve holdings of a country and the level of imports. If one is talking about the structure of an entire economy, the macro model of that economy, which includes many variables, should be considered.

Frenkel (1978) has analyzed the role of international reserves under a regime of pegged exchange rates and under a regime of managed float. The model he used looks exactly like what we have seen so far. The level of reserves is related to three main variables: imports (IM), import-GNP ratio (m), and a measure of variability of balance of payment (δ). The functional form of the demand function is assumed to be:

$$\ln R = a_0 + a_1 \ln \delta + a_2 \ln IM + a_3 \ln m + u$$

The cross-sectional ordinary least-squares estimates of the demand for reserves by developed and less developed countries was obtained for each year from 1963 to 1975, and

the results were satisfactory.

In the second step, estimates of demand for international reserves were obtained by pooling time series and cross-section data. In order to examine the effect of the move to a regime of flexible exchange rates, the sample was divided into two periods: the pegged exchange rate period (1963-1972) and the flexible exchange rate period (1973-1975). This division was justified using the method proposed by Quandt (1958, 1960) to analyze switching regressions.

The coefficients of the cross-sectional equations remained stable within each of the periods. Comparing developed and less developed countries, it was seen that in both periods the coefficients of the constant term, the variability measure and the average propensity to import were higher for the developed countries, while the coefficients of imports were lower. All of these differences were significant at the 95 percent confidence level for the period of pegged exchange rates; for the latter period, however, the two groups differed significantly only in their constant term. It was also concluded that the demand for reserves by less developed countries is less sensitive to variability measures than the demand by the developed countries.

In addition, a Chow test was applied; it led to the conclusion that the developed and less developed countries manifest different behavior concerning the holdings of international reserves.

Both the Quandt method and the Chow test led to rejection of the hypothesis that regression coefficients remained stable before and after 1972. The overall inference is that the system had changed by the end of 1972.

Heller and Khan (1978) have examined the demand for international reserves during the period when the international monetary system shifted from par value arrangements to greater exchange rate flexibility. Their analysis focused on the question of whether there was a shift in demand functions in 1973, and if so, in which direction. Their work is similar to that of Frenkel (1978), but with different country groupings. Following the literature on the subject, they used the standard model in which demand for international reserves (R^D) is related to three variables: (a) the ratio of imports to domestic income ($\frac{I}{Y}$); (b) the level of imports (I); and (c) a measure of variability of balance of payment (δ^2). Their estimating equation for reserves is specified in log-linear terms as:

$$(18) \quad \log R_t = a_0 + a_1 \log \left(\frac{I}{Y} \right)_t + a_2 \log I_t + a_3 \log \delta^2_t + u_t$$

Their definition of δ^2 differs from what we have seen so far. They define it as the variability of reserves and employ a two-step procedure to calculate it. In the first stage, they use the time-series methodology of Box and Jenkins (1970) and estimate autoregressive integrated moving average (ARIMA) models for reserves. 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 fit the ARIMA model described as:

$$(19) \quad \phi(L)R^*_t = \theta(L)v_t$$

where $\phi(L)$ and $\theta(L)$ are polynomial functions of the lag operator, L , and v_t is serially uncorrelated with noise errors. The results, $\hat{v}_t$, are obtained after estimating equation (19), and their squares values, $\hat{v}_t^2$, are interpreted as a measure of the variability of reserves.

In the second stage, they estimate equation (18) with a polynomial lag function imposed on $\hat{v}_t^2$.

$$(20) \quad \log R_t = a_0 + a_1 \log \left(\frac{I}{y} \right)_t + a_2 \log I_t \\ + a_3 \sum_{i=0}^k \alpha_i \log \hat{v}_{t-i}^2 + u_t$$

the α_i are the weights attached to the current & lagged values of $\hat{v}_t^2$, and k represents the number of lagged periods to be considered.¹

The model was tested for six different country groups: 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 less developed areas, using quarterly data over the period 1964-1976.

In considering their results, an important point must be made. As was observed before, all studies so far have obtained a positive a_1 (elasticity with respect to import-GNP ratio). Even Kelly (1970), who argued that we would expect a_1 to be negative, got a positive coefficient. Heller and Khan came up with a negative a_1 for all six groups. This supports Kelly's position and also implies a more "Keynesian" role for the import-GNP variable.

Heller (1966) has described the argument for the negative relation between reserves and marginal propensity to import. He concluded that, for a given change in foreign demand,

Assume that foreign demand for the countries exports falls off, creating a balance of payments deficit....The amount of dampening necessary to bring about balance of payments equilibrium will depend mainly on the propensity to import....It is evident that the dampening required in the closed economy is larger than the dampening required in the open economy and inversely proportional to the propensity to import....It is possible to avoid the adjustment to an external disequilibrium if the monetary authorities of the country have resources at its disposal which can be used to finance the external disequilibrium, thus rendering adjustment unnecessary. The resources which are at the disposal of the monetary authority and which can be used for such contingencies are the liquid international reserves....An increase of m would decrease the level optimal reserves. This is to be expected, as an increase in the propensity to import will lower the benefits per unit of reserves used to finance the imbalance as measured in incomes which would have to be foregone otherwise.²

The positive coefficient for import-GNP ratio may have many explanations. First, it is not representative of the marginal propensity to import, and it represents the

openness of the economy, that is, the larger the import-GNP ratio, the more open is the economy. Consequently, the more reserves are needed to finance any external disequilibrium. Second, the marginal propensity to import has a positive influence on reserves because there are income fluctuations due to internal exogenous shifts in demand as well as external shifts.

The result of Heller and Khan's stability test indicates that there was clearly a shift in the demand for international reserves by industrial countries when the move to a floating rate system occurred. However, the change was not sudden and appears to have taken place toward the end of 1973, rather than in the earlier part of the year, when the actual change occurred. Insofar as non-oil developing countries are concerned, the move toward more flexibility in exchange rates did not appear to affect their behavior significantly. This group seems to have had a shift in demand function in the period 1971-1972 rather than at the inception of managed floating. That they did not change their basic behavior pattern can perhaps 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.

Heller and Khan found that, after the structural change in 1973, the function explaining reserve behavior continued to be stable in the period of managed floating.

This was the case for both industrial and developing countries.

Finally, it was observed that there was some empirical evidence supporting the hypothesis that, for industrial countries, the demand for reserves should be reduced as exchange rates become more flexible. Surprisingly, the reverse seems 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 believe that the greater degree of uncertainty and variability in these countries' payments balances resulting from being pegged to a floating currency may well be the explanation.

Two articles, one by Frenkel (1978) and the other by Heller and Khan (1978), have supported the idea that the demand for international reserves will be affected if there is a move from a pegged exchange rate system to a managed floating system.

Using new and revised data, (1963-1977) Frenkel (1980) has extended his 1978 analysis to cover the period up to 1977. The analysis of this new and revised data base has altered the numerical values of the parameter estimates (particularly for the less developed countries) but has not altered the conclusion reached originally, namely, the system underwent a structural change by the end of 1972.

He found that during the pegged exchange rate period (1963-1972) the two groups of countries differed significantly in terms of their response to the exogenous variables. These differences have diminished significantly during the more recent period of the managed float.

In an unpublished paper, Bilson and Frenkel (1979) have developed a dynamic adjustment model of the demand for international reserves. They have shown that countries' behavior with respect to their holdings of international reserves can be described in terms of a small number of variables. They have found evidence that deviations of actual from desired reserve holdings triggers a process of adjustment that is fairly rapid.

2.5 - Reserves and Speed of Adjustment

A typical model used to estimate the speed of adjustment has been the partial adjustment model, that is, countries adjust their current stock of reserves in proportion to the discrepancy between actual and desired reserves. The partial adjustment model can be written as:

$$(21) \quad R_t - R_{t-1} = \gamma(R_t^* - R_{t-1}) + w_t$$

where R_t and R_t^* denote, respectively, actual and desired stocks of reserves at period t , γ denotes the speed of adjustment, and w_t denotes an error term.

Since the desired level of reserves is unobservable,

the partial adjustment model must be supplemented by an hypothesis concerning the determinants of the desired stock. In the Bilson and Frenkel model, the desired reserves function pertaining to country n for period t takes the following form:

$$(22) \quad \ln R_{nt}^* = \beta_0 + \beta_1 \ln \delta_{nt} + \beta_2 \ln y_{nt} + \beta_3 \ln m_{nt} + u_{nt}$$

where δ , y , and m are defined to be the variability measure, the value of GNP, and average propensity to import, respectively. Bilson and Frenkel have taken account of country-specific factors (which affect the demand for reserves) by employing the error component model pioneered by Balestra and Nerlove (1966). In that model, the error term u_{nt} in equation (22) is decomposed into two independent components: u_n , specific to the country, fixed through time, and independent of other countries' specific components; and e_{nt} , serially uncorrelated. Formally, u_{nt} can be expressed as:

$$(23) \quad u_{nt} = u_n + e_{nt}$$

Equation (22) can be rewritten as:

$$(24) \quad \ln R_{nt}^* = \beta_0 + \beta_1 \ln \delta_{nt} + \beta_2 \ln y_{nt} + \beta_3 \ln m_{nt} + u_n + e_{nt}$$

Substituting equation (24) in the dynamic adjustment equation (21) and after some manipulation, they got:

$$(25) \quad \ln R_{nt} = \beta_0 + \beta_1 \ln \delta_{nt} + \beta_2 \ln y_{nt} + \beta_3 \ln m_{nt} \\ - \frac{1-\gamma}{\gamma} \Delta \ln R_{nt} + u_n + \frac{1}{\gamma} v_{nt}$$

where $\Delta \ln R_{nt} = \ln R_{nt} - \ln R_{nt-1}$ and $v_{nt} = \gamma e_{nt} + w_{nt}$.

Equation (25) has been rewritten in terms of country averages. Using "n" to denote the average over time of a series pertaining to country n_0 , they obtain

$$(26) \quad \ln R_{n0} = \beta_0 + \beta_1 \ln \delta_{n0} + \beta_2 \ln y_{n0} \\ + \beta_3 \ln m_n - \frac{1-\gamma}{\gamma} \Delta \ln R_n + u_n + \frac{1}{\gamma} v_n$$

Equation (26) was estimated for a sample of 22 developed countries and for a sample of 32 less developed countries over the period 1964-1972. During these years the international monetary system was characterized as a pegged exchange rate regime. Since the estimates showed that the coefficient of the average growth rate was insignificant, it was removed from the estimating equation. Even so, the residual from the cross-sectional equation (26) was used as an estimate of the country-specific factor in the desired reserves function, which is:

$$(27) \quad \ln R_{nt}^* = \hat{\beta}_0 + \hat{\beta}_1 \ln \delta_{nt} + \hat{\beta}_2 \ln y_{nt} + \hat{\beta}_3 \ln m_{nt} + \hat{u}_n$$

The estimated coefficients from (26) were used to generate the desired reserves, R_{nt}^* , from equation (27), then incorporated into the partial adjustment model by writing

the adjustment equation as

$$(28) \quad \ln R_{nt} = a_0 + a_1 \ln R_{nt}^* + a_2 \ln R_{nt-1} + v_{nt}$$

where the country specific factor, u_n , has been incorporated into the definition of desired reserves. In equation (28), a_1 provides an estimate of the speed of adjustment. The estimated value of the speed of adjustment is .541 for developed countries, .435 for less developed countries.

Bilson and Frenkel also estimated the speed of adjustment without including the country-specific factor. In this case, we need to substitute equation (22) in (21) and estimate the following equation:

$$(29) \quad \ln R_{nt} = \gamma\beta_0 + \gamma\beta_1 \ln \delta_{nt} + \gamma\beta_2 \ln y_{nt} + \gamma\beta_3 \ln m_{nt} \\ + (1-\gamma) \ln R_{nt-1} + v_n$$

Equation (29) was estimated for the same countries and same time period (1964-1972), and the estimated value of γ happens to be low. Bilson and Frenkel concluded that including the country-specific factor provides higher estimates of the speed of adjustment.

They also discussed the determinants of the speed of adjustment, and it was shown that the parameter is not a fixed one, but rather a stable function of a limited number of variables. They extended their analysis to the post-Bretton-Woods period of managed float, and the result was that the move to a new exchange rate regime was

associated with changes in the speed of adjustment by which countries eliminate divergencies between desired and actual levels of reserves.

2.6 - Concluding Remarks

In most of these studies, there is general agreement that imports, average propensity to import, and the measure of balance of payment variability are the three major determinants in the reserve demand functions. These variables always had significant coefficients and the expected signs. In a cross-section study, the use of a measure of balance of payment variability has been a tradition, even if there are some limitations. The main drawback is that actual changes in reserves need not provide the exact measure of the disturbance since countries may use some other policies, Kenin and Yudin (1968, p. 348), who used this measure are aware of this possibility and assume that the estimate is not affected by national policies. To what extent this assumption holds is questionable. It might be true that in a cross-section study we can ignore the limitation and follow Heller, who claims "any bias that might actually be introduced is probably very small and negligible."³ However, in a time-series study, the effect of national policies on this variable cannot be ignored.

The second variable most authors agree should be

dropped from the reserve demand function is the opportunity cost of holding reserves. The major reason is that any proxy that has been used for this variable has shown insignificant coefficients. Iyoha (1976) was the first to claim that he had found a significant relation, but we have discussed the criticism of his work by Hipple (1979) and Shinkai (1979).

We agree that the opportunity cost of holding reserves is not a major independent variable in reserve demand functions. First, it is impossible to measure the true opportunity cost of holding reserves. Second, it is difficult to come up with a proxy for this variable, and in all the studies reviewed, the opportunity cost had insignificant coefficients. For these reasons, we will not include this variable in our demand function.

The third and major issue that the studies agree on is the implicit assumption that the supply of international reserves is elastic enough to meet the demand of the countries for reserves. Emphasis in the literature has been on the demand for reserves, but it is important to point out that the supply is also likely to be related, in part, to the variables that enter the demand function. However, these variables enter the supply function with opposite signs. To the extent that the assumption of elastic supply is not fulfilled, the estimate of the demand functions may embody a simultaneous-equation bias. However, in a model that involves both demand and supply, the problem of estimating

parameters has special features that are not present when a model involves only a single relation. We will specify a supply function and try to solve this simultaneity problem.

The last topic that must be mentioned is the gold market. The soaring price of gold in the 1970s has been one of the most important features of the international money market. None of the studies reviewed has tried to look at the effect of gold prices on the demand for international reserves. We will try to capture this effect.

In the next chapter, an attempt will be made to build a framework in which the demand for and supply of international reserves will be taken care of simultaneously. In that model, we will also take into account the last problem mentioned above, gold prices.

2.7 - Features of Major Studies

Table 2-1 summarizes all the studies reviewed here, by author and year of publication, in terms of the independent variables used and other features as indicated in the table.

TABLE 2-1

FEATURES OF MAJOR STUDIES ON DEMAND FOR RESERVES. REGRESSION TECHNIQUES

Author, Year	Main Regression	Cross Section	Dependent Variable	Relevant Explanatory Variables (Proxy in Parentheses)	Countries	Frequency	Time Period
Kenen & Yudin (1965)			Reserves	1 - e These variables were 2 - ρ estimated for each 3 - δ country from $\Delta R_t = e + \rho \Delta R_{t-1} + \epsilon$ 4 - Marginal productivity of capital (per capita income) 5 - Liquid liabilities of bank 6 - Money Supply	14 DC's	Monthly	1957-1962
Thorn (1961)			Reserves	1 - Time 2 - Imports 3 - Reserves/Imports in 1960	14 DC's	Annually	1954, 1957, 1962, 1964
Courchene & Youssef (1967)		Time Series	Reserves	1 - Imports 2 - Money Supply 3 - Long Run Interest Rates	9 DC's	Quarterly	1958, 1964
Kelly (1970)		Time Series & Cross Section	Reserves	1 - Standard Deviation of Exports	46	Annually	1953-1965

TABLE 2-1 (cont'd.)

