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Reserve-Currency Diversification and the Substitution Account

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1 INTRODUCTION

During the 1970s, it became increasingly apparent to a number of economists that the U.S. dollar constituted too high a proportion of total reserves in the portfolios of many countries (see, for example, Group of 30, 1980). This gap between optimal and actual reserve portfolios, they felt, could generate pressures in foreign-currency markets that would bring about instability in exchange rates and in the international monetary system.

In this Study, I examine the size of this gap and its distribution among groups of countries and compare optimal policy with the policies that were actually pursued. An analysis of the main factors responsible for the disparity may contribute to an understanding of central-bank behavior in foreign-exchange markets. I describe first the normative approach to international reserve investment and then present a model of optimal portfolio selection for a central bank. The model emphasizes the effects of the import basket and of the distribution of the returns on the various currencies. The empirical application of the model and an analysis of actual central-bank foreign-exchange portfolios, taking account of the country's level of development and exchange-rate regime, provide preliminary answers to major problems with which central banks have been grappling since the shift to floating exchange rates:

1. How much of a gap exists between current reserve composition and optimal reserve composition for different groups of countries, and is this gap narrowing?

2. What factors explain the composition of optimal and actual foreign-currency portfolios and the differences between them?

3. How might reserve transfers between central banks with different optimal portfolios affect the stability of the total demand for various currencies?

Analysis of the findings for the years 1972-80 confirms the existence of a gap between the optimal and actual portfolios at the end of 1980.

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Although it narrowed during the 1970s, this gap was the main reason for renewed interest in 1979-80 in the proposal to create a substitution account. Under this proposal, countries could sell dollars to the International Monetary Fund (IMF) in exchange for an asset denominated in Special Drawing Rights, up to an initial limit of SDR 50 billion. The IMF would then deposit in the U.S. Treasury the dollars received. In this manner, the international monetary system would be spared the shocks and instability of such conversions when carried out in the market. The strengthening of the dollar since 1980 has increased demand for it, thereby reducing the gravity of the problem in the short run. But the fluctuations in exchange rates since they began to float are largely cyclical, and many believe that sooner or later the problem will recur (see, for example, Kenen, 1981, p. 425).

It would be easier to evaluate the proposal for a substitution account if we had the answers to a number of questions. Chapter 8 of this Study illustrates the application of the model and of the empirical findings about central-bank behavior to two such questions:

1. What is the projected demand for participation in a substitution account and what is the preferred size of such an account, under given supply and demand conditions in foreign-currency markets?

2. Which countries would benefit and which would lose from the creation of the substitution account?

2 THE ANALYTICAL APPROACH

Recent studies dealing with the actual and optimal composition of foreign-currency reserves cast some light on the questions raised in the Introduction. In fact, the findings support the assumption on which the substitution-account proposal is based that a gap exists between the optimal and the actual composition of foreign-currency reserves throughout the world.

The earlier studies, dealing with the composition of central-bank reserves, include those of Kenen (1963), Officer and Willett (1969), Stekler and Piekarz (1970), and Makin (1971), but these authors concentrated primarily on investigating the share of gold in total reserves. Heller and Knight (1978) were the first to present and analyze data on the actual currency composition of the total reserves of seventy-six countries, and also of groups of countries classified by exchange-rate regime. In their opinion, the factors determining the currency composition of reserves of a particular country include the type of exchange-rate regime, currency agreements entered into by the country, and the structure of the balance of payments. To be specific, the weight of currency i in the home country's reserves will increase (a) if the home country pegs its currency to currency i and (b) directly with the weight of currency i in the international trade of the home country. The authors also note that countries participating in the European System of Narrower Exchange Rate Margins (snake countries) tend to hold a relatively large proportion of their reserves in dollars, as they are prohibited from holding other members' currencies except as working balances. The effect of these factors on the weights of the dollar, pound sterling, French franc, Deutsche mark, and other currencies (considered as a group) was examined empirically by means of a regression run on fifty-five countries and found to be statistically significant. According to Heller and Knight, although risk and return also play a role in determining the choice of currencies held, they are less important to central banks than to individual investors. Moreover, the authors argue that the distribution of returns in a cross-sectional analysis cannot help to explain the composition of reserves, since all countries face the same distribution of returns on currencies at any point in time.