FEATURES OF MAJOR STUDIES ON DEMAND FOR RESERVES. REGRESSION TECHNIQUES

Author, Year	Main Regression	Dependent Variable	Relevant Explanatory Variables (Proxy in Parentheses)	Countries	Frequency	Time Period
Kelly (1970) (cont'd.)	Time Series & Cross Section Pooled	Reserves	2 - Average Propensity to Import 3 - Opportunity Cost of Funds (per capita income)	46	Annually	1953-1965
Clark (1970)	Time Series	Reserves	1 - Time 2 - Reserves at t-1	38	Monthly	1958-1967
	Cross Section	Reserves	1 - Marginal Propensity to Import	38	Monthly	1958-1967
			2 - Per Capita Income			
Archibald & Richmond (1971)	Time Series	Reserves	3 - Standard Deviation of Disturbance Term 1 - Time 2 - Reserves at t-1	14 DC's	Monthly	1961-1967
Flanders (1971)	Cross Section	Reserves/ Imports	1 - Foreign Exchange Holding by Private Banks 2 - Official Holdings of Foreign Exchange	57 Countries & Sub-Groups	Annually	1963, 1964, 1965, 1966, 1967

TABLE 2-1 (cont'd.)
FEATURES OF MAJOR STUDIES ON DEMAND FOR RESERVES. REGRESSION TECHNIQUES

Author, Year	Main Regression	Dependent Variable	Relevant Explanatory Variables (Proxy in Parentheses)	Countries	Frequency	Time Period
Flanders (1971) (cont'd.)	Cross Section	Reserves/ Imports	3 - Variance of Change in Reserves 4 - Rate of Growth in GNP 5 - Exchange Rate/Cost of Living Index 6 - Per Capita Income 7 - Indices of Export Instability	57 Countries 6 Sub-Groups	Annually	1963, 1964, 1965, 1966, 1967
Frankel (1974)	Cross Section	Reserves	1 - Average Propensity to Import 2 - Imports 3 - Measure of Balance-of Payment Variability	55	Annually	1963, 1964, 1965, 1966, 1967
Frankel (1974)	Cross Section & Time Series Pooled	Reserves	1 - Average Propensity to Import 2 - Imports 3 - Measure of Balance-of Payment Variability	22 LDC's 33 DC's	Annually	1963, 1964, 1965, 1966, 1967

TABLE 2-1 (cont'd.)
FEATURES OF MAJOR STUDIES ON DEMAND FOR RESERVES. REGRESSION TECHNIQUES

Author, Year	Main Regression	Dependent Variable	Relevant Explanatory Variables (Proxy in Parentheses)	Countries	Frequency	Time Period
Officer (1976)	Time Series (official)	Reserves (official)	1 - Value of Int. Transactions (Total Credit or Debit)	25	Annually	1959-1970
Officer (1976)	Time Series	Foreign Exchange Holdings of Commercial Banks	1 - Value of Int. Transactions	25	Annually	1959-1970
Iyoha (1976)	Cross Section	Reserves	1 - Expected Export Earning 2 - Variability of Export Earning 3 - Interest Rate on Foreign Exchange Holdings 4 - Degree of Openness of Economy (Average Propensity to Import) 5 - Reserve at t-1 6 - Reserve at t-2	29 LDC's	Annually	1970

TABLE 2-1 (cont'd.)
FEATURES OF MAJOR STUDIES ON DEMAND FOR RESERVES. REGRESSION TECHNIQUES

Author, Year	Main Regression	Time Series	Dependent Variable	Relevant Explanatory Variables (Proxy in Parentheses)	Countries	Frequency	Time Period
Worrell (1976)		Time Series	Reserves	1 - Change in the Money Supply 2 - Export Earnings 3 - Capital Inflow From Abroad 4 - Government Expenditure 5 - Reserves at t-1	Jamaica	Monthly	January 1968- December 1971
Frankel (1978)		Cross Section	Reserves	1 - Imports 2 - Measure of Variability of Balance of Payment 3 - Average Propensity to Import	22 DC's 32 LDC's	Annually	1963-1975
Heller & Khan (1978)		Time Series	Reserves	1 - Imports 2 - Measure of Variability of Balance of Payments [Moving Average]	1 - World 2 - World (excluding oil exporting countries)	Quarterly	1960 (II)-1976 (V)

TABLE 2-1 (cont'd.)
FEATURES OF MAJOR STUDIES ON DEMAND FOR RESERVES. REGRESSION TECHNIQUES

Author, Year	Main Regression	Time Series	Dependent Variable	Relevant Explanatory Variables (Proxy in Parentheses)	Countries	Frequency	Time Period
Heller & Khan (1978)			Reserves	3 - Average Propensity to Import	3 - World (excluding oil exporting countries) 4 - DC's 5 - DC's excluding U. S. A. 6 - LDC's	Quarterly	1960(II)- 1976 (V)
Bilson & Frenkel (1979)		Cross Section	Reserves	1 - Average Propensity to Import 2 - GNP 3 - Measure of Variability of Balance of Payments	22 DC's 32 LDC's	Annually	1964-1972 F F
Frenkel (1980)		Cross Section	Reserves	1 - Imports 2 - Measure of Variability of Balance of Payment 3 - Average Propensity to Import	22 DC's 32 LDC's	Annually	1963-1977
		Cross Section and Time Series Pooled					

CHAPTER THREE

THE THEORY OF DEMAND FOR AND SUPPLY OF INTERNATIONAL RESERVES

3.1 Introduction

If economists could measure the need for reserves, they might be able to agree on the right way to predict their growth rate. Most of the economists who suggest drastic reform do so because they predict a shortage of international reserves. Consequently, if we can measure the need for reserves or, more precisely, the amount of international money that countries would like to hold, then we might be able to answer or give some suggestions about the proper growth rate. Quantitative methods may answer important factual questions pertaining to international liquidity. We may ask, for example, if national holdings of reserves exhibit any rational pattern; if they do, we may be able to describe the national demand for reserves of a "typical" country, then appraise the distribution of global reserves.

Quantitative approaches to the optimal reserve problem have been adopted in the literature. This approach concentrates on the purely statistical examination of time series data of international reserves and attempts to assess the

relative adequacy of reserves by relating present stock to past performance. Papers of varying degrees of statistical sophistication by all those who were listed in Table 1 of the previous chapter have adopted this approach and shall be adopted by us. But as mentioned in the previous chapter, all previous works have assumed the supply of international reserves is elastic enough to meet the demand, but what if this is not the case? Even in 1914, the year in which the gold standard broke down, Triffin suggested that the demand for reserves was growing faster than the supply could do unless the United States ran a deficit. This indicates that the assumption of elastic supply of reserves is not valid. Especially in econometric studies, when one attempts to estimate the demand side without taking into account the supply equation, the results embody a simultaneous-equation bias. Thus, it is our task in this chapter not only to specify a demand function, but also to write down a supply function and discuss its determinants.

Most discussions of the adequacy of international reserves have pointed out the trade-off which exists between financing a payments deficit by drawing on reserves and making adjustments within the economy to reduce the deficit.¹ The primary function of reserves is to serve as a buffer stock which finances temporary discrepancies between a country's international payments and receipts, thereby making it unnecessary for a country to adjust completely to every balance of payments disturbance. Nevertheless, most countries

can be expected to reconstitute reserves which have been lost in the course of financing a payments deficit. This implies that any given reserve movement has two components; one which represents adjustments to present and past balance of payments disturbances, and one which represents the true disturbance. In the last section of this chapter, a modified partial adjustment model will be specified, and we will try to estimate the speed of adjustment.

Since our study covers the period of managed floating system, one might ask whether in the period of free float there is any need to hold international reserves, since exchange rate variations will eliminate any imbalances. Several attempted explanations for the absence of a decline in reserve use were contained in the Fund's Annual Report, 1974. These, briefly, are as follows:

- I. Exchange rates are managed in the present system rather than being allowed to float freely without intervention.
- II. There are motives for holding reserves other than to finance payments imbalances, and these motives, such as the need to use reserves as a basis for foreign borrowing, may not have changed.
- III. Countries that were floating at that time may well have been anxious to return to fixed rates and accordingly maintained an appropriate level

of reserves.

IV. The present system is one in which the currencies of the majority of countries are pegged to a single currency or a composite of currencies. In such a framework, it is possible that countries pegged to a single floating currency would increase reserve use because of the added variability in payments balances caused by the movement of exchange rates between third currencies and the intervention currency. While the Annual Report of 1974 was concerned with the behavior of reserves in the period 1973-1974, some of these arguments continue to be relevant. In particular, the last argument can be viewed as applicable to most non-oil developing countries even now.

Also, Williamson (1974) has argued that the standard view rests on the key assumption that demand and supply curves for foreign exchange are invariant with respect to the exchange rate system, and this assumption may not be warranted. In addition, destabilizing capital flows may result in an increased use of reserves in the move from a par value system, and if there is a secular rise in these destabilizing flows, the use of reserves may increase over time.²

Recent SDR allocation in late 1979, early 1980, and 1981 (forthcoming) is also an indication of need for reserves and supports the general idea that in the period of managed

float countries still want to hold reserves.

Heller and Khan (1978) and Frankel (1979) statistically tested and concluded that there has been structural change in the system with respect to demand for reserves which occurred in 1973. But in his recent work, using revised and correct data, Frankel (1980) accepts the fact that the change was not that drastic:

"Finally it should be noted that even though, as a statistical matter, the system underwent a structural change, the extent of the change has not been as drastic as one might have expected. In fact, forecasting reserve holdings during the period 1973-1977, yield extremely good predictions." Frankel (1980), p. 301.

We conclude that there is a general agreement that demand for reserves will depend on what kind of exchange rate system is in existence. If all countries in the world were in the system of free float, maybe there would not be any need for reserves. However, for reasons mentioned above, that is not the case for our period of study (1972-1977), in which the gold price has been soaring.

3.2 The Demand for International Reserves

In this section an attempt is made to ascertain the determinants of the demand for international reserves by the monetary authorities of the countries studied. An important aim of this section is to improve on the specifications of the demand for reserve functions that exist in the literature.

Reserves and imports - The relationship between reserves and imports has been highly popularized in discussions of reserve adequacy. The most common variant of this approach to the demand for reserves is nothing but an application of the strict quantity theory to the international payments sphere, with the level of imports taking the place of transaction, T . The question that remains is whether the growth of trade (measured by the growth of imports) will raise the demand for reserves. There really cannot be serious doubt that it will. Most of the models that we reviewed in Chapter Two agree that reserve demand should grow in line with imports. Implicit in much of the discussion (and a property of the strict quantity theory) is the assertion that reserves should grow proportionally with the level of imports (that is, the demand for reserves with respect to the level of imports is unit elastic). This, of course, need not be the case. Olivera (1969) derived a square root laws, analogous to the Baumol-Tobin theorem on the demand for money, which stated that the demand for reserves would grow in proportion to the square root of trade, implying an elasticity of 0.5. This was tested by Officer (1976) and an affirmative answer obtained, that is, the elasticity of demand for reserves with respect to imports is between $1/2$ and 1.

It has been generally accepted that countries hold international reserves in order to finance their imbalances (deficits). Allowing for the fact that a proportional

increase in trade (approximated by the size of imports, M) may also increase the deficit of a country, we would expect a positive relation between reserves held by that country (in order to finance the increased deficit) and its level of imports. So we conclude that the first determinant of demand for reserves in our model is the level of imports, M , and we would expect the relation to be a positive one, that is, more reserves will be demanded, the higher is the level of imports.

Reserves and propensity to import - The second determinant of the demand for international reserves is propensity to import. The rationale for the use of this variable stems from an application of the Keynesian "price-less" model of the foreign trade multiplier.

Let us consider the simplest Keynesian version of a small economy with fixed prices of commodities; furthermore, let us set the prices to equal unity. In equilibrium aggregate demand must be equal to aggregate supply, that is:

$$Y = C + I + G + x - M \quad (1)$$

where Y = level of total output;

C = consumption expenditure, which depends on the level of output in the economy. Let us assume the following consumption function:

$$C = \bar{C} + cY \quad \text{where} \quad \frac{\Delta C}{\Delta Y} = c \text{ is marginal propensity to consume;}$$

I = investment expenditure, independent of output level ($\bar{I}$);

De

eq

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or

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Re

G = government expenditure ($\bar{G}$);

X = level of exports which is determined by foreign demand ($\bar{X}$);

M = level of imports which depends on output level. Let us assume that the import-function takes the following form:

$$M = \bar{M} + mY \quad \text{where} \quad \frac{\Delta M}{\Delta Y} = m \text{ is marginal propensity to import.}$$

Let us now substitute all the above mentioned functions in equation (1); we get:

$$Y = \bar{C} + cY + \bar{I} + \bar{G} + \bar{X} - (\bar{M} + mY) \quad (2)$$

Solving equation (2) for Y yields the following:

$$Y = \frac{1}{1 - c + m} (\bar{C} + \bar{I} + \bar{G} + \bar{X} - \bar{M}) \quad (3)$$

The balance of trade could be expressed as:

$$T = X - M = \bar{X} - \bar{M} - mY \quad (4)$$

and substituting (3) into (4) we get:

$$T = \bar{X} - \bar{M} - \frac{m}{1 - c + m} (\bar{C} + \bar{I} + \bar{G} + \bar{X} - \bar{M}) \quad (5)$$

Assume there is a decline in export earnings. The resulting deficit in the balance of trade due to a given reduction in export earning is:

$$\frac{dT}{d\bar{X}} = 1 - \frac{m}{1 - c + m} = \frac{1 - c}{1 - c + m}$$

or

$$\frac{dT}{d\bar{X}} = \frac{s}{s + m} \quad \text{where} \quad 1 - c = s \quad (6)$$

From equation (6), it is obvious that the larger is marginal propensity to import, the smaller becomes deficit and

consequently the smaller will be the demand for reserves in order to finance the deficit.³ This implies an inverse relation between the optimal holdings of reserves and the marginal propensity to import.⁴

In the absence of data on the marginal propensity to import, earlier empirical studies employed instead the ratio of imports to income, that is, the average propensity (typically referred to as the degree of "openness" of the economy). The coefficient of the average propensity to import frequently appeared with the "wrong" (positive) sign when used to estimate the demand for reserves, except in Heller and Khan (1978). This positive coefficient led many authors to argue that average propensity to import should not be interpreted as a proxy for marginal propensity to import but rather as a proxy for "openness," thus measuring the extent to which the economy is vulnerable to external disruptions. Accordingly, the positive coefficient on the average propensity reflects the fact that the demand for reserves is a positive function of external vulnerability.

Frenkel (1974-A) has investigated the relation between reserve holdings and the average propensity to import, using an alternative theory of the adjustment mechanism. The basic characteristic of his theory is its emphasis on the role of relative prices and the price level. His analysis is confined to the long-run equilibrium of a stationary, fully employed economy. An affirmative answer was concluded from this theory: demand for reserves is

positively related to the average propensity to import.

Frenkel (1974-A) assumed a fully employed economy in long-run equilibrium (that is, the long-run stock demand for assets is satisfied and thus savings are zero, and income equals expenditures). Furthermore, he assumed a two-commodity economy which is specialized in the production of first commodity. Let the output of the fully employed economy be:

$$Q_1 = \bar{Q}_1 \quad (7)$$

The demand functions for the two goods are homogeneous of degree zero in money prices (P_1, P_2) and money income ($P_1 \bar{Q}_1$) and thus can be written as:

$$C_1 = C_1(q, q\bar{Q}_1) \quad (8)$$

$$C_2 = C_2(q, q\bar{Q}_1) \quad (9)$$

where $q \equiv \frac{P_1}{P_2}$ represents the terms of trade. It is also assumed that the price of importables (P_2) is exogenously given by the rest of the world. The terms of trade, however, are not assumed to be given since the price of exportables (P_1) is determined endogenously.

Long-run equilibrium requires that:

$$P_1 C_1 + P_2 C_2 = P_1 \bar{Q}_1 \quad (10)$$

Dividing both sides of (10) by P_2 yields:

$$qC_1 + C_2 = q\bar{Q}_1 \quad (11)$$

Similar relationships hold in the foreign country. In particular, foreign demand for domestic output is given by:

$$C_1^f = C_1^f(q, \alpha^f), \quad \frac{\partial C_1^f}{\partial \alpha^f} > 0 \quad (12)$$

where (f) denotes the foreign country and α^f is a shift parameter of foreign demand.

The stock demand for cash balances depends on the price level (P) and on real income ($\frac{P_1 \bar{Q}_1}{P}$). Let us assume this demand function is linearly homogeneous in all prices:

$$M^d = PL \left(\frac{P_1 \bar{Q}_1}{P} \right) \quad (13)$$

The consumer price level (P) is a linear homogeneous function of the prices of the two goods with elasticities that are equal to the relative shares of expenditures on these goods in total expenditures, such that

$$\frac{\partial P}{\partial P_1} \cdot \frac{P_1}{P} = \bar{m}_1; \quad \frac{\partial P}{\partial P_2} \cdot \frac{P_2}{P} = \bar{m}_2 \quad (14)$$

where $\bar{m}_i = \frac{P_i C_i}{P_1 \bar{Q}_1}$ ($i = 1, 2$) is the average propensity to consume the i th good, and $\bar{m}_1 + \bar{m}_2 = 1$.

Furthermore, assume the exchange rate is pegged. Accordingly, the stock supply of cash balances (M^S) is proportional to the holdings of international reserves (R). For simplicity assume:

$$M^S = R \quad (15)$$

The long-run equilibrium conditions are: (a) the demand for

domestic output equals its supply; and (b) the existing stock of cash balances equals the desired stock. Using equations (7) - (15) these conditions can be written as:

$$C_1(q, q\bar{Q}_1) + C_1^f(q, \alpha^f) - \bar{Q}_1 = 0 \quad (16)$$

$$PL\left(\frac{P_1\bar{Q}_1}{P}\right) - R = 0 \quad (17)$$

From equation (11) it is seen that a given change in foreign demand $\left(\frac{\partial C_1^f}{\partial \alpha^f}\right)d\alpha^f$ affects the price of exportables (the terms of trade) according to:

$$\frac{dq}{d\alpha^f} = \frac{-\partial C_1^f / \partial \alpha^f}{(\partial C_1 / \partial q)' + (1 - \bar{m}_1) \bar{m}_1 / q \bar{Q}_1 + \partial C_1^f / \partial q} \quad (18)$$

where $\left(\frac{\partial C_1}{\partial q}\right)'$ and $\left(\frac{\partial C_1^f}{\partial q}\right)$ are, respectively, the slopes of the domestic and foreign excess demand for exportables. The term in the denominator of equation (18) is the standard Marshall-Lerner condition which has to be negative for stability. Thus, assuming stability, $\frac{dq}{d\alpha^f} > 0$.

A given improvement in terms of trade raises real income and creates excess demand for money that [from (17)] is equal to:

$$R[\bar{m}_1 + \eta_L(1 - \bar{m}_1)]/q$$

$$\text{where } \eta_L \equiv \frac{\partial L}{\partial Y} \frac{Y}{L} > 0 \quad \text{and } Y = \frac{P_1\bar{Q}_1}{P}.$$

η_L is the elasticity of the demand for real cash balances with respect to real income. Therefore, the given change in foreign demand will affect the holdings of international

reserves according to:

$$\frac{1}{R} \frac{dR}{d\alpha^f} = \frac{-\frac{1}{q} \frac{\partial C_1^f}{\partial \alpha^f}}{\left(\frac{\partial C_1}{\partial q}\right)' + (1 - \bar{m}_1) \frac{\bar{m}_1 \bar{Q}_1}{q} + \frac{\partial C_1^f}{\partial q}} > 0 \quad (19)$$

If openness is defined in terms of the share of imports in GNP ($\bar{m}_2$), the effect of $\bar{m}_2$ on reserve holdings can be ascertained by differentiating equation (19) with respect to $\bar{m}_1 = (1 - \bar{m}_2)$. It can be verified that the condition for a positive association between reserve holdings and openness is that:

$$\eta_L > \frac{\left(\frac{\partial C_1}{\partial q}\right)' + \frac{\partial C_1^f}{\partial q} + \left(\frac{m_1}{q}\right) \bar{Q}_1}{\left(\frac{\partial C_1}{\partial q}\right)' + \frac{\partial C_1^f}{\partial q}} \quad (20)$$

Since the denominators or denominator of the right-hand side of (20) are negative (from the Marshall-Lerner condition), and since $\eta_L > 0$, it is clear that if the numerator of (20) is positive, the conditions must be satisfied. If, however, the numerator of the right-hand side of (20) is negative, a sufficient condition for a positive association between openness and reserves is that $\eta_L \geq 1$ (for $m_1 > 0$). Empirical studies on the demand for money suggest that, in general, η_L does not fall short of unity and accordingly imply that condition (20) is satisfied; thus, reserve holdings depend positively on the average propensity to import.

In any case, the expected sign between reserve holding behavior of a country and average propensity to import

could be either negative, supporting the "priceless" Keynesian model, or positive, supporting the price-adjustment model of Frenkel. As we saw in the previous chapter, empirical results have supported both.

Reserves and the Price of Gold⁵ - The third determinant of the demand for international reserves in our model is the gold price. Between 1949, when the U.S. Treasury's gold holdings peaked at \$24 billion, and 1960, U.S. gold holdings declined by \$8 billion. This redistribution of gold among the world's central banks was deemed necessary to provide the financial basis for the postwar growth in world trade. But by 1960 there was growing recognition that the total supply of gold available for central banks as a group was too small to meet their demand. By 1965 the private demand for gold had increased above the level of production; central banks sold \$50 million of gold from their reserves to hold the price at \$35. Uncertainties about the future sterling parity led to a surge in the private demand for gold. In 1967 central banks sold \$1.6 billion of gold to private parties to prevent the price from rising above \$35. And in the first ten weeks of 1968, sales to private parties reached \$700 billion. These flows of gold from central banks to the private parties led the Nixon administration to close the so-called "gold window."

The suspension of gold transactions by the U.S. Treasury in 1971 reflected a shortage of gold which has persisted for most of the following years. The supply of gold

available to central banks has been less than the desired level because, while production has grown slowly, the private demand for gold as a commodity - for use in industry and especially for hoarding and speculation - has grown rapidly. Thus, if private demand for gold increases, less gold is available to central banks. Similarly, if the central bank demand for gold increases - that is, if the banks agree to pay a higher price for gold - they will bid gold away from private users.

Two kinds of measures might have resolved the shortage; either the private demand for gold might have been reduced by lowering the commodity price level, or the supply might have been increased by raising the monetary price of gold. Since the scope for reducing the private demand was small, this led some economists to suggest the latter course: increasing the gold price in order to reduce not only the shortage of gold, but also the shortage of international reserves as a whole.

Some other economists have argued that an increase in the gold price would be inflationary; private parties would spend more as a result of their revaluation gains. This concern might be valid if gold were still used as a domestic money, but with gold's monetary role limited to transactions among central banks and with private gold holdings such a small fraction of private wealth, it has much less force now. Some central banks might follow a somewhat more expansive policy as a result of their revaluation gains. Any increase

in commodity price levels from an increase in the monetary price of gold would be small relative to the increases resulting from other sources.

Higher gold price not only will stimulate gold production, but also will reduce the demand for it. Since the gold component of total reserves of a country will be revalued, this will make the demand of that country for international reserves as a whole drop. Consequently, a negative relation between the reserve holding behavior of a country and gold price would be expected.

Reserves and Measure of Balance of Payment Variability -

The need for reserves is obviously related to the degree of variability in a country's international transactions. All authors adopting a quantity-theory approach to the demand for reserves have used the level of a country's imports as an index of the value of transactions to be financed with reserves. Realizing that reserves are actually used to finance the difference between payments and receipts, others have used measures of the variability in this difference as an indicator of the need for international reserve assets. For example, Kenen and Yudin (1965) have taken the variance of the error term of an estimated first-order autoregressive scheme as a measure of the variability in a country's external account: $\Delta R_t = \rho \Delta R_{t-1} + \epsilon_t$.

In cross-section studies the use of measure of balance of payment variability has been a tradition even if there

are some limitations. The main limitation of this measure is that actual changes in reserves need not provide the exact measure of the disturbance since countries may use some other policies. Monetary, fiscal, and trade policies, such as tariffs and quotas, are often used by countries for the purpose of reducing the impact of these disturbances on their reserves. If these policies are successful, then the observed fluctuations in reserves will be reduced. Kenen and Yudin (1965, p. 246), who used this measure, are aware of this possibility and assume that the estimate is not affected by national policies. To what extent this assumption holds is questionable. It might be true that in a cross-section study we can ignore that limitation and follow Heller, who claims "any bias that might actually be introduced is probably very small and negligible" (1966, p. 310). However, in a time-series study (or pooled cross-section and time-series) the effect of national policies on this variable cannot be ignored, and since our study is one of pooled cross-section, time-series we will not include this variable in our model.

Reserves and Opportunity Cost of Holding Reserves -

Liquid international reserves held by the monetary authorities are part of the total capital resources of a country. These reserve assets could have been invested productively. The differential between the social yield on capital invested and the yield on liquid international reserves is the

appropriate concept of the opportunity cost of holding liquid international reserves. The measurement of the proper opportunity cost is complicated, and as our table at the end of the previous chapter indicates, different studies have used different proxies for this variable. For example, Kenen and Yudin (1965) have used per capita income; Courchene and Youssef (1967), long run interest rates; Kelly (1970), per capita income; Clark (1970), per capita income; Flanders (1971), per capita income; Iyoha (1976), interest rate on foreign exchange holdings. All of these studies found an insignificant relationship between reserves and the opportunity cost variable. Iyoha (1976) was the first one who claimed a significant relation between reserve and opportunity cost, but he misinterpreted his results. He makes no allowance in his regression for compositional differences in the reserve stock of different countries. Not all components of reserves of a country can earn interest. Another weakness of Iyoha's analysis is his selection of a statistical series for the yield rate in each country, which is an internal yield rate. This is incorrect since the only meaningful yield rate for invested foreign exchange reserves must be an external yield rate.

Therefore, we assume that the opportunity cost of holding reserves is not a major independent variable in reserve demand functions. First, it is impossible to measure the true opportunity cost of holding reserves. Second, it is difficult to come up with a good proxy for it,

and in all studies reviewed the opportunity cost had an insignificant coefficient. For those reasons we will not include this variable in our demand functions.

There are other determinants that have been used in specific studies. Since no significant relation has been found, we will not include them in our study. They are, for example, money supply or change in money supply, used by Kenen and Yudin (1965), Courchene and Youssef (1967), and Worrell (1976). Expected export earnings were used by Iyoha (1976) and export earnings by Worrell (1976).

Let us now put all determinants of the reserve demand function together:

$$R^d = f(M, \frac{M}{y}, P_g, \delta^2, r, M^S, X)$$

where M = imports, $\frac{M}{y}$ = average propensity to import, P_g = gold price (\$), δ^2 = measure of variability of balance of payment, r = opportunity cost of holding reserves, M^S = money supply, and X = export earning, with $f_1 > 0$, $f_2 \geq 0$, $f_3 < 0$, $f_4 < 0$, $f_5 > 0$, $f_6 < 0$.

But for reasons which were explained above, we will exclude several determinants in our demand function. The demand function which we will utilize is:

$$R^d = F(M, \frac{M}{y}, P_g) .$$

3.3 The Supply of International Reserves

In this section we will try to assert the determinant of the supply of international reserves and specify a supply function.

Supply of reserves consists of three components:

- I. Gold
- II. Convertible foreign exchange (mainly dollars)
- III. Special Drawing Rights (SDR's)

Reserves and Gold - The fact that a high price of gold will stimulate gold production is no surprise. A glance through Table 3.1 and the following estimated relation between gold flows and dollar price of gold supports the idea that there exists a positive relation between these two variables.

The positive and almost significant coefficient of 1.59 supports our claim. An important question which is related to our analysis is: will there be a contribution to official gold stocks (and consequently to official reserves) due to the higher price of gold?

Table 3.1 again shows that the higher market price of gold (relative to official price of gold) prompts the central authority to sell gold. Assuming that they have sold gold in exchange for convertible foreign currencies (mainly dollars), then it is safe to conclude an affirmative answer to our question: the higher market price of gold will make the official supply of reserves increase. We conclude

TABLE 3.1

Gold Flows 1971-1978

Components of Supply
Metric Tons

	1971	1972	1973	1974	1975	1976	1977	1978
Non-Communist World Mine Production	1236	1183	1121	1006	853	967	968	969
Net Trade with Communist Bloc	54	213	275	220	149	412	401	410
Official Sales	96	-151	6	20	9	58	269	362
Net Private Purchases	1386	1245	1402	1242	1111	1437	1638	1741
Dollar Price of Gold in London	43.63	64.90	112.25	186.5	140.25	134.75	164.95	226

To put these data in perspective, consider the following estimated relation:

$$\text{NNP} = 1187.18 + 1.59 \text{ PG} \\ (6.52)*(1.27)*$$

$$R^2 = 0.2125$$

where NNP = net private purchases

Pg = dollar price of gold in London

that a positive relation between gold price and supply of international reserves would be expected.

Reserve and Convertible Foreign Exchange (Dollars) -

The other reserve component is foreign exchange, which consists principally of dollars. We can distinguish two theories about the mechanism governing the supply of dollar reserves. The traditional theory, expounded by Triffin (1960) and repeated by him and many others on innumerable subsequent occasions, treats the supply of dollars as determined by the U.S. deficit. The deficit is the result of complex factors, such as demand-management policies (monetary or fiscal) in the United States and the rest of the world and historical relative cost levels. This is a supply-oriented theory of the supply of dollar reserves.

The second theory is, in contrast, demand oriented. As Williamson (1973) argues, "the theory claims that the United States deficit is primarily a residual which is determined by the reserve-accumulation desires of the rest of the world; any American effort to reduce the deficit would be countered by adjustment policies on the part of other countries designed to reestablish their desired rate of reserve growth." The supply-oriented theory emphasizes the dependence of the U.S. deficit on U.S. actions, and the demand-oriented theory emphasizes the dependence of the U.S. deficit on the policy of the rest of the world. There is no empirical result showing which theory is

better. Williamson (1971) argued, on the basis of a casual inspection of the time series on the U.S. deficit, that there is every sign of its being supply determined in the short run, but conceded that it was probably influenced by the desire for reserves in the long run. For our purpose, there is no need to distinguish which theory is better. The fact is that the dollar component of international reserves is affected by the size of the U.S. deficit. Even if the above discussion applies for the period of the par-value system, for reasons cited in the introductory part of this chapter, we still believe that the deficit of the reserve-currency countries, and mainly the United States, will contribute to the bulk of international reserves. This is the case whether it is caused by the excess demand of other nations for international reserves, or by an excess supply of dollars due to U.S. unwillingness to eliminate its deficit.

The U.S. balance of payment includes two major accounts: the capital account and the current account. The capital account will be in deficit if American investment overseas exceed that of foreigners in the United States. An econometric study by Bell led to the general conclusion that "shifts in the flow of private capital, in particular in U.S. private capital flowing overseas, have been a major cause of United States deteriorating balance of payments position since 1956."

What makes American investors invest overseas

(especially in industrialized countries) or foreigners invest in the United States? We assume it is the real rate of return on investment. Whenever this rate is higher in the rest of the world compared to the United States, then capital outflow will take place, and that will lead to a growing U.S. deficit and, consequently, to the supply of dollars (and the supply of international reserves as a whole will grow). In contrast, if the rate of return on investment is higher in the United States compared to that of the rest of the world, then capital inflow will take place, which will result in a surplus in U.S. balance of payment. That will reduce the supply of dollars and, consequently, the total supply of international reserves will go down. We can conclude that it is the differential rate of return on investment between the United States and the rest of the world which will cause the capital account and, consequently, the U.S. deficit to fluctuate.

Another part of the U.S. deficit, as mentioned above, is due to current accounts, which include the exports and imports of goods and services plus private remittances and government grants. The last items, that is, private remittances and government grants, are assumed to be insensitive to any economic variable. They are controlled by private parties and government, and since they are the minor items in current accounts, we will concentrate on exports and imports of goods and services. The question is, what will cause the U.S. current accounts to fluctuate? We will assume it is the differential price level between

the United States and the rest of the world that gives rise to the fluctuating U.S. deficit. If the prices are higher in the United States than they are in the rest of the world, then the United States will export less and import more, and this will result in deficit. If the U.S. price level happens to be less than that of the rest of the world, then the opposite will be the case. It is also evident that the imports of any country are positively related to its real output level. So, if the U.S. economy is growing faster than the rest of the world, then the United States will import more, its deficit will increase, and the supply of reserves will go up.

It is worth allocating some space at this point to the monetarist view of this issue. The balance of payments is viewed by the monetarists as essentially a monetary phenomenon. Payments imbalances are rooted in the relationship between the demand for and the supply of money. The demand for nominal money balances (M^d) is a stable function of the price level (P), level of real income (Y), and of the interest rate (i). $M^d = f(P, Y, i)$, with $f_1' > 0$, $f_2' > 0$, and $f_3' < 0$. Money supply (M^s), for which demand is a stable function, is a constant multiple (k) of the monetary base. In turn that base has two components: domestic credit created by the monetary authorities (D) and an international component (R). In notational form, $M^s = k[D + R]$, where k is the money multiplier.

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A surplus or deficit in the balance of payments reflects stock disequilibrium between demand for and supply of money. A surplus on the basis of "official reserve transactions" occurs when demand for money balances exceeds the money stock. If the excess demand for money is not satisfied from domestic sources, such as by an increase in domestic money supply, funds will be attracted from abroad to satisfy it. And such an inflow can be generated through a surplus on commodity trade or on the service account; direct investment for foreign companies; or an attraction of private long-term or short-term portfolio funds. The precise composition is immaterial; the important point is that the excess demand for money stock will generate a balance of payments surplus. But assuming no intervention by the monetary authorities to "offset" or "neutralize" the resulting inflow of funds, such a surplus is necessarily temporary and self-correcting. It will continue only until the money stock rises to the level necessary to satisfy the demand for money balances, that is, until the excess demand for money is eliminated.⁷

Alternatively, a balance of payments deficit reflects an excess supply of money as a stock. When the stock of money exceeds the demand for money balances, people try to get rid of the excess supply. They do that by increasing purchases of foreign goods and services, by investing abroad, or by transferring short- or long-term portfolio funds abroad to acquire foreign assets. Thus the deficit on

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official reserve transactions is viewed as a spillover of the excess supply of money; its composition is immaterial. Again the deficit is temporary and self-correcting.

To recapitulate, the monetary approach to the balance of payments is concerned strictly with long-run equilibrium and rests on two central assumptions: (a) the demand for money is a stable function of a limited set of variables; and (b) countries do not pursue stabilization or offsetting policies, either because they cannot stabilize over a long period or because they do not wish to do so. Although not central to the approach itself, many of its adherents also believe that (c) wage-price flexibility fixes output at the full employment level, at least in the long run, so that the Keynesian income adjustment mechanism is irrelevant, and (d) perfect substitution in consumption (that is, infinite cross-elasticity of substitution) across countries in both the product and the capital markets ensures a single price for each commodity and a single rate of interest. In other words, the world consists of a single integrated market for all traded goods and for capital. The "law of one price" obtains throughout the globe. Consequently, changes in relative prices are not possible, and the elasticities approach is rejected. Adherents to assumption (c) and (d) in addition to (a) and (b) are often called "global monetarists." In previous pages we concluded that if real rate of return on investment is higher in the United States

compared to that of the rest of the world, there will be an inflow of funds that will create a balance of payments surplus in the United States.

Since interest rates could be used as a proxy for rate of return on investment, if the rate of interest is higher in the United States compared to that of the rest of the world, that means the opportunity cost of holding money is higher in the United States, which in turn brings a decrease in the demand for money. The resulting excess supply of money would be dissipated abroad in the form of an external deficit, which is in disagreement with our conclusion. With respect to the current account, we concluded that a differential price level will play a role in the U.S. deficit, that is, if the U.S. price level is higher than that of the rest of the world, then the U.S. balance of payments will deteriorate. Again, monetarists would disagree with our conclusion. An exogenous rise in the U.S. price level relative to the price level of the rest of the world, with real income held constant, increases the demand for money in accordance with the demand-for-money function. The portion of this increase not supplied from domestic sources is reflected in a balance of payments surplus. As in the case of interest rates, this result conflicts with what we concluded in our model.

Because of the "law of one price," global monetarists would be in complete disagreement with us also. In their view there will be neither differential interest rates nor

differntial price levels among the countries.

Reserves and SDRs - Under the system of fixed exchange rates, which existed prior to the early 1970s, the value of many currencies were fixed in terms of the U.S. dollar. The value of the dollar, in turn, was fixed in terms of gold. Since the United States guaranteed other central banks that dollars could be converted into gold, central banks in general regarded their dollar as being "as good as gold." Thus, the dollar was used to supplement gold as international reserves.

While other central banks were willing to accept dollars as reserve assets, foreign holdings of dollars could not expand sufficiently to satisfy foreign central banks' demand for reserves without a continuous U.S. balance of payments deficit. The United States could not continue running such deficits, however, without casting doubt upon the ability of the U.S. government to maintain the fixed relative value of dollars.

The elimination of the U.S. deficit and a corresponding reduction in the growth of international reserves during the last half of the 1960s led to increasing uncertainty as to how future increases in the demand for reserves could be satisfied. It was against this background that the International Monetary Fund (IMF) member countries decided to create an international reserve asset. The supply of, and confidence in, this new asset would be

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independent of any one country's domestic economic policies.

The new type of reserve asset which was created to help improve the functioning of the international payments system was the Special Drawing Right, which came into existence in 1969. SDRs were created as bookkeeping entries and were essentially given to all IMF member countries electing to receive them. These bookkeeping entries were designed to be transferred directly between central banks in settlement of balance of payments deficits, with the IMF guaranteeing their value in terms of a fixed amount of gold. Actual holders of SDRs have included only the central banks and treasuries of IMF member countries which have agreed to accept them, and the IMF itself. Private institutions (such as commercial banks) and individuals (such as importers and exporters) cannot hold SDRs.

By allocating SDRs, the world supply of reserves could be increased while the U.S. balance of payments deficit could be corrected. Elimination of the U.S. deficit would ensure confidence that the prevailing foreign currency value of the dollar could be maintained. The fixed exchange rate system could thus be preserved, with the SDR becoming the main reserve asset.

Although the SDR has become generally accepted as an international reserve asset, the quantitative impact of SDRs upon total international reserves has been relatively minor. Following their initial allocation in 1970, SDRs accounted for about 3 percent of total international

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reserves. Following the second and third allocations in 1971 and 1972, SDRs accounted for about 5 percent and 6 percent, respectively, of total world reserves.

Because our estimation results are based on the period 1972-1977, no further allocations of SDRs have been made during that period, and the total amount of SDRs in that period remained at 9.31 billion, we cannot include any identifiable independent variables in our supply function which accounts for variation in SDR component of supply of reserves, because there has been no variation in that component.⁸

Taking into account all factors that might affect the supply of international reserves, we will assume our supply function takes the following form:

$$R^S = F[P_g, (r_{U.S.} - r_{R.O.W.}), (P_{U.S.} - P_{R.O.W.}), y_{U.S.} - y_{R.O.W.}]$$

where P_g = gold price;

$r_{U.S.}$ = real rate of return on investment in the United States;

$r_{R.O.W.}$ = real rate of return on investment in the rest of the world;

$P_{U.S.}$ = average price level in the United States;

$P_{R.O.W.}$ = average price level in the rest of the world corrected by exchange rates;

$y_{U.S.}$ = real GNP in the United States; and

$y_{R.O.W.}$ = real GNP in the rest of the world.