A number of recent studies have examined the optimal composition of foreign-currency reserves for an individual country (Ben-Bassat, 1978, 1980; Kouri and de Macedo, 1978; and Healey, 1981). In these papers, the general approach is, for the most part, to minimize variance for a given level of return, using the import-currency basket as numeraire.

It seems to me that the optimal composition depends on three principal factors: the country's motive for holding foreign-currency reserves, the risk and return on the various currencies, and the country's interest in maintaining international monetary stability. While the importance of these factors varies from country to country, two main groups can be distinguished:

1. Industrialized countries with floating exchange rates whose currencies serve as reserve assets for other central banks. The composition of these countries' reserves is generally considered to be influenced chiefly by considerations of international monetary stability. Profit and loss considerations are thought to be of only secondary importance.
2. Semi-industrialized and developing countries, most of which have pegged exchange rates. Unlike the industrialized countries, these countries need not take into account the stability of the international monetary system. The composition of their reserves is therefore mainly determined by profit, risk, and liquidity considerations.

The portfolio-selection model presented in this Study is clearly appropriate for the second group but might also adequately describe the behavior of certain countries belonging to the first group.

Although there are differences between portfolio selection by a central bank and by an individual, the two principal factors guiding an individual's choice of portfolio under uncertainty—risk and rate of return—also apply to the selection of a central bank's reserve portfolio. In addition to risk and return, however, the purpose for which the reserves are held must also be considered. Since the future flow of international receipts and payments is uncertain, countries must hold reserves in order to finance imports during periods when receipts fall short of outlays. This variability in international net payments is crucial to the determination of the optimal level of reserves. However, it is the optimal composition of reserves at a given level that is the focus of this Study. The composition of reserves is affected by another kind of uncertainty—uncertainty as to the future value of the foreign currencies in which the central bank invests, in terms of its objective function. I shall attempt to model these considerations formally.

Owing to the variability of the future flow of funds, the investment horizon of reserves is short. Actually, the central bank faces the problem of selecting a portfolio for many periods, but the optimal portfolio for the current period can be derived from an analysis of a two-period model, where the second period represents all future periods. This simplification gives the same solution that would be obtained from solving a model of an infinite number of periods, where the economy consumes its accumulated reserves in the "last" (infinitely deferred) period.

Since I am concerned with the allocation of foreign-currency resources, I shall regard local production as exogenous and define the central bank's utility function on imports alone. In this two-period model, the utility function is defined as

$$U = U(M_1, M_2) , \qquad (1)$$

where M_1 and M_2 are total imports of goods and services (including debt service) in periods 1 and 2 respectively.

The economy faces two budget constraints, one for each period. The constraints are expressed in real import terms, each variable being translated from transactions currency to import terms according to each currency's real effective exchange rate (P_i). It is assumed that the composition of imports, the composition of exports (X), and the composition of net capital imports (K) are given and are thus expressed in aggregate terms, so that the economy determines only the composition of reserves. The constraints are

$$M_1 + \sum_{i=1}^{m} R_{i1}/P_{i1} = X_1 + K_1 + R_0 \qquad (2)$$

$$M_2 = \sum_{i=1}^{m} (R_{i1}/P_{i1})(1 + \rho_i) , \qquad (3)$$

where R_0 = initial reserves in import terms,

R_{i1} = number of units of country i's currency held in reserves during the first period,

ρ_i = expected rate of return of currency i, including both interest and capital gain or loss due to changes in the exchange rate and price level,

X_1 = export receipts during the first period in import terms,

K_1 = net capital imports during the first period in import terms,

P_{i1} = real effective exchange rate of currency i in the first period, defined as the nominal effective exchange rate deflated by the average import price level; the nominal effective exchange rate expresses the exchange rate of the import-weighted basket of currencies in units of currency *i*.