We can now put together the demand for and supply of reserve functions:

$$\text{Demand } R^D = f(M, \frac{M}{Y}, P_g)$$

$$\text{Supply } R^S = F[P_g, (r_{U.S.} - r_{R.O.W.}), (P_{U.S.} - P_{R.O.W.}), \\ (Y_{U.S.} - Y_{R.O.W.})]$$

The identification of the system and its specification and estimation results are presented in the next chapter.

3.4 Disequilibrium Model

In order to introduce the possibility of disequilibrium behavior into our model, we use an adjustment equation.

It seems reasonable to assume that the behavior of economic policymakers is governed, at least implicitly, by the desire to maintain a given target level of reserves. This stock of reserves is used to finance discrepancies between payments and receipts, but eventually steps will be taken to bring the level of reserves back to the target level. More specifically, it is assumed that a country wishes to hold an average stock of reserves, R^* , and in each period wishes to eliminate any gap between R^* and the stock of reserves at the beginning of the period, R_{t-1} , by a certain proportion γ . As long as reserves depart from the desired level, the country will attempt to induce a balance of payment surplus (or deficit), ΔR_t , which is given by the following stock-adjustment equation:

$$\Delta R_t = \gamma(R^* - R_{t-1}) \quad (3.5.1)$$

Substituting our demand function from the previous section for R^* , we get:⁹

$$\Delta R_t = \gamma(a_0 + a_1 M_t + a_2 \left(\frac{M}{Y}\right)_t + a_3 P_{g_t} - R_{t-1}) \quad (3.5.2)$$

or

$$R_t = a_0 + a_1 M_t + a_2 \gamma \left(\frac{M}{Y}\right)_t + a_3 \gamma P_{g_t} + (1-\gamma)R_{t-1} \quad (3.5.3)$$

Since ΔR_t is specified as adjusting to excess demand, the gold price adjusts to condition of excess supply.

$$\Delta P_{g_t} = \lambda(R_t - \frac{S}{R_t}), \lambda > 0 \quad (3.5.4)$$

In this framework an increase in excess supply will lower the gold price, and conversely for a decrease.

Substituting our supply function from the previous section in (3.5.4), we get:¹⁰

$$\begin{aligned} \Delta P_{g_t} = & \lambda [R_t - b_0 - b_1 P_{g_t} - b_2 (r_{U.S.} - r_{R.O.W.})_t \\ & - b_3 (P_{U.S.} - P_{R.O.W.})_t + b_4 (y_{U.S.} - y_{R.O.W.})_t] \end{aligned} \quad (3.5.5)$$

Relation (3.5.5) could be summarized and written in the following form:

$$\begin{aligned} R_t = & b_0 + (b_1 + \frac{1}{\lambda}) P_{g_t} - \frac{1}{\lambda} P_{g_{t-1}} + b_2 (r_{U.S.} - r_{R.O.W.})_t \\ & + b_3 (P_{U.S.} - P_{R.O.W.})_t + b_4 (y_{U.S.} - y_{R.O.W.})_t \end{aligned} \quad (3.5.6)$$

Equations (3.5.3) and (3.5.6) together form a simultaneous equation model which we will estimate in the next chapter.

CHAPTER FOUR

MODEL SPECIFICATION AND ESTIMATION RESULTS

4.1 - Introduction

In this chapter, we will try to specify the model of demand for and supply of reserves in several different ways. The difficulty and problems of each model will be pointed out. Then the estimated results for each model will be presented.

Our concern is to estimate the demand function by taking into account the endogeneity of the supply side, too, but no estimates of the supply function will be presented.

When one attempts to estimate any single equation of a system of equations, one faces the problem of identification. Our model is no exception, and in the next section we will look at the identification problem and then at the method of estimation.

4.2 - Identification

The basic requirement an economic model must satisfy is that the number of the variables whose values are to be explained must be equal to the number of independent relationships in the model, i.e., to the number of

different pieces of relevant information; otherwise, the values of these variables would not be determinate. In addition to the variables whose values are to be explained, a model may, and usually does, contain variables whose values are not affected by the mechanism described by the model. This leads to a distinction between those variables whose values are to be explained by the model and those that contribute to providing such an explanation; the former are called endogenous and the latter exogenous variables.

In order to identify the endogenous and exogenous variables in our model, we shall write down the demand and supply equations again. More specifically, we shall specify them in a linear form, so that we can look at the identification problem easily:

$$\text{(Demand)} \quad R = a_0 + a_1 M + a_2 \frac{M}{y} + a_3 P_g + \epsilon$$

$$\begin{aligned} \text{(Supply)} \quad R = & b_0 + b_1 P_g + b_2 (r_{\text{U.S.}} - r_{\text{R.O.W.}}) \\ & + b_3 (P_{\text{U.S.}} - P_{\text{R.O.W.}}) + b_4 (y_{\text{U.S.}} - y_{\text{R.O.W.}}) + u \end{aligned}$$

Endogenous variables: R and P_g

Exogenous variables: M , $\frac{M}{y}$, $r_{\text{U.S.}}$, $r_{\text{R.O.W.}}$, $P_{\text{U.S.}}$, $P_{\text{R.O.W.}}$, $y_{\text{U.S.}}$, $y_{\text{R.O.W.}}$.

Since our concern is to estimate the demand function, we shall only identify that function.

The model in matrix form reads thus:

$$\begin{pmatrix} 1, R, M, \frac{M}{Y}, P_g, (r_{U.S.} - r_{R.O.W.}), \\ (P_{U.S.} - P_{R.O.W.}), (y_{U.S.} - y_{R.O.W.}) \end{pmatrix} \begin{pmatrix} a_0 & b_0 \\ -1 & -1 \\ a_1 & 0 \\ a_2 & 0 \\ a_3 & b_1 \\ 0 & b_2 \\ 0 & b_3 \\ 0 & b_4 \end{pmatrix} + \begin{pmatrix} \epsilon \\ u \end{pmatrix} = 0$$

In order for the demand function to be identified, two conditions must hold, order and rank conditions.

(I) The order condition says that the number of restrictions (i.e., the exogenous variables that are not in the demand function) in the demand function must be greater than or equal to the number of equations in the system minus one. In our case, $(3 \geq 2-1 = 1)$, so the order condition holds.

(II) The rank condition says:

$$\text{Rank of } \delta\beta = G-1,$$

where β is the matrix of coefficients in the system, G is the number of equations, and δ is the matrix to be formed based on the number of restrictions on the demand function.

$$\delta\beta = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} a_0 & b_0 \\ -1 & -1 \\ a_1 & 0 \\ a_2 & 0 \\ a_3 & b_1 \\ 0 & b_2 \\ 0 & b_3 \\ 0 & b_4 \end{pmatrix} = \begin{pmatrix} 0 & b_2 \\ 0 & b_3 \\ 0 & b_4 \end{pmatrix}$$

$$\text{Rank of } \begin{pmatrix} 0 & b_2 \\ 0 & b_3 \\ 0 & b_4 \end{pmatrix} = 1, \text{ which is the same as } G-1 = 2-1 = 1,$$

the rank condition holds also, and our demand function is identified.

4.3 - Method of Estimation and Data

The model will be tested for two groups of countries, developed and less developed, according to the IMF classification ¹. The major concern is with the developed countries because they usually hold 60 percent of the total world reserves. Oil exporting countries, which are excluded from our study, hold 25 percent. Only 15 percent is held by other countries (the less developed).

Quarterly data have been examined for the period 1972-1977. The initial year was chosen because it was in 1972 that the official dollar price of gold began its increase; 1977 was the last year for which data were available ².

The long-run government bond yield has been used as a proxy for rate of return on investment in each country. Our study uses pooled time series and cross-section data. One approach to specifying the behavior of the disturbances when dealing with cross-section and time series data is to combine the assumptions that we frequently make about cross-sectional observations with those that are usually made when dealing with time series. The frequent assumption about cross-sectional observations (for example, observations on individual countries) is that the regression disturbances are mutually independent but heteroskedastic. One usually suspects that the disturbances in time series data are autoregressive, although not necessarily heteroskedastic. When dealing with pooled cross-section and time series observations, we may combine these assumptions and adopt a cross-sectionally heteroskedastic and time-wise autoregressive model. This model is characterized as follows:

$$(4.3.1) \ E (\epsilon_{it}^2) = \sigma_i^2 \text{ (heteroskedasticity)}$$

$$(4.3.2) \ E (\epsilon_{it}\epsilon_{jt}) = 0 \ (i \neq j) \text{ (cross-sectional independence)}$$

$$(4.3.3) \ \epsilon_{it} = \rho_i \epsilon_{i,t-1} + u_{it} \text{ and } i = \# \text{ countries}$$

(autoregression)

We need an estimate of ρ_i and σ_i^2 for each country, and we then transform the data in order to get an unbiased and consistent estimate of coefficients.

Following Kmenta (1971, pp. 510-11), we first apply the ordinary least-squares method to all (NxT) observations to obtain the regression residuals e_{it} . From these we can obtain estimates of ρ_i , let us say, $\hat{\rho}_i$, by

$$\hat{\rho}_i = \frac{\sum e_{it}e_{i,t-1}}{\sum e_{i,t-1}^2} . \text{ Next, we use the } \hat{\rho}_i \text{'s to transform the}$$

observations in accordance with the following relation:

$$y_{it} - \hat{\rho}_i y_{it-1} = \alpha (1 - \hat{\rho}_i) + \beta (x_{it} - \hat{\rho}_i x_{it-1}) + u_{it} \quad (4.3.4)$$

Now we can apply the ordinary least-squares method to the above equation, for which we have $N(T-1)$ observations.

The resulting regression residuals, let us say, $\hat{u}_{it}$, can be used to estimate the variances of u_{it} (i.e., σ_{ui}^2)

$$\text{by } s_{ui}^2 = \frac{1}{T-K-1} \sum_{t=2}^T \hat{u}_{it}^2 \quad \text{where } k \text{ is \# of regressors}$$

$$\text{since } \sigma_{ui}^2 = \sigma_i^2 (1 - \rho_i^2)$$

It follows that σ_i^2 can be estimated by:

$$s_i^2 = \hat{\sigma}_i^2 = \frac{s_{ui}^2}{1 - \hat{\rho}_i^2}$$

Since $\hat{\rho}_i$ is a consistent estimator of ρ_i and s_{ui}^2 is a consistent estimator of σ_{ui}^2 , $\hat{\sigma}_i^2$ is a consistent estimator of σ_i^2 .

With one more transformation our task is completed.

This is the transformation of (4.3.4) in accordance with

the following relation:

$$(4.3.5) \quad \frac{y_{it} - \hat{\rho}_i y_{it-1}}{\hat{\sigma}_i} = \frac{\alpha(1 - \hat{\rho}_i)}{\hat{\sigma}_i} + \beta \left(\frac{x_{it} - \hat{\rho}_i x_{it-1}}{\hat{\sigma}_i} \right) + \frac{u_{it}}{\hat{\sigma}_i}$$

In (4.3.5) the disturbance $\frac{u_{it}}{\hat{\sigma}_i}$ has the ideal conditions

$$\text{because } E\left(\frac{u_{it}}{\hat{\sigma}_i}\right)^2 = \frac{Eu_{it}^2}{E\hat{\sigma}_i^2} = \frac{\sigma_i^2}{\sigma_i^2} = 1 \quad \text{and } \frac{u_{it}}{\hat{\sigma}_i} \text{ is homoskedastic.}$$

$\hat{\rho}_i$ was calculated for developed countries using

$$\hat{\rho}_i = \frac{\sum e_{it} e_{it-1}}{\sum e_{it-1}^2}, \text{ and the results are shown in Table 4-1.}$$

A glance through Table 4-1 gives the impression that the $\hat{\rho}_i$'s are almost the same for all countries. For that reason we will assume that all countries have the same ρ in other words,

$$(4.3.6) \quad \rho_i = \rho_j \quad \text{for } i \neq j \\ \text{and } i, j = 1, 2, 3, \dots, 19$$

Furthermore, due to computational problems, we will also assume that

$$(4.3.7) \quad \sigma_i^2 = \sigma_j^2 \quad \text{for } i \neq j \\ \text{and } i, j = 1, 2, \dots, 19$$

This second assumption simply means, since we are putting all countries in one group, we are assuming that the observations of all countries come from the same population. All our estimated results are based on those two assumptions.

The Two-stage least-squares method was employed in

ESTIMATES OF $\hat{\rho}$ FOR DIFFERENT COUNTRIES

TABLE 4-1

COUNTRY	$\hat{\rho}_i$
Germany	0.98754
Switzerland	0.98660
U.K.	0.97752
New Zealand	0.97310
Canada	0.98221
France	0.99345
Ireland	0.99111
Italy	0.98781
Netherland	0.98124
Norway	0.99888
Denmark	0.97762
Belgium	0.98880
Austria	0.98791
Japan	0.98792
Australia	0.99729
Sweden	0.98659
Spain	0.97521
Iceland	0.96982
Finland	0.98827

estimating the demand function for developed countries, with the assumption that

$$(4.3.8) \quad \begin{array}{l} \epsilon_{it} = \rho \epsilon_{it-1} + u_{it} \\ t = 1, 2, \dots, 24 \\ i = 1, 2, \dots, 19 \end{array}$$

Of course, we have assumed that the relation (4.3.8) holds within each country, but not between countries.

4.4 - Model Specification and Results

All of our models have been specified in linear form. This is the form that all previous studies have assumed, including that of Box and Jenkins (1970), which concentrates on the linear model with an autoregressive process. We first tried to specify the system in log-linear form:

(4.4.1)

$$\begin{aligned} (\text{Demand}) \quad \log R_{it} = & a_0 + a_1 \log M_{it} + a_2 \log \left(\frac{M}{y} \right)_{it} + a_3 \log P_{gt} \\ & + \epsilon_{it} \end{aligned}$$

$$\begin{aligned} (\text{Supply}) \quad \log R_{it} = & b_0 + b_1 \log P_{gt} + b_2 \log (r_t^{\text{U.S.}} - r_{it}^{\text{R.O.W.}}) \\ & + b_3 \log (P_t^{\text{U.S.}} - P_{it}^{\text{R.O.W.}}) \\ & + b_4 \log (y_t^{\text{U.S.}} - y_{it}^{\text{R.O.W.}}) + u_{it} \end{aligned}$$

The terms $(r_t^{\text{U.S.}} - r_{it}^{\text{R.O.W.}})$ and $(P_t^{\text{U.S.}} - P_{it}^{\text{R.O.W.}})$ happen to be sometimes zero or a negative number, the logs for which do not exist; for that reason, we had to choose other specifications.

In order to solve this difficulty, we propose two different models. The first choice is to specify the system in linear form only.

(4.4.2)

MODEL I

$$\text{(Demand)} \quad R_{it} = \alpha_0 + \alpha_1 M_{it} + \alpha_2 \left(\frac{M}{y}\right)_{it} + \alpha_3 P_{git} + \epsilon_{it}$$

(4.4.3)

$$\begin{aligned} \text{(Supply)} \quad R_{it} = & \beta_0 + \beta_1 P_{git} + \beta_2 (r^{U.S.} - r^{R.O.W.})_{it} \\ & + \beta_3 (P^{U.S.} - P^{R.O.W.})_{it} + \beta_4 (y^{U.S.} - y^{R.O.W.})_{it} \\ & + u_{it} \end{aligned}$$

$i = 1, 2, 3, \dots, 19$ (19 DC's)

$t = 1, 2, \dots, 24$ (1972I - 1977IV)

where r = real rate of return

But $r^{U.S.} = r^n^{U.S.} - PE^{R.O.W.}$ - depreciation (Expected)

$$r^{R.O.W.} = r^n^{R.O.W.} - PE^{R.O.W.}$$

then $r^{U.S.} - r^{R.O.W.} = r^n^{U.S.} - r^n^{R.O.W.}$ - depreciation of \$

(4.4.4)

and r^n = nominal rate

PE = Expected rate of inflation

Long-run government bond yield has been used as a proxy for r^n and unit value of imports, which is adjusted by exchange rates for P .

There is no generally accepted way in which to model expectations. Traditionally, inflationary

expectations have been thought of as some average of past inflation rates. One example would be a weighted average of inflation rates in the last four years, with relatively heavy weight on the more recent past. There is no particular advantage that attaches to a four-year average, nor any evidence that makes us select that number. We will make the simplifying assumption that the expected rate of inflation is equal to the last period's rate of inflation. The same applies for the expected depreciation of the dollar.

The second choice is, rather than taking differential interest rates, differential price levels, and differential real GNP, we can take their ratios. In this case, we can specify the system in log-linear form and look at the elasticities. Thus we have:

MODEL II

$$\text{(Demand)} \ln R_{it} = \alpha_0 + \alpha_1 \ln M_{it} + \alpha_2 \ln \left(\frac{M}{y} \right)_{it} + \alpha_3 \ln P_{git} + \epsilon_{it}$$

$$\begin{aligned} \text{(Supply)} \ln R_{it} = & \beta_0 + \beta_1 \ln P_{git} + \beta_2 \ln \left(\frac{r^{U.S.}}{r^{R.O.W.}} \right) \\ & + \beta_3 \ln \left(\frac{p^{U.S.}}{p^{R.O.W.}} \right)_{it} + \beta_4 \ln \left(\frac{y^{U.S.}}{y^{R.O.W.}} \right)_{it} + u_{it} \end{aligned}$$

$$\text{where } \alpha_1 = \frac{\partial \ln R_{it}}{\partial \ln M_{it}} = \text{Elasticity of demand for reserves with respect to imports}$$

$$\alpha_2 = \frac{\partial \ln R_{it}}{\partial \left(\frac{M}{y} \right)_{it}} = \text{Elasticity of demand with respect to average propensity to import.}$$

$$\alpha_3 = \frac{\partial \ln R_{it}}{\partial \ln P_{git}} = \text{Elasticity of demand with respect to gold price.}$$

As mentioned in the previous chapter, we also are interested in the speed of adjustment. This led us to conclude that we must estimate our model when the market is in disequilibrium.

We borrow the model from the previous chapter and again specify it in linear and log-linear form.³

MODEL III

$$R_{it} = c_0 + c_1 M_{it} + c_2 \left(\frac{M}{y}\right)_{it} + c_3 P_{git} + c_4 R_{it-1} + \epsilon_{it}$$

$$R_{it} = d_0 + d_1 (r^{U.S.} - r^{R.O.W.})_{it} + d_2 (p^{U.S.} - p^{R.O.W.})_{it}$$

$$+ d_3 (y^{U.S.} - y^{R.O.W.})_{it} + d_4 P_{git} + d_5 P_{git-1} + u_{it}$$

Again, we specify Model III in log-linear form by including the ratios instead of differentials. This leads us to our last model.

MODEL IV

$$\ln R_{it} = c_0 + c_1 \ln M_{it} + c_2 \ln \left(\frac{M}{y} \right)_{it} + c_3 \ln P_{git} \\ + c_4 \ln R_{it-1} + \epsilon_{it}$$

$$\ln R_{it} = D_0 + D_1 \ln \left(\frac{r^{U.S.}}{r^{R.O.W.}} \right)_{it} + D_2 \ln \left(\frac{P^{U.S.}}{P^{R.O.W.}} \right)_{it} \\ + D_3 \ln \left(\frac{y^{U.S.}}{y^{R.O.W.}} \right)_{it} + D_4 \ln P_{git} + D_5 \ln P_{git-1} + u_{it}$$

Tables 4-2 through 4-5 show the estimated results for all four models (only for the demand function) using the official dollar price of gold as well as the market price of gold (dollar price of gold in London), as indicated. Two kinds of results are represented in these tables, estimates without autoregressive assumptions and estimates with autoregressive assumptions about disturbance terms. The former are indicated by INST (two-state least-squares) and the latter by TSCORC (two-stage least-squares combined with Cochrane-Orcutt transformation).

Let us elaborate on our results. First, in all 16 cases, all variables have the theoretically expected sign. In particular, the gold price has a negative coefficient in all the cases, supporting our model.⁴ Secondly, the coefficients are significantly different from zero in most of the cases. For example, gold price

TABLE 4-2
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
DEVELOPED COUNTRIES (using official price of gold)

Model I	INST	$R = 52373.7 + .02819 M - 1801.9 \frac{M}{Y} - .265.93 P_g$ $(2.96)*** (12.7)*** (1.84)** (2.91)***$ $R^2 = -.3434 \quad DW = .2972$ $F = -36.89 \quad N = 437$
	TSCORC	$R = 11538.2 + 0.036 M - 1819.4 \frac{M}{Y} + 19.31 P_g$ $(1.32)* (1.51)* (2.25)** (.362)$ $R^2 = 0.9773 \quad DW = 1.8566 \quad \rho = 0.9983$ $F = 5932.2 \quad N = 418 \quad (347)***$
Model II	INST	$\ln R = 188.68 + 1.07 \ln M - .463 \ln \frac{M}{Y} - 51.51 \ln P_g$ $(2.71)*** (11.6)*** (2.503)** (2.73)***$ $R^2 = -.9554 \quad DW = .3498$ $F = -70.52 \quad N = 437$
	TSCORC	$\ln R = 11.68 + 0.09 \ln M - 0.22 \ln \frac{M}{Y} = 1.41 \ln P_g$ $(1.94)** (0.649) (1.299)* (0.804)$ $R^2 = 0.9757 \quad DW = 2.16 \quad \rho = .9862$ $F = 5532 \quad N = 418 \quad (121.69)***$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level

** - significantly different from zero at 95% level

*** - significantly different from zero at 99% level

TABLE 4-3

ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
DEVELOPED COUNTRIES (using official price of gold)

Model III	INST	$R = 1365.3 + 0.01 M - 25.43 \frac{M}{Y} - 33.33 P_g + 0.99 R_{t-1}$ $(3.07) *** (2.45) ** (0.201) (3.06) *** (74) ***$ $R^2 = 0.9745 \quad DW = 1.854$ $F = 4121 \quad N = 437$
	TSCORC	$R = 840.8 + 0.059 M + 33.79 \frac{M}{Y} - 20.94 \ln P_g + 1.004 \ln R_{t-1}$ $(2.17) ** (1.71) ** (0.319) (2.22) ** (88.9) ***$ $R^2 = .9777 \quad DW = 1.6495 \quad \rho = -0.145178$ $F = 4526.62 \quad N = 418 \quad (2.99) ***$
Model IV	INST	$\ln R = 81.59 + 0.388 \ln M - 0.144 \ln \frac{M}{Y} - 22.24 \ln P_g + 0.65 \ln R_{t-1}$ $(7.16) *** (5.97) *** (1.69) ** (7.2) *** (10.86) ***$ $R^2 = 0.6232 \quad DW = .5471$ $F = 178.5 \quad N = 437$
	TSCORC	$\ln R = 2.76 + 0.0244 \ln M - 0.738 \ln \frac{M}{Y} - 0.747 \ln P_g + .97 \ln R_{t-1}$ $(2.46) *** (1.49) * (0.373) (2.47) *** (60.99) ***$ $R^2 = 0.9776 \quad DW = 2.04 \quad \rho = -.1087$ $F = 4502.24 \quad N = 418 \quad (2.23) **$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 4-4

ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
DEVELOPED COUNTRIES (using market price of gold)

Model I	INST	$R = 6828.41 + 0.31 M - 1202.92 \frac{M}{Y} - 51.44 P_g$ $(2.26)^{**} \quad (8.49)^{***}(0.95)$ $R^2 = 0.0904 \quad DW = 0.3645$ $F = 11.97 \quad N = 437$
	TSCORC	$R = 7985.01 + 0.048 M - 1007.76 \frac{M}{Y} - 6.689 P_g$ $(2.67)^{***} \quad (2.06)^{**} \quad (0.901)$ $R^2 = 0.9711 \quad DW = 1.8762 \quad \rho = 0.99196$ $F = 4640 \quad N = 418 \quad (160.25)^{***}$
Model II	INST	$\ln R = 7.17 + 0.994 \ln M - 0.585 \ln \frac{M}{Y} - 1.94 \ln P_g$ $(1.94)^{**}(22.5)^{***} \quad (7.92)^{***} \quad (2.39)^{***}$ $R^2 = 0.7122 \quad DW = 0.3008$ $F = 357.26 \quad N = 437$
	TSCORC	$\ln R = 10.73 + 0.122 \ln M - 0.149 \ln \frac{M}{Y} - 0.805 \ln P_g$ $(2.84)^{***} \quad (1.01) \quad (0.889)$ $R^2 = 0.9672 \quad DW = 2.1426 \quad \rho = 0.973487$ $F = 4072 \quad N = 418 \quad (87.01)^{***}$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 4-5

ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
DEVELOPED COUNTRIES (using market price of gold)

Model III	INST	$R = 122.57 + 0.011 M - 31.49 \frac{M}{Y} - 0.953 P_g + 0.989 R_{t-1}$ $(1.69)** (2.56)*** (0.25) (1.87)** (73.2)***$ $R^2 = 0.9745 \quad DW = 1.8388$ $F = 4124 \quad N = 437$
	TSCORC	$R = 63.56 + 0.0067 M + 31.87 \frac{M}{Y} - 0.645 P_g + 1.002 R_{t-1}$ $(.958) (1.86)** (0.297) (1.41)* (87.19)***$ $R^2 = 0.9776 \quad DW = 1.649 \quad \rho = -0.1366$ $F = 4510.83 \quad N = 418 \quad (2.82)***$
Model IV	INST	$\ln R = 2.64 + 0.347 \ln M - 0.2006 \ln \frac{M}{Y} - 0.71 \ln P_g - .656 \ln R_{t-1}$ $(7.43)*** (11.82)*** (5.27)*** (9.59)*** (23.97)***$ $R^2 = 0.923 \quad DW = 1.0739$ $F = 1295.4 \quad N = 437$
	TSCORC	$\ln R = 0.415 + 0.031 \ln M - 0.00995 \ln \frac{M}{Y} - 0.093 \ln P_g + 0.967 \ln R_{t-1}$ $(2.24)** (1.83)** (0.502) (2.42)*** (59.53)***$ $R^2 = 0.9776 \quad DW = 2.0329 \quad \rho = -0.108383$ $F = 4511.17 \quad N = 418 \quad (2.229)**$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

has a significant coefficient in 14 of 16 cases.

The import-GNP ratio has a negative coefficient in 14 cases, supporting the "priceless" Keynesian theory discussed in the previous chapter.

Imports has a positive coefficient in all cases, significantly different from zero in most. In some cases, the elasticity of reserve demand with respect to imports happens to be between 0.5 and unity, supporting the "square-root" law.

In any estimated relations, economists are concerned with the policy implications of the results. For policy purposes, our main concern is to look at the suggested proposal for which provisions were made in the IMF articles. These suggest that one possible method of dealing with the shortage of liquidity is gold revaluation.

Our Model III-INST (table 4-3) suggests that if the official price of gold is increased by one dollar, the demand for total international reserves will drop by \$33.33 million. This is based on the assumption that these 19 developed countries represent the major demanders in the world. ⁵ Model II-TSCORC, Table 4-2, suggests that, again, if the official price of gold goes up by one percent, then demand for total reserves will drop by 1.41 percent, which is an indication of elastic demand with respect to the price of gold. However, Model II-TSCORC, table 4-4, which uses the market price of gold, shows an inelastic demand with respect to gold price. (In that equation,

elasticity is 0.805.)

We may conclude that demand for international reserves is elastic with respect to the official price of gold. However, it is inelastic with respect to the market price of gold. As for the speed of adjustment, we must refer to the disequilibrium model. Model IV-INST, tables 4-3 and 4-5, suggests that the estimated speed of adjustment is almost 35 percent,⁶ which means, in the developed countries sample, that more than 35 percent of the adjustment is completed within one year.

For the purpose of comparison, we estimated four models for a group of 21 less developed countries; the results are presented in Tables 4-6 through 4-9. Five countries had to be excluded because data were not available on their government bond yield or their discount rate and real GNP. These were the Dominican Republic, Panama, El Salvador, Paraguay, and the People's Republic of China.

Some insights may be given concerning our estimated results. In table 4-6, Model I-INST happens to have a low R^2 and a low Durbin-Watson statistic. Again, the TSCORC might be the relevant method of estimation. However, as Model I-TSCORC or Model II in table 4-6 indicate, the coefficient of gold price takes the wrong (positive) sign. But if we consider a disequilibrium market, the results

TABLE 4-6
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
21 LDC's (using official price of gold)

Model I	INST	$R = 694.342 + 0.2707 M - 273.14 \frac{M}{Y} - 14.21 P_g$ $(-.433) \quad (13.3)^{***} \quad (2.66)^{***} \quad (0.357)$ $R^2 = 0.5024 \quad DW = 0.1323$ $F = 122.5 \quad N = 368$
	TSCORC	$R = -30349.3 + 0.014 M - 206.8 \frac{M}{Y} + 26.89 P_g$ $(1.95)^{**} \quad (0.696) \quad (1.68)^{**} \quad (2.26)^{**}$ $R^2 = 0.9604 \quad DW = 1.3819 \quad \rho = 1.0002$ $F = 2814.92 \quad N = 352$
Model II	INST	$\ln R = -20.58 + 0.5887 \ln M - 0.177 \ln \frac{M}{Y} + 5.87 \ln P_g$ $(1.26)^* \quad (11.65)^{***} \quad (2.37)^{**} \quad (1.33)^*$ $R^2 = 0.4314 \quad DW = 0.1276$ $F = 92.04 \quad N = 368$
	TSCORC	$\ln R = 1.663 - 0.143 \ln M + 0.0316 \ln \frac{M}{Y} + 1.62 \ln P_g$ $(0.284) \quad (1.68)^{**} \quad (0.231) \quad (1.02)$ $R^2 = 0.963 \quad DW = 1.9289$ $F = 3021 \quad N = 352$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 4-7
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
21 LDC's (using official price of gold)

Model III	INST	$R = 390.47 - 0.003 M - 20.17 \frac{M}{Y} - 9.28 P_g + 1.033 R_{t-1}$ $(3.89)^{***} (0.545) (0.892) (3.75)^{***} (68.34)^{***}$ $R^2 = 0.9642 \quad DW = 1.4348$ $F = 2443.13 \quad N = 368$
	TSCORC	$R = 413.93 + 0.00325 M - 33.26 \frac{M}{Y} - 9.7 P_g + 1.008 R_{t-1}$ $(2.64)^{**} (0.443) (1.09) (2.54)^{**} (50.98)^{***}$ $R^2 = 0.9669 \quad DW = 1.9674 \quad \rho = 0.290508$ $F = 2530.3 \quad N = 352 \quad (5.696)^{***}$
Model IV	INST	$\ln R = 51.41 + 0.1411 \ln M + 0.0873 \ln \frac{M}{Y} - 13.87 \ln P_g + 0.89 \ln R_{t-1}$ $(6.11)^{***} (3.34)^{***} (1.72)^{**} (6.07)^{***} (22.13)^{***}$ $R^2 = 0.6785 \quad DW = 0.7400$ $F = 191.5 \quad N = 368$
	TSCORC	$\ln R = 3.37 - 0.01199 \ln M - 0.019 \ln \frac{M}{Y} - 0.863 \ln P_g + 0.98 \ln R_{t-1}$ $(2.63)^{**} (0.86) (1.18) (2.49)^{**} (67.03)^{***}$ $R^2 = 0.9621 \quad DW = 1.9526 \quad \rho = -0.011193$ $F = 2200 \quad N = 352 \quad (0.0210009)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 4-8
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
21 LDC's (using market price of gold)

Model I	INST	$R = 96.73 + 0.2624 M - 307.782 \frac{M}{y} + 0.229 P_g$ $(0.636) (10.56)*** (2.73)*** (0.161)$ $R^2 = 0.4981 \quad DW = 0.1219$ $F = 120 \quad N = 368$
	TSCORC	$R = 2999.1 + 0.00647 M - 242.39 \frac{M}{y} + 1.671 P_g$ $(0.813) (0.285) (1.78)** (1.72)**$ $R^2 = 0.9538 \quad DW = 1.6303 \quad \rho = 0.998669$ $F = 2394.16 \quad N = 352 \quad (363.24)***$
Model II	INST	$\ln R = 2.28 + 0.664 \ln M - 0.083 \ln \frac{M}{y} - 0.285 \ln P_g$ $(1.25)*(11.76)*** (1.09) (0.688)$ $R^2 = 0.4898 \quad DW = 0.1408$ $F = 116.49 \quad N = 368$
	TSCORC	$\ln R = 5.78 - 0.0876 \ln M - 0.0693 \ln \frac{M}{y} + 0.234 \ln P_g$ $(3.006)*** (1.08) (0.4904) (0.9884)$ $R^2 = 0.9622 \quad DW = 1.9512 \quad \rho = 0.97459$ $F = 2949.84 \quad N = 352 \quad (81.63)***$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 4-9

ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
21 LDC's (using market price of gold)

Model III	INST	$R = 55.97 + 0.00001 M - 15.17 \frac{M}{Y} - 0.376 P_g + 1.02 R_{t-1}$ $(3.76)*** (0.00176) (0.655) (3.12)*** (67.61)***$ $R^2 = 0.9640 \quad DW = 1.4155$ $F = 2431.73 \quad N = 368$
	TSCORC	$R = 84.47 + 0.009376 M - 20.65 \frac{M}{Y} - 0.571841 P_g + 1.001 R_{t-1}$ $(3.76)*** (0.00176) (0.655) (3.12)*** (67.61)***$ $R^2 = 0.9663 \quad DW = 1.9712 \quad \rho = 0.302244$ $F = 2487.89 \quad N = 352 \quad (5.948816)***$
Model IV	INST	$\ln R = 3.13 + 0.115 \ln M + 0.0255 \ln \frac{M}{Y} - 0.639 \ln P_g + 0.87 \ln R_{t-1}$ $(8.74)*** (4.69)*** (0.9008) (8.21)*** (36.95)***$ $R^2 = 0.8892 \quad DW = 1.204$ $F = 727.93 \quad N = 368$
	TSCORC	$\ln R = 0.5899 - 0.00756 \ln M - 0.016 \ln \frac{M}{Y} - 0.091 \ln P_g + 0.98 \ln R_{t-1}$ $(2.77)*** (0.518) (0.979) (2.02)*** (66.76)***$ $R^2 = 0.9622 \quad DW = 1.9462 \quad \rho = -0.0093$ $F = 2207.82 \quad N = 352 \quad (0.1751)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

in table 4-7 with Model III-INST show a satisfactory result, suggesting that if the official price of gold goes up by one dollar, the demand for reserves by less developed countries will drop by \$9.28 million. Model IV-INST suggests that if the official gold price went up by one percent, then demand for reserves would drop by 13.87 percent, indicating an elastic demand with respect to the official gold price. The same argument applies for tables 4-8 and 4-9, which show the result when the market price of gold is used. Again, the result of the disequilibrium model is much more satisfactory than the result of the equilibrium model.

With respect to speed of adjustment, we need to refer to model III-INST and model IV-INST. Our result shows that the speed of adjustment happens to be about 0.11, indicating that in the less developed countries sample, 11 percent of adjustment is completed within one year.

To compare the result for developed with less developed countries, we put all results together in tables 4-10 and 4-11.⁷

The models that should be used to compare the results are Model I-TSCORC, Model II-TSCORC, Model III-INST, and Model IV-INST. Because in the equilibrium model the other two models have a very low R^2 and in the

TABLE 4-10
COMPARISON OF DC'S AND LDC'S REGRESSION COEFFICIENTS USING OFFICIAL \$ PRICE OF GOLD

	Constant Term		M		$\frac{M}{y}$		P_g		R_{t-1}	
	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's
Model I	INST	52373.7 (2.96)***	694.342 (0.433)	0.2819 (12.7)***	0.2707 (13.3)***	-1801.9 (1.84)**	-273.14 (2.66)***	-1265.93 (2.91)***	-14.21 (0.357)	-----
	TSCORC+	11538.2 (1.32)*	-30349 (1.95)*	0.036 (1.51)*	0.014 (0.696)	-1819.4 (2.25)**	-206.8 (1.68)**	+19.31 (0.362)	+26.89 (2.26)**	-----
Model II	INST	118.68 (2.71)***	-20.58 (1.26)*	1.07 (11.6)***	0.5887 (11.65)***	-0.463 (2.503)**	-0.177 (2.37)**	-51.51 (2.73)***	+5.87 (1.33)*	-----
	TSCORC+	11.68 (1.94)**	1.663 (0.284)	0.09 (0.649)	-0.143 (1.68)**	-0.22 (1.299)*	0.0316 (0.231)	-1.41 (0.804)	+1.62 (1.02)	-----
Model III	INST+	1365.3 (3.07)***	390.47 (3.89)***	0.01 (2.45)**	-0.003 (0.545)	-25.43 (0.201)	-20.17 (0.892)	-33.33 (3.06)***	-9.28 (3.75)***	1.033 (68.34)***
	TSCORC	840.8 (2.17)**	413.93 (2.64)**	0.059 (1.71)**	0.00325 (0.443)	33.79 (0.319)	-33.26 (1.09)	-20.94 (2.22)**	-9.70 (2.54)**	1.008 (50.98)***
Model IV	INST+	81.59 (7.16)***	51.41 (6.11)***	0.388 (5.97)***	0.1411 (3.34)***	-0.144 (1.69)**	0.0873 (1.72)**	-22.24 (7.2)***	-13.87 (6.07)***	0.89 (22.13)***
	TSCORC	2.76 (2.46)***	3.37 (2.63)**	0.0244 (1.49)*	-0.012 (0.86)	-0.738 (0.373)	-0.019 (1.18)	-0.747 (2.47)***	0.863 (2.49)***	+0.98 (67.03)***

* These are the relevant models which we use for comparison purposes.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Numbers in parentheses are the t-values.

TABLE 4-11
COMPARISON OF DC'S AND LDC'S REGRESSION COEFFICIENTS USING MARKET PRICE OF GOLD

	Constant Term		M		H y		P _g		R _{t-1}	
	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's
Model I	INST	6828.41 (2.26)**	96.73 (0.636)	0.31 (8.49)***	0.2624 (10.56)***	-1202.92 (0.95)	-307.78 (2.73)***	-51.44 (1.95)**	0.229 (0.161)	-----
	TSCORC+	7985.01 (2.67)***	2999.1 (0.813)	0.048 (2.06)**	0.00647 (0.285)	-1007.76 (0.901)	-242.39 (1.78)**	-6.689 (1.53)*	+1.671 (1.72)**	-----
Model II	INST	7.17 (1.94)**	2.28 (1.25)*	0.994 (22.5)***	0.664 (11.76)***	-0.585 (7.92)***	-0.083 (1.09)	-1.94 (2.39)***	-0.285 (0.688)	-----
	TSCORC+	10.73 (2.84)***	5.78 (3.006)***	0.122 (1.01)	-0.0876 (1.08)	-0.149 (0.889)	-0.0693 (0.4904)	-0.805 (1.42)*	+0.234 (0.9884)	-----
Model III	INST+	122.57 (1.69)**	55.97 (3.76)***	0.011 (2.56)***	0.00001 (0.00176)	-31.49 (0.25)	-15.17 (0.655)	-0.953 (1.87)**	-0.376 (3.12)***	1.02 (67.61)***
	TSCORC	63.56 (0.958)	84.47 (3.14)***	0.0067 (1.86)**	0.009376 (1.18)	31.87 (0.297)	-20.65 (0.644)	-0.645 (1.41)*	-0.5718 (2.695)***	1.001 (49.43)***
Model IV	INST+	2.64 (7.43)***	3.13 (8.74)***	0.347 (11.82)***	0.115 (4.69)***	0.2006 (5.27)***	0.0255 (0.9008)	-0.71 (9.59)***	-0.639 (8.21)***	0.87 (36.95)***
	TSCORC	0.415 (2.24)**	0.5899 (2.77)***	0.031 (1.83)**	-0.0076 (0.518)	-0.00995 (0.502)	-0.016 (0.979)	-0.093 (2.42)***	-0.091 (2.02)***	0.98 (66.76)***

+ These are the relevant models which we use for comparison purposes.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Numbers in parentheses are the t-values.

disequilibrium model the inclusion of R_{t-1} in demand function makes the Durbin-Watson statistic biased toward 2, model III-TSCORC and Model IV-TSCORC are irrelevant.

However, if the criterion for forecasting and prediction purposes is the model with a high R^2 and significant coefficients, then model IV-TSCORC is relevant also. In that model, the R^2 for both developed and less developed countries is about 0.98, and all variables have the theoretically expected signs and significant coefficients. The exception is the gold price for less developed countries, and this might lead us to choose Model IV-INST; in it all variables have the expected signs, and all coefficients are significantly different from zero. As Model IV-INST indicates, a one percent increase in the official price of gold will make developed countries' demand for reserves drop by 22.24 percent, whereas it will make demand for reserves in less developed countries drop by 13.87 percent.

With respect to the speed of adjustment, the figures are $1 - 0.65 = 0.35$ for developed countries and $1 - 0.89 = 0.11$ for the less developed. This indicates that in the developed countries sample, 35 percent of the adjustment is completed within one year, whereas in the less developed countries the comparable figure is only 11 percent.

As Model I-TSCORC indicates, the gold price for both groups of countries takes the wrong (positive) sign. This fact will be investigated in the next chapter.

CHAPTER FIVE

FURTHER RESULTS AND CONCLUSIONS

5.1 - Introduction

In the previous chapter, we found that the official gold price took the wrong (positive) sign in Model I-TSCORC using data from both developed and less developed countries. However, this was not the case in any of the disequilibrium models. One might conclude that the disequilibrium model is more appropriate than the equilibrium model.

In this chapter, we shall discuss our model in more detail and try to find out why the gold price did not take the theoretically expected sign. Before doing so, we should point out one implication of our model of demand for and supply of reserves.

5.2 - Implication of the Model

In the last chapter, we used the two-stage least-squares method to estimate our demand function. We know that, in the first stage, the right hand side endogenous variable, gold price, was regressed on all other exogenous variables. We obtained:

$$P_{git} = a_0 + a_1 M_{it} + a_2 \left(\frac{M}{y}\right)_{it} + a_3 (r^{U.S.} - r^{R.O.W.})_{it} \\ + a_4 (P^{U.S.} - P^{R.O.W.})_{it} + a_5 (y^{U.S.} - y^{R.O.W.})_{it} + u_{it}$$

The official price of gold was obtained by multiplying the SDR value of gold by the dollar value of SDR. Since the SDR value of gold is fixed at 35 SDR per ounce, if we divide both sides of the above equation by 35, then the left-hand side variable will be only the exchange rate between the dollar and SDR, or the dollar value of SDR. We wanted to know how much variation in the dollar value of SDR is explained by the above equation; for that reason, we estimated the equation and the results are as follows;

$$P_g = 40.45 + 0.00004M + 1.69 \frac{M}{y} - 0.007 (r^{U.S.} - r^{R.O.W.}) \\ (134.6)*** (2.79)*** (2.6)** (2.42)** \\ - 0.007 (P^{U.S.} - P^{R.O.W.}) - 0.0004 (y^{U.S.} - y^{R.O.W.}) \\ (1.82)** (0.842) \\ \text{with } R^2 = 0.0467.$$

As the R^2 indicates, about 5 percent of the variation of the dollar against SDR is explained by our model. It seems that the income differential between the United States and the rest of the world exerts no effect (insignificant coefficient). For that reason, we dropped real income from our model and tried to see how this affected our results.

5.3 - The Model of Demand for and Supply of Reserves Without Income

After dropping income differential, our model looks like:

$$R^D = f(M, \frac{M}{Y}, P_g)$$

$$R^S = F[P_g, (r^{U.S.} - r^{R.O.W.}), (p^{U.S.} - p^{R.O.W.})]$$

Again, we specified the model in linear and log-linear form in both the equilibrium and disequilibrium cases, as in the previous chapter. However, this time we used CPI for p instead of the unit value of imports. Also, we assumed that the expectations are exact, so the expected rate of inflation at this period is the current year inflation rate. With those assumptions, we first estimated the same four models discussed previously for developed countries. The results are shown in tables 5-1 through 5-4.

Let us elaborate on our results. First, in all 16 cases, all variables have the theoretically expected signs. In particular, the gold price has a negative coefficient in all the cases; this supports our model, which was not the case in Model I-TSCORC of Chapter 4. Second, the coefficients are significantly different from zero in most of the cases. For example, gold price has a significant coefficient in 14 of 16 cases.

The import-GNP ratio has a negative coefficient in 10 cases, thus supporting the "priceless" Keynesian theory,

TABLE 5-1
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
DEVELOPED COUNTRIES (using official price of gold)
(after we dropped income variable from supply side)

Model I	INST	$R = 80855.6 + 0.323 M - 522.4 \frac{M}{y} - 1979.44 P_g$ $(1.98)** \quad (6.74)*** \quad (0.277) \quad (1.95)**$ $R^2 = -2.14 \quad DW = 0.286$ $F = -102$
	TSCORC	$R = 14379.5 + 0.121 M - 3824.23 \frac{M}{y} - 265.57 P_g$ $(2.65)*** \quad (3.93)*** \quad (3.70)*** \quad (2.23)**$ $R^2 = 0.9603 \quad DW = 1.58 \quad \rho = 0.9714$ $F = 3339 \quad (83.65)***$
Model II	INST	$\ln R = 127.3 + 1.05 \ln M - 0.494 \ln \frac{M}{y} - 34.98 \ln P_g$ $(2.35)*** (13.3)*** \quad (3.47)*** \quad (2.38)***$ $R^2 = -0.047 \quad DW = 0.2885$ $F = 6.76$
	TSCORC	$\ln R = 17.08 + 0.21 \ln M - 0.35 \ln \frac{M}{y} - 3.19 \ln P_g$ $(1.82)** (1.22) \quad (1.71)** \quad (1.15)$ $R^2 = 0.9735 \quad DW = 2.1024 \quad \rho = 0.988$ $F = 5076 \quad (102)***$

Numbers in parentheses are the t-values.

- * - significantly different from zero at 90% level.
- ** - significantly different from zero at 95% level.
- *** - significantly different from zero at 99% level.

TABLE 5-2

ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
DEVELOPED COUNTRIES (official dollar price of gold)
(after we dropped income variable from supply side)

Model III	INST	$R = 1017.83 + 0.0074 M + 13.79 \frac{M}{y} - 25.26 P_g + 1.002 R_{-1}$ $(2.71)*** (1.96)** (0.12) (2.74)*** (81)***$ $R^2 = 0.9778 \quad DW = 1.86$ $F = 4976$
	TSCORC	$R = 876.55 + 0.0065 M + 31.17 \frac{M}{y} - 21.82 P_g + 1.003 R_{-1}$ $(2.12)** (1.77)** (.279) (2.17)*** (84)***$ $R^2 = 0.9774 \quad DW = 1.71 \quad \rho = -0.095$ $\bar{F} = 4471$
Model IV	INST	$\ln R = 2.94 + 0.032 \ln M - 0.0162 \ln \frac{M}{y} - 0.797 \ln P_g + 0.963 \ln R_{-1}$ $(2.85)*** (1.86)** (0.774) (2.85)*** (57)***$ $R^2 = 0.9782 \quad DW = 2.15$ $F = 5052$
	TSCORC	$\ln R = 2.07 + 0.012 \ln M + 0.0037 \ln \frac{M}{y} - 0.553 \ln P_g + 0.986 \ln R_{-1}$ $(2.34)** (.856) (.225) (2.32)** (74)***$ $R^2 = 0.9783 \quad DW = 1.76 \quad \rho = -0.318$ $F = 4650$

Numbers in parentheses are t-values.

- * - significantly different from zero at 90% level.
- ** - significantly different from zero at 95% level.
- *** - significantly different from zero at 99% level.

TABLE 5-3

ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL

19 DC's (using market price of gold in London)

(after we dropped income variable from supply side)

Model I	INST	$R = 2341.54 + 0.266 M - 2653.6 \frac{M}{Y} - 12.55 P_g$ $(4.29)*** (21.96)*** (5.36)*** (2.55)***$ $R^2 = 0.6271 \quad DW = 0.1352$ $F = 253$
	TSCORC	$R = 7171.32 + 0.057 M - 440 \frac{M}{Y} - 11.68 P_g$ $(2.48)*** (2.14)** (0.277) (1.54)*$ $R^2 = 0.9597 \quad DW = 1.96 \quad \text{value of } \rho = 0.985$ $F = 3289 \quad (116)***$
Model II	INST	$\ln R = 1.20 + 0.9436 \ln M - 0.635 \ln \frac{M}{Y} - 0.636 \ln P_g$ $(1.12) (37.66)*** (12.21)*** (2.67)***$ $R^2 = 0.8218 \quad DW = 0.1898$ $F = 694$
	TSCORC	$\ln R = 10.67 + 0.142 \ln M - 0.167 \ln \frac{M}{Y} - 0.847 \ln P_g$ $(2.54)** (1.18) (0.964) (1.301)*$ $R^2 = 0.9663 \quad DW = 2.14 \quad \rho = 0.9715$ $F = 3951 \quad (83.7)***$

Number in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-4
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
19 DC's (Market price of gold)
(after we dropped income variable from supply side)

Model III	INST	$R = 57.63 + 0.0074 M + 2.34 \frac{M}{Y} - 0.5468 P_g + 1.001 R_{-1}$ $(0.976) (1.90)** (0.020) (1.33)* (80.75)***$ $R^2 = 0.9779 \quad DW = 1.85$ $F = 4985.67$
	TSCORC	$R = 57.25 + 0.007 M + 27.66 \frac{M}{Y} - 0.593 P_g + 1.001 R_{-1}$ $(0.81) (1.88)** (.246) (1.21) (83)***$ $R^2 = 0.9774 \quad DW = 1.71 \quad \rho = -0.0879$ $F = 4464 \quad (1.81)**$
Model IV	INST	$\ln R = 0.329 + 0.036 \ln M - 0.018 \ln \frac{M}{Y} - 0.076 \ln P_g + 0.96 R_{-1}$ $(2.23)**(2.02)** (0.864) (2.46)*** (56)***$ $R^2 = 0.9783 \quad DW = 2.14$ $F = 5079$
	TSCORC	$\ln R = 0.313 + 0.016 \ln M + 0.0016 \ln \frac{M}{Y} - 0.065 \ln P_g + 0.98 R_{-1}$ $(2.11)**(1.15) (0.097) (2.10)** (72)***$ $R^2 = 0.9783 \quad DW = 1.75 \quad \rho = -0.313$ $F = 4646 \quad (6.73)***$

Number in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

discussed in the previous chapter.

Imports have a positive coefficient in all cases and are significantly different from zero in most cases. In some, the elasticity of reserve demand with respect to imports happens to be between 0.5 and unity, supporting the "square-root" law.

As noted earlier, in any estimated relations we are concerned with the policy implications of the results. For policy purposes, our main concern is with the proposal for which provisions were made in the I.M.F. Articles, that is, one possible method of dealing with the shortage of liquidity is gold revaluation.

Our Model I-TSCORC, (Table 4-2) suggests that if the official price of gold is increased by one dollar, then demand for total international reserves will drop by \$265.57 million, based on the assumption that the 19 developed countries in our sample represent the major demanders in the world.

Model II-TSCORC, (Table 4-2), suggests that, again, if the official price of gold rises by one percent, then the demand for total reserves will drop by 3.19 percent, which is an indication of elastic demand with respect to gold price. However, Model II-TSCORC, (Table 4-4) which uses the market price of gold, shows an inelastic demand with respect to gold price. In that equation, elasticity is 0.847, which is an indication of inelastic demand.

We may conclude that the demand for international reserves is elastic with respect to the official price of gold. However, it is inelastic with respect to the market price of gold. With respect to the speed of adjustment, we need to refer to the disequilibrium model. Model IV-INST (Tables 4-3 and 4-5), suggests that the estimated speed of adjustment is almost 4 percent¹, which means that in the developed countries sample, more than 4 percent of the adjustment is completed within one year. Our estimated speed of adjustment happens to be low, as was the case in Clark's (1970) and Iyoha's (1976) studies.

For the purpose of comparison, we estimated four models for a group of 21 less developed countries. The results are presented in Tables 5-5 through 5-8.

Let us elaborate on our estimated results. In table 5-5, Model I-INST happens to have a very low R^2 (i.e., $R^2 = 0.073$) and low Durbin-Watson statistic. Again, the TSCORC might be the relevant method of estimation. However, as Model 1-TSCORC in table 5-5 indicates, the coefficient of gold price again takes the wrong (positive) sign, and it is not significantly different from zero. But if we consider the disequilibrium market, the results in table 5-6 with Model III-INST show a satisfactory result. This suggests that if the official price of gold rises by one dollar, the demand for reserves by less developed

TABLE 5-5
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
21 LDC (official price of gold)
(after we dropped income variable from supply side)

Model I	INST	$R = 5468.71 + 0.314 M - 136.1 \frac{M}{Y} - 132.89 P_g$ $(2.53)*** (10.54)*** (1.01) (2.46)**$ $R^2 = 0.0728 \quad DW = 0.3489$ $F = 10.59$
	TSCORC	$R = 794.1 + 0.02 M - 197.4 \frac{M}{Y} + 18.28 P_g$ $(0.74) (1.06) (1.71)** (1.21)$ $R^2 = 0.9614 \quad DW = 1.36 \quad \rho = 0.994683$ $F = 3075 \quad (186.78)***$
Model II	INST	$\ln R = -40.04 + 0.53 \ln M - 0.25 \ln \frac{M}{Y} + 11.18 \ln P_g$ $(2.35)*** (9.39)*** (3.21)*** (2.41)***$ $R^2 = 0.2906 \quad DW = 0.2228$ $F = 55.29$
	TSCORC	$\ln R = 2.18 - 0.126 \ln M + 0.02 \ln \frac{M}{Y} + 1.42 \ln P_g$ $(0.36) (1.52)* (0.152) (0.864)$ $R^2 = 0.9627 \quad DW = 1.9194 \quad \rho = 0.974078$ $F = 3182 \quad (83.27)***$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Following 4 countries had to be excluded because of non-availability of data on their gov. bond yield or their discount rate, Dominican Rep., Panama, El Salvador, and Paraguay.

TABLE 5-6
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
21 LDC (official price of gold)
(after we dropped income variable from supply side)

Model III	INST	$R = 692.35 + 0.041 M - 27.34 \frac{M}{Y} - 16.95 P_g + 0.91 R_{-1}$ $(2.96)*** (4.66)*** (0.779) (2.91)*** (39.74)***$ $R^2 = 0.8974 \quad DW = 1.6398$ $F = 884$
	TSCORC	$R = 416.8 + 0.00377 M - 32.98 \frac{M}{Y} - 9.77 P_g + 1.006 R_{-1}$ $(2.77)*** (0.546) (1.16) (2.66)*** (52.4)***$ $R^2 = 0.9666 \quad DW = 1.978 \quad \rho = 0.296526$ $F = 2669$
Model IV	INST	$\ln R = 35.47 + 0.239 \ln M + 0.046 \ln \frac{M}{Y} - 9.6 \ln P_g + 0.758 \ln R_{-1}$ $(4.66)*** (5.89)*** (1.003) (4.64)*** (20.59)***$ $R^2 = 0.6908 \quad DW = 1.0491$ $F = 226$
	TSCOR	$\ln R = 2.62 - 0.009 \ln M - 0.0165 \ln \frac{M}{Y} - 0.66 \ln P_g + 0.982 \ln R_{-1}$ $(2.17)*** (0.687) (1.10) (2.02)** (66.77)***$ $R^2 = 0.962 \quad DW = 2.0017 \quad \rho = 0.051698$ $F = 2334 \quad (0.4008)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Following 4 countries had to be excluded because of non-availability of data on their gov. bond yield or their discount rate, Dominican Rep., Panama, El Salvador, Paraguay.

TABLE 5-7
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
21 LDC's (Market price of gold)
(after we dropped the income variable from supply side)

Model I	INST	$R = 259.26 + 0.276 M - 295.68 \frac{M}{Y} - 1.22 P_g$ $(2.68)*** (13.55)*** (3.29)*** (1.29)**$ $R^2 = 0.4949 \quad DW = 0.2373$ $F = 132.3$
	TSCORC	$R = -1292.92 + 0.013 M - 200.56 \frac{M}{Y} + 0.943 P_g$ $(1.41)* (0.655) (1.65)** (1.16)$ $R^2 = 0.9602 \quad DW = 1.4766 \quad \rho = 1.005512$ $F = 2974$
Model II	INST	$\ln R = -2.52 + 0.529 \ln M - 0.239 \ln \frac{M}{Y} + 0.836 \ln P_g$ $(2.18)** (11.03)*** (3.65)*** (3.12)***$ $R^2 = 0.4002 \quad DW = 0.2189$ $F = 90.06$
	TSCORC	$\ln R = 3.92 - 0.5683 \ln M - 0.128 \ln \frac{M}{Y} + 0.48 \ln P_g$ $(1.76)** (0.679) (0.8656) (1.697)***$ $R^2 = 0.9581 \quad DW = 2.02 \quad \rho = 0.974073$ $F = 2118 \quad (83.27)***$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Following 4 countries had to be excluded because of non-availability of data on their gov. bond yield or their discount rate, Dominican Rep., Panama, El Salvador, and Paraguay.

TABLE 5-8
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
21 LDC (Market price of gold)

(after we dropped income variable from supply side)

Model III	INST	$R = 97.61 + 0.0496 M - 12.54 \frac{M}{Y} - 0.843 P_g + 0.8982 R_{-1}$ $(3.83)*** (5.15)*** (0.348) (3.76)*** (38.38)***$ $R^2 = 0.895 \quad DW = 1.6705$ $F = 860.5$
	TSCORC	$R = 89.29 + 0.01 M - 21.47 \frac{M}{Y} - 0.607 P_g + 1.001 R_{t-1}$ $(3.39)*** (1.35)* (0.719) (2.94)*** (50.85)***$ $R^2 = 0.9659 \quad DW = 1.9849 \quad \rho = 0.308578$ $F = 2614 \quad (6.27)***$
Model IV	INST	$\ln R = 2.26 + 0.21 \ln M + 0.00679 \ln \frac{M}{Y} - 0.485 \ln P_g + 0.761 \ln R_{-1}$ $(5.17)*** (6.95)*** (0.203) (4.97)*** (26.62)***$ $R^2 = 0.8139 \quad DW = 1.445$ $F = 441.85$
	TSCOR	$\ln R = 0.6013 - 0.0038 \ln M - 0.01265 \ln \frac{M}{Y} - 0.9326 \ln P_g + 0.98 \ln R_{-1}$ $(2.87)*** (0.2657) (0.8171) (2.11)** (66)***$ $R^2 = 0.962 \quad DW = 1.9984 \quad \rho = 0.022569$ $F = 2333 \quad (.436569)$

Numbers in parentheses are the t-values.

- * - significantly different from zero at 90% level.
 - ** - significantly different from zero at 95% level.
 - *** - significantly different from zero at 99% level.
- Following 4 countries had to be excluded because of non-availability of data on their discount rate; Dominican Rep., Panama, El Salvador, and Paraguay.

countries will drop by \$16.95 million. Model IV-INST suggests that if the official gold price rises by one percent, then demand for reserve will drop by 9.6 percent, indicating an elastic demand with respect to the official gold price.

The same argument applies for tables 4-8 and 4-9, which show the results when the market price of gold is used. Again, the result of the disequilibrium model is much more satisfactory than the result of the equilibrium model.

With respect to the speed of adjustment, we need to refer to Model III-INST and Model IV-INST. Our results show that the figure is between 9 percent and 24 percent; that is, in the less developed countries sample, between 9 percent and 24 percent of the adjustment is completed within one year.

To compare developed and less developed countries, we again put all results together in tables 5-9 and 5-10².

The models that should be used to compare the results are Model I-TSCORC, Model II-TSCORC, Model III-INST, and Model IV-INST. Because in the equilibrium model the other two models have a very low R^2 and in the disequilibrium model the inclusion of R_{t-1} in the demand function makes the Durbin-Watson statistic biased toward 2, so

TABLE 5-9
COMPARISON OF DC'S AND LDC'S REGRESSION COEFFICIENTS USING OFFICIAL \$ PRICE OF GOLD
(after we dropped income variable from supply side)

		Constant Term		M		H y		P _g		R _{t-1}	
		DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's
Model I	INST	80855.6 (1.98)**	5468 (2.53)***	0.323 (6.74)***	0.314 (10.54)***	-522.4 (0.277)	-136.1 (1.01)	-1979 (1.95)**	-132.89 (2.46)	-----	-----
	TSCORC+	14379.5 (2.65)***	794 (0.74)	0.121 (3.93)***	0.02 (1.06)	-3824 (3.7)***	-197.4 (1.71)**	-265.6 (2.23)**	18.28 (1.21)	-----	-----
Model II	INST	127.3 (2.35)***	-40.04 (2.35)***	1.05 (13.3)***	0.53 (9.39)***	-0.494 (3.47)***	0.25 (3.21)***	-34.98 (2.38)***	11.18 (2.41)***	-----	-----
	TSCORC+	17.08 (1.82)**	2.18 (0.36)	0.21 (1.22)	0.126 (1.52)*	-0.35 (1.71)**	0.02 (0.152)	-3.19 (1.15)	1.42 (0.864)	-----	-----
Model III	INST+	1017.83 (2.71)***	692.35 (2.96)***	0.0074 (1.96)**	0.041 (4.66)***	13.79 (0.12)	-27.34 (0.779)	-25.26 (2.74)***	-16.95 (2.91)***	1.002 (81)***	0.91 (39.74)***
	TSCORC	876.55 (2.12)**	416.8 (2.77)***	0.0065 (1.77)**	0.0038 (0.546)	31.17 (0.279)	-32.98 (1.16)	-21.82 (2.17)***	-9.77 (2.66)***	1.003 (84)***	1.006 (52.4)***
Model IV	INST+	2.94 (2.85)***	35.47 (4.66)***	0.032 (1.86)**	0.239 (5.89)***	-0.016 (0.774)	0.046 (1.003)	-0.797 (2.85)***	-9.6 (4.64)***	0.963 (57)***	0.758 (20.59)***
	TSCORC	2.07 (2.34)**	2.62 (2.17)***	0.012 (0.856)	0.009 (.687)	0.0037 (.225)	-0.0165 (1.10)	-0.553 (2.32)**	-0.66 (2.02)**	0.986 (74)***	0.982 (66.77)***

+ These are the relevant models which should be used for comparison purposes.

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-10
COMPARISON OF DC'S AND LDC'S REGRESSION COEFFICIENTS USING MARKET PRICE OF GOLD
(after we dropped income variable from supply side)

	Constant Term		M		$\frac{M}{y}$		P_g		R_{t-1}	
	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's	DC's	LDC's
Model I	INST	2341.54 (4.29)***	259.26 (2.68)***	0.266 (21.96)***	-2653.6 (5.36)***	-295.68 (3.29)***	-12.44 (2.55)***	-1.22 (1.29)*	-----	-----
	TSCORC+	7171.32 (2.48)***	-1292.92 (1.41)*	0.013 (2.14)**	-440 (0.277)	-200.56 (1.65)**	-11.68 (1.54)*	0.943 (1.16)	-----	-----
Model II	INST	1.20 (1.12)	-2.52 (2.18)**	0.9436 (37.66)***	-0.635 (12.21)***	-0.239 (3.65)***	-0.636 (2.67)***	0.836 (3.12)***	-----	-----
	TSCORC+	10.67 (2.54)**	3.92 (1.76)**	0.142 (1.18)	-0.167 (0.964)	-0.128 (0.8656)	-0.847 (1.301)*	0.48 (1.697)**	-----	-----
Model III	INST+	57.63 (0.976)	97.61 (3.83)***	0.0074 (1.90)**	2.34 (.02)	-12.54 (0.348)	-0.5468 (1.33)*	-0.843 (3.76)***	1.001 (80.75)***	0.8982 (38.38)***
	TSCORC	57.25 (0.81)	89.29 (3.39)***	0.007 (1.88)**	27.66 (0.246)	-21.47 (0.719)	-0.593 (1.21)	-0.607 (2.94)***	1.001 (83)***	1.0001 (50.85)***
Model IV	INST+	0.329 (2.23)**	2.26 (5.17)***	0.036 (2.02)**	-0.018 (0.864)	0.00679 (0.203)	-0.076 (2.46)***	-0.485 (4.97)***	0.96 (56)***	0.761 (26.62)***
	TSCORC	0.313 (2.11)**	0.6013 (2.87)***	0.016 (1.15)	-0.0016 (0.097)	-0.0127 (0.8171)	0.065 (2.10)**	-0.9326 (2.11)**	0.98 (72)***	0.98 (66)***

+ These are the relevant models which should be used for comparison purposes.

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Model III-TSCORC and Model IV-TSCORC are irrelevant.

In Model I-TSCORC or Model II-TSCORC for less developed countries, most of the coefficients are insignificant, and the gold price again takes the wrong (positive) sign. This led us to investigate the demand function in less developed countries in much more detail. We again looked at the first stage of the two-stage least-squares method, in which the gold price was regressed on all exogenous variables. The estimated relation between gold price and all other exogenous variables using the ordinary least-squares method is:

$$\begin{aligned}
 P_g &= 40.11 + 0.00058 M + 1.38 \frac{M}{Y} + 0.075 (r^{U.S.} - r^{R.O.W.}) \\
 &\quad (232.8) \quad (5.19) \quad (2.62) \quad (3.5) \\
 &\quad - 0.002 (P^{U.S.} - P^{R.O.W.}) \\
 &\quad (1.4) \\
 R^2 &= 0.097 \quad DW = 0.4125
 \end{aligned}$$

The same relation was estimated using the Cochrane-Orcutt procedure; the result is as follows:

$$\begin{aligned}
 P_g &= 41.78 + 0.000021 M + 0.0397 \frac{M}{Y} + 0.0135 (r^{U.S.} - r^{R.O.W.}) \\
 &\quad (136.6) \quad (0.132) \quad (0.047) \quad (0.369) \\
 &\quad + 0.00096 (P^{U.S.} - P^{R.O.W.}) \\
 &\quad (0.478) \\
 R^2 &= 0.71 \\
 DW &= 1.31
 \end{aligned}$$

As the results indicate, the fit is very poor in the first

equation, and all coefficients are insignificant in the second. This led us to assume that the supply of reserves is given for less developed countries, and they have no control over it. Consequently, we estimated the demand function for less developed countries by using the ordinary least-squares method; the results are presented in tables 5-11 through 5-14.

As the results indicate, the estimated coefficient of gold price is not satisfactory in the equilibrium model. In Model I-OLSQ or Model II-OLSQ it is negative but insignificant, and in Model I-CORC and Model II-CORC it has a positive but significant sign³. Thus, we need further investigation of the behavior of less developed countries with respect to gold price.

We looked at the gold holding of less developed countries during our period of estimation, 1972-1977. The data in table 5-15 show that the gold holdings of some countries did not vary as gold prices increased. One reason might be the fact that the gold component of their total reserve is very small. For example, for countries such as Honduras and Paraguay, it was so small that they only began reporting data in 1977. It was thus necessary

TABLE 5-11
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
21 LDC's (official price of gold)

Model I	OLSQ	$R = 286.48 + 0.269 M - 342.482 \frac{M}{Y} - 4.23 P_g$ $(1.26) \quad (23.7)*** \quad (5.44)*** \quad (0.75)$ $R^2 = 0.5607 \quad DW = 0.2518$ $F = 212$
	CORC	$R = 1192.40 + 0.0227 M - 189.9 \frac{M}{Y} + 5.41 P_g$ $(3.01)*** \quad (23.7)*** \quad (5.44)*** \quad (0.75)$ $R^2 = 0.9673 \quad DW = 1.33 \quad \rho = 0.994214$ $F = 4509 \quad (198)***$
Model II	OLSQ	$\ln R = 1.81 + 0.831 \ln M - 0.287 \ln \frac{M}{Y} - 0.675 \ln P_g$ $(0.536)(27.42)*** \quad (5.07)*** \quad (0.736)$ $R^2 = 0.63 \quad DW = 0.177$ $F = 283$
	CORC	$\ln R = 3.06 - 0.065 \ln M - 0.042 \ln \frac{M}{Y} + 1.026 \ln P_g$ $(1.61)**(0.86) \quad (0.324) \quad (2.21)**$ $R^2 = 0.976 \quad DW = 2.05 \quad \rho = 0.976881$ $F = 6208 \quad (98)***$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-12
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
21 LDC's (official price of gold)

Model III	OLSQ	$R = -122.68 + 0.067 M - 90.5 \frac{M}{Y} + 3.51 P_g + 0.785 R_{-1}$ $(0.97) \quad (7.74)*** \quad (2.54)** \quad (1.12) \quad (33.63)***$ $R^2 = 0.8655 \quad DW = 1.7634$ $F = 803$
	CORC	$R = 224.5 + 0.0042 M - 35.01 \frac{M}{Y} - 5.11 P_g + 1.006 R_{-1}$ $(2.34) \quad (0.688) \quad (1.43)* \quad (2.19)** \quad (58.003)***$ $R^2 = 0.9712 \quad DW = 1.9799 \quad \rho = 0.305215$ $F = 3847 \quad (6.889)$
Model IV	OLSQ	$\ln R = -3.29 + 0.189 \ln M - 0.091 \ln \frac{M}{Y} + 0.826 \ln P_g + 0.779 \ln R_{-1}$ $(1.75)**(7.50)*** \quad (2.86)*** \quad (1.62)* \quad (33.8)***$ $R^2 = 0.8876 \quad DW = 1.564$ $F = 985$
	CORC	$\ln R = 1.67 - 0.0096 \ln M - 0.022 \ln \frac{M}{Y} - 0.413 \ln P_g + 0.986 \ln R_{-1}$ $(1.74)**(0.792) \quad (1.54)* \quad (1.59)* \quad (86.99)***$ $R^2 = 0.9759 \quad DW = 1.9768 \quad \rho = -0.05847$ $F = 0.9759 \quad (1.258)*$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-13
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
21 LDC's (Market price of gold)

Model I	OLSQ	$R = 164.71 + 0.274 M - 321.324 \frac{M}{Y} - 0.473 P_g$ $(5.14)*** (23.52)*** (5.05)*** (1.906)**$ $R^2 = 0.5634 \quad DW = 0.2627$ $F = 215$
	CORC	$R = 1406.11 + 0.02299 M - 199.25 \frac{M}{Y} + 0.158 P_g$ $(3.97)*** (1.38)* (2.03)** (1.27)$ $R^2 = 0.9671 \quad DW = 1.3232 \quad \rho = 0.994075$ $F = 4494. \quad (196.57)$
Model II	CORC	$\ln R = 6.15 - 0.0355 \ln M - 0.0946 \ln \frac{M}{Y} + 0.0792 \ln P_g$ $(6.77)** (0.474) (0.731) (1.34)*$ $R^2 = 0.9758 \quad DW = 2.04 = 95.78$ $F = 6161.88$
	OLSQ	$\ln R = -0.076 + 0.839 \ln M - 0.276 \ln \frac{M}{Y} - 0.135 \ln P_g$ $(0.151) (26.87)*** (4.82)*** (1.28)*$ $R^2 = .6308 \quad DW = 0.183 \quad \rho = 0.975734$ $F = 284 \quad (95.78)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-14
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
21 LDC's (Market price of gold)

Model III	OLSQ	$R = 2.299 + 0.066 M - 92.93 \frac{M}{Y} + 0.156 P_g + 0.787 R_{-1}$ $(0.125) (7.35)*** (2.58)*** (1.12) (33.48)***$ $R^2 = 0.8655 \quad DW = 1.759$ $F = 803$
	CORC	$R = 39.3487 + 0.00598 M - 32.8 \frac{M}{Y} - 0.1996 P_g + 1.00274 R_{-1}$ $(2.69)*** (.9637) (1.32)* (1.96)** (57.35)***$ $R^2 = 0.9711 \quad DW = 1.9807 \quad \rho = 0.311422$ $F = 3840.18 \quad (7.044052)***$
Model IV	OLSQ	$\ln R = -0.894 + 0.1776 \ln M - 0.0999 \ln \frac{M}{Y} + 0.146 \ln P_g + 0.784 \ln R_{-1}$ $(3.19)*** (6.83)*** (3.12)*** (2.49)** (33.93)***$ $R^2 = 0.8884 \quad DW = 1.54$ $F = 992.6$
	CORC	$\ln R = 0.368 - 0.00723 \ln M - 0.021 \ln \frac{M}{Y} - 0.049 \ln P_g + 0.985 \ln R_{-1}$ $(2.298)** (0.580) (1.42)* (1.49)* (86.18)***$ $R^2 = 0.9759 \quad DW = 1.9736 \quad \rho = 0.056$ $F = 4631 \quad (1.21)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-15
GOLD HOLDING OF LDC's
(Million Ounces)

Country	1972	1973	1974	1975	1976	1977
Brazil	1.33	1.33	1.33	1.33	1.33	1.52
Columbia	0.43	0.43	0.43	1.13	1.41	1.73
China	2.30	2.30	2.30	2.30	2.23	2.41
Dominican Rep.	0.09	0.09	0.09	0.09	0.09	0.10
El Salvador	0.49	0.49	0.49	0.49	0.49	0.50
Egypt	2.43	2.43	2.43	2.43	2.43	2.43
Greece	3.50	3.50	3.61	3.63	3.65	3.73
Honduras	-----	-----	-----	-----	-----	0.01
Israel	1.14	1.10	1.10	1.10	1.10	1.16
India	6.95	6.95	6.95	6.95	6.95	7.36
Jordan	0.80	0.80	0.80	0.80	.80	.81
Korea	0.11	0.11	0.11	0.11	0.11	0.15
Mexico	4.94	4.63	3.66	3.66	1.60	1.76
Peru	1.09	1.00	1.00	1.00	1.00	1.00
Paraguay	-----	-----	-----	-----	-----	0.01
Portugal	26.88	27.54	27.84	27.72	27.67	24.11
Panama	-----	-----	-----	-----	-----	-----
Pakistan	1.57	1.60	1.59	1.59	1.62	1.62
Srilanka	-----	-----	-----	-----	-----	-----
South Africa	17.93	18.99	18.25	17.75	12.67	9.72
Turkey	3.57	3.57	3.57	3.57	3.57	3.63

Source: International Financial Statistic.

to classify the less developed countries into two groups.

The classification is based on real GDP per capita. In their paper, Kravis, Heston and Summer (1980) calculated real GDP per capita for almost all countries in terms of dollars, using the purchasing power parity theory. We borrowed the numbers from their study and used these in table 5-16, which shows the dollar value of real GDP per capita for our period of estimation.

A glance at table 5-16 shows that real GDP differs from country to country. In the first less developed group are those countries that had a real per capita income of more than \$1,000 in 1977. In the second group are those with real per capita income of less than \$1,000. Why was \$1,000 chosen as a benchmark? We simply looked at the last year (1977) and noted where the gap was the widest. As table 5-16 indicates, the widest gap was between \$1,040 and \$821. Fortunately, our classification coincides with what we found in table 5-15. In other words, countries in the second group are also those whose holding did not change as the gold price increased.

The estimation results for the 13 less developed countries⁵ in the first group are presented in tables 5-17 through 5-20.⁶

As our results indicate, Model II-OLSQ and

TABLE 5-16
DOLLAR VALUE OF REAL GDP PER CAPITA
OF LESS DEVELOPED COUNTRIES
IN A DECREASING ORDER

	Countries	1972	1973	1974	1975	1976	1977
First Group of LDC's (Rich LDC's)	Israel	3108	3168	3254	3366	3187	3088
	Greece	2137	2325	2234	2362	2518	2449
	Brazil	1300	1438	1516	1565	1669	1717
	Portugal	1461	1618	1616	1494	1526	1633
	South Africa	1399	1440	1494	1499	1513	1506
	Panama	1437	1496	1504	1508	1485	1437
	Mexico	1300	1358	1391	1404	1375	1365
	Turkey	959	971	1069	1110	1175	1196
	Peru	1105	1126	1179	1192	1201	1175
	Colombia	914	966	998	1014	1091	1076
	Dominican Rep	877	974	969	1009	1058	1070
	Korea	767	774	818	867	961	1040
Second Group (Poor LDC's)	Paraguay	640	673	707	720	753	821
	El Salvador	680	688	716	744	742	755
	Jordan	576	552	596	540	590	692
	Honduras	621	625	599	584	611	627
	Srilanka	461	493	543	538	550	553
	Egypt	508	500	478	506	517	544
	Pakistan	437	442	445	450	445	459
	India	317	321	313	332	329	343

Source: International Comparison of Real Product and its Composition: 1950-1977, R. Summers, I.B. Kravis, and A. Heston, Review of Income and Wealth, March 1980.

TABLE 5-17
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
13 LDC's (official price of gold)

Model I	OLSQ	$R = 296.07 + 0.2788 M - 691.5 \frac{M}{Y} - 2.95 P_g$ (.95) (19.9)*** (7.18)*** (0.38) $R^2 = 0.5826$ DW = 0.2199 F = 143.28
	CORC	$R = 3550.76 + 0.035 M - 176.47 \frac{M}{Y} + 7.44 P_g$ (1.79)** (1.42)* (0.85) (1.68)** $R^2 = 0.9653$ DW = 1.28 $\rho = 0.998132$ F = 2612 (276)***
Model II	OLSQ	$\ln R = 4.07 + 1.146 \ln M - 0.624 \ln \frac{M}{Y} - 2.02 \ln P_g$ (1.196)(28.81)*** (10.11)*** (2.18)** $R^2 = 0.7629$ DW = 0.2401 F = 330
	CORC	$\ln R = 3.225 + 0.0717 \ln M - 0.00638 \ln \frac{M}{Y} + 0.684 \ln P_g$ (1.35)* (0.645) (.029) (1.20) $R^2 = 0.9777$ DW = 1.87 $\rho = 0.978629$ F = 4119 (80.48)***

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-18
ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
13 LDC's (official price of gold)

Model III	OLSQ	$R = -35.14 + 0.071 M - 164.03 \frac{M}{Y} + 1.58 P_g + 0.7848 R_{-1}$ $(0.21) \quad (6.32)*** \quad (2.90)*** \quad (0.37) \quad (26.73)***$ $R^2 = 0.8745 \quad DW = 1.7201$ $F = 535$
	CORC	$R = 333.66 + 0.0138 M - 64.78 \frac{M}{Y} - 7.65 P_g + 0.9735 R_{-1}$ $(2.27)** \quad (1.52)* \quad (1.41)* \quad (2.13)*** \quad (38.68)***$ $R^2 = 0.9704 \quad DW = 1.9533 \quad \rho = 0.378037$ $F = 2300 \quad (6.91)***$
Model IV	OLSQ	$\ln R = 0.214 + 0.414 \ln M - 0.245 \ln \frac{M}{Y} - 0.411 \ln P_g + 0.648 \ln R_{-1}$ $(0.094) \quad (0.04)*** \quad (5.39)*** \quad (0.668) \quad (19.62)***$ $R^2 = 0.8948 \quad DW = 1.2875$ $F = 653$
	CORC	$\ln R = 2.9 + 0.024 \ln M - 0.033 \ln \frac{M}{Y} - 0.78 \ln P_g + 0.96 \ln R_{-1}$ $(2.29)*** (0.96) \quad (1.39)* \quad (2.27)*** \quad (50.5)***$ $R^2 = 0.9782 \quad DW = 1.9498 \quad \rho = 0.044907$ $F = 3148 \quad (0.76)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-19
ESTIMATES OF DEMAND FUNCTION: EQUILIBRIUM MODEL
13 LDC's (Market price of gold)

Model I	OLSQ	$R = 263.01 + 0.291 M - 646.5 \frac{M}{Y} - 0.877 P_g$ $(5.95)*** (19.20)*** (6.71)*** (2.57)***$ $R^2 = 0.5912$ $DW = 0.2417$ $F = 148.45$
	CORC	$R = 12297.5 + 0.0392 M - 240.95 \frac{M}{Y} + 0.2548 P_g$ $(1.85) (1.58) (1.14) (1.42)$ $R^2 = 0.9652$ $DW = 1.2722$ $\rho = 0.999425$ $F = 2607$ (498)***
Model II	OLSQ	$\ln R = -1.26 + 1.195 \ln M - 0.587 \ln \frac{M}{Y} - 0.507 \ln P_g$ $(2.53)*** (29.75)*** (9.71)*** (4.86)***$ $R^2 = 0.7764$ $DW = 0.289$ $F = 356$
	CORC	$\ln R = 5.198 + 0.107 \ln M - 0.0814 \ln \frac{M}{Y} + 0.0314 \ln P_g$ $(3.79)*** (0.9712) (0.3795) (0.4359)$ $R^2 = 0.9776$ $DW = 1.86$ $\rho = 0.976929$ $F = 4096$ (77.3598)***

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

TABLE 5-20

ESTIMATES OF DEMAND FUNCTION: DISEQUILIBRIUM MODEL
13 LDC's (Market price of gold)

Model III	OLSQ	$R = 35.46 + 0.073 M - 158.25 \frac{M}{Y} - 0.073 P + 0.783 R_{-1}$ $(1.36)^* (6.21)^{***} (2.799)^{***} (0.381)^g (26.33)^{***}$ $R^2 = 0.8745 \quad DW = 1.73$ $F = 535$
	CORC	$R = 66.25 + 0.0176 M - 60.36 \frac{M}{Y} - 0.382 P_g + 0.9684 R_{-1}$ $(2.9)^{***} (1.90)^{**} (1.33)^* (2.52)^{***} (38.95)^{***}$ $R^2 = 0.9705 \quad DW = 1.9533 \quad \rho = 0.371334$ $F = 2314 \quad (6.76)^{***}$
Model IV	OLSQ	$\ln R = -0.836 + 0.4405 \ln M - 0.243 \ln \frac{M}{Y} - 0.122 \ln P_g + 0.636 \ln R_{-1}$ $(2.45)^{***} (9.02)^{***} (5.38)^{***} (1.64)^{**} (18.72)^{***}$ $R^2 = 0.8956 \quad DW = 1.3035$ $F = 658$
	CORC	$\ln R = 0.617 + 0.0459 \ln M - 0.0338 \ln \frac{M}{Y} - 0.143 \ln P_g + 0.952 \ln R_{-1}$ $(2.96)^{***} (1.74)^{**} (1.47)^* (3.27)^{***} (49.64)^{***}$ $R^2 = 0.9786 \quad DW = 1.94 \quad \rho = 0.037348$ $F = 3209 \quad (0.6321)$

Numbers in parentheses are the t-values.

* - significantly different from zero at 90% level.

** - significantly different from zero at 95% level.

*** - significantly different from zero at 99% level.

Model IV-CORC are satisfactory in terms of our theory⁷. Based on these two models, the elasticity of demand with respect to the official price of gold is 2.02 percent, which means as gold prices rise by one percent, demand for total reserves by this sample of less developed countries will drop by 2.02 percent. As we saw before, the elasticity for developed countries was 3.19 percent.

Model IV-CORC indicates that the speed of adjustment for this group of less developed countries is 4 percent ($1 - .96 = .04$), which means that in the 13-country sample, 4 percent of the adjustment is completed within one year. It should be pointed out that the speed of adjustment for developed countries also was 4 percent.

The results for the second group of less developed countries were not satisfactory (that is, a very low R^2 and insignificant coefficients). Therefore, we do not present the results.

5.4 - Conclusions

An interesting finding is that the price of gold (official or market) exerts a negative effect on the demand for liquidity. Furthermore, the demand for reserves with respect to the official price of gold is elastic, but with respect to the market price it is inelastic. It appears that this elasticity is smaller for less developed than for developed countries. This might be due to the fact that the latter hold larger amounts of gold than do the former. Table 5-21 summarizes our findings.

TABLE 5-21
DEMAND ELASTICITIES WITH RESPECT TO GOLD PRICE
FROM THE MOST APPROPRIATE MODELS

	DC's		LDC's	
	Equilibrium Model	Disequilibrium Model	Equilibrium Model	Disequilibrium Model
Official Price of Gold	-3.19	-0.797	-2.02	-0.411
Market Price of Gold	-0.847	-0.076	-0.507	-0.122

Our results indicate that market price of gold would be a more appropriate measure to use in valuing the gold component of official reserves of all countries. More precisely, if IMF allows the official price of gold to be the same as its market price, an increase of almost 1100 percent then if the demand for reserves will drop by almost 13 billion dollars. In other words, by revaluing the gold, we will be able to solve the shortage of reserves by almost 13 billion dollars.⁸

With respect to the speed of adjustment, it was almost four percent for both groups of countries, indicating that almost four percent of adjustment is completed within one year.

We also found that the coefficient of the import-GNP ratio takes a negative sign in all models, regardless of whether the official or market price of gold is used. This negative coefficient implies a more "Keynesian" role for this variable.

The effect of imports is small for developed as compared to less developed countries. The elasticity is less than unity for developed countries, indicating economies of scale. It is greater than unity (1.14) for less developed countries, indicating diseconomies of scale. This difference might be due to the fact that in the period of estimation (1972-1977), most developed countries moved to a managed float, whereas most less developed countries did not. Moving from a fixed exchange rate system to a managed

floating system will reduce the demand for reserves because fluctuations in exchange rates will reduce the deficit due to higher import levels.

5.5 - Concluding Remarks

In this thesis, we developed a simultaneous equation model of demand for and supply of international reserves, and we applied it in analyzing the behavior of developed and less developed countries. We have shown that the reserve demand function as well as the supply function can be specified in terms of a small number of variables. We provided evidence that the demand for international reserves is negatively related to gold price, which is a unique finding in the literature. We also provided evidence that deviations of actual from desired reserve holdings trigger a process of adjustment, this led us to estimate our model when the market is in disequilibrium. We found that log-linear models give a better result than linear models, which supports Box-and Jenkins (1970), who claim that log-linear models have the best fit for international data.

FOOTNOTES

CHAPTER TWO

FOOTNOTES

¹See see how these lagged periods are determined, see the original paper, pp. 631.

²For more details see Heller (1966), pp. 209-304.

³Heller (1966), p. 310.

CHAPTER THREE

FOOTNOTES

¹See, for example, Archibald and Richmond (1971).

²See Williamson (1974) and Haberler (1977).

³For more discussion, see Frenkel (1974-A) and Heller (1966).

⁴In this model we have assumed a linear consumption function with constant marginal propensity to consume, which implies a constant marginal propensity to save. If, however, an increase in m is associated with a decline in s , then the effects of "openness" on the balance of trade is ambiguous and depends on the difference of $(m-s)$.

⁵For source of data on this page, see Robert Z. Aliber, The International Money Game, 3rd ed., (1979), pp. 75-94.

⁶Numbers in brackets are t-ratios, and the gold price coefficient is almost significant at $\alpha = 0.10$.

⁷For more details and for reasons for the self-correcting mechanism, see M.E. Kreinin and L.H. Officer, The Monetary Approach to the Balance of Payments: A Survey, Princeton Studies in International Finance, No. 43, 1978.

⁸SDRs were allocated to those IMF member countries that elected to receive them in proportion to the size of each country's quota. Upon becoming a member of the IMF, a country must agree upon the size of its quota. Twenty-five percent of the quota is deposited in the form of an international reserve asset (usually gold or U.S. dollars). The remaining 75 percent is deposited in the form of the country's domestic currency. These quotas then form a pool of IMF members' currencies from which one member can borrow another member's currency. The specific SDR allocations are: SDR 3.41 billion on January 1, 1970 (each participant received 16.8 percent of its quota), SDR 2.95 billion in 1971 (10.7 percent of quota), SDR 4.03 billion in 1979 (10.4 percent of quota), and SDR 4.033 billion in 1980.

⁹The specification of demand for reserves is assumed to take the following form:

$$R_t^d = a_0 + a_1 M_t + a_2 \left(\frac{M}{Y}\right)_t + a_3 P_{g_t}$$

¹⁰The supply function is specified in the following form:

$$R_t^s = b_0 + b_1 P_{g_t} + b_2 (r_{U.S.} - r_{R.O.W.})_t \\ + b_3 (P_{U.S.} - P_{R.O.W.})_t + b_4 (y_{U.S.} - y_{R.O.W.})_t$$

CHAPTER FOUR

FOOTNOTES

¹List of countries on which analysis is based:

DC's	LDC's
Australia	Brazil
Austria	China
Belgium	Colombia
Canada	Dominican Rep.
Denmark	Egypt
France	El Salvador
Finland	Greece
Germany	Honduras
Iceland	Israel
Ireland	India
Italy	Jordan
Japan	Korea
Netherlands	Mexico
New Zealand	Peru
Norway	Paraguay
Spain	Portugal
Sweden	Panama
Switzerland	Pakistan
United Kingdom	Srilanka
	South Africa
	Turkey

All data for all countries were available from International Financial Statistics and IMF tapes.

²Since quarterly GNP was not available for some countries, a quarterly figure was generated using annual GNP. The method used was based on a linear import function: $M = a + bY$, where M = imports and Y = GNP. However, for our purposes, the quarterly series to be estimated (Y) was regressed on imports (See Chow and Lin (1976)). So, using annual observations, we estimated the following function for those countries;

$$Y_t = c + d M_t + \varepsilon_t .$$

By then using quarterly data for M , we obtained a quarterly series for y . However, the generated quarterly data for y , let us say $\hat{y}$, were adjusted, such that $\hat{y}_I + \hat{y}_{II} + \hat{y}_{III} + \hat{y}_{IV} = y$, where y is the the annual observed data. Countries to which this procedure was applied are: Belgium, Denmark, Iceland, Ireland, the Netherlands, New Zealand, Norway, Sweden, Switzerland, Spain, and all 21 less developed countries. The R^2 ranged from 0.65 to .92.

³These are equations (3.5.3) and (3.5.6) from Chapter 3 with the following changes:

$$c_0 = a_0\gamma, c_1 = a_1\gamma, c_2 = a_2\gamma, c_3 = a_3\gamma$$

$$c_4 = 1-\gamma \text{ therefore } \gamma = 1-c_4 = \text{speed of adjustment}$$

$$d_0 = b_0, d_1 = b_1, d_2 = b_2, d_3 = b_3$$

$$b_4 = \frac{1}{\mu} + b_4 \text{ and } d_5 = -\frac{1}{\lambda}$$

⁴Only in model I-TSCORC does the gold price take the wrong sign.

⁵"Gold revaluation needs to be distinguished from dollar devaluation, such as was embodied in the Smithsonian Agreement in December 1971. Both involve a change in the gold/dollar parity, but gold revaluation is directed to changing the relationship between gold and currencies in general while dollar devaluation changes the relation between the dollar and other currencies essentially unchanged." Williamson (1973, p. 714).

⁶(1-coefficient next to R_{t-1}) = γ , where γ = speed of adjustment.

⁷Table 4-10 reflects the results when the official gold price has been used, and table 4-11 shows the result when the market price of gold is used.

CHAPTER FIVE

FOOTNOTES

¹(1-coefficient next to R_{t-1}) = γ . Where γ = speed of adjustment.

²Table 5-9 reflects the results when the official gold price is used, and Table 5-10 shows the results when the market price of gold is used.

³Numbers in parentheses are t-values.

⁴Other coefficients have the right sign, and they are significant, especially in Model II-OLSQ; in that model, the elasticity of demand with respect to imports is 0.831, supporting the square root-law.

⁵The People's Republic of China was put back into the first group.

⁶In both cases, that is, using the official gold price and the market price of gold.

⁷In both cases, that is, using the official gold price and the market price of gold.

⁸These estimates are based on an elasticity of 3.19 and total reserve at the end of 1977 which stood at 261699 million SDR.

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