The economy starts the first period with reserves R_0 and obtains additional foreign-currency receipts from exports and net capital imports. The economy must decide upon the allocation of its total foreign-currency resources between import consumption, M_1, and investment in reserves, R_1, for the purpose of financing imports in the second period, M_2. Uncertainty regarding the exchange rates of the various currencies introduces uncertainty as to the total amount of imports the economy will be able to consume. Therefore, the optimal currency allocation of reserves will be determined by the maximization of expected utility, subject to the budget constraints.[1]

A solution can be reached either by assuming a quadratic utility function or by assuming that the distribution of returns belongs to the family of two-parameter distributions (such as the normal distribution). Either of these assumptions makes possible a two-step solution of the problem. The first step is the computation of the efficiency frontier representing all efficient combinations of risk and return, obtained by minimizing the variance for a given return (see Tobin, 1958, and Markowitz, 1952):

$$\min \sigma^2(\rho) = \sum_{i=1}^{n} a_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j>i}}^{n} a_i a_j \operatorname{cov}(\rho_i, \rho_j)$$

$$\text{s.t.} \quad \rho = \sum_{i=1}^{n} a_i \rho_i \tag{4}$$

$$\sum_i a_i = 1 ,$$

where σ_i^2 = standard deviation of returns on currency *i*,
$\operatorname{cov}(\rho_i, \rho_j)$ = covariance of returns on currencies *i* and *j*,
a_i = weight of currency *i* in the reserve portfolio.

In the second step, we find the optimal risk-return combination for the economy at the point of tangency of the efficiency frontier, with indifference curves defined on risk and return $[EU = V(\rho, \sigma)]$. Since each

[1] In principle, this model is similar to that for an individual investor; the difference between them is the choice of objective function. The major difference between individuals and central banks is that the former also consume domestic goods.

point on the efficiency frontier represents a unique combination of currencies, the optimal portfolio composition can be found by substituting the optimal return and standard deviation into the system of equations.

A central bank aims to maximize its country's expected utility from imports, subject to the foreign-currency resources available to it. It follows that in the optimization of its foreign-currency portfolio, risk and return must be expressed in terms of the basket of imports of its country:[2]

$$\rho_i = (1 + r_i)/(1 + \pi_i) - 1 \,, \tag{5}$$

where r_i is the interest rate on currency i and π_i is the rate of change of the real effective exchange rate of currency i (P_i).

This point is of considerable importance, since the numeraire of the model influences the optimal composition of the portfolio. While the relative return expressed in different currencies is unaffected by the choice of numeraire, the same is not true for risk. For example, let us analyze the effect of fluctuations in the return caused by exchange-rate shocks. In the case of a central bank whose objective function is expressed in terms of dollars, the dollar is a riskless asset, while sterling is a risky asset. However, for the central bank that views its objective function in terms of sterling, the situation is exactly the opposite. For that bank, sterling is a riskless asset, and dollars a risky one. Clearly, the relative weight of different currencies in the two portfolios will not be identical. Our two central banks will choose identical portfolios only under two extreme assumptions: perfect positive correlation between the exchange rates of the different currencies (which is equivalent to assuming a single world currency) and perfect capital markets. Since these conditions are not fulfilled, the optimal portfolio will vary by country.[3]

The solution of the problem in import-basket terms assumes that "im-

[2] It should be emphasized that the relevant numeraire is the basket of imports by currency of invoicing and not by currency of payment. The economy obtains utility from consuming imported goods and services; therefore, the numeraire must be the price of this basket (see also Kouri and de Macedo, 1978). The currency distribution of payments affects the optimal portfolio only through conversion costs, but this has no bearing on the determination of the numeraire.

[3] This point, in relation to the optimal international portfolio for an individual investor, is discussed in Levy and Sarnat (1975) and Solnik (1973). It is also discussed in relation to optimal composition of foreign-currency reserves by Ben-Bassat (1980), where I show that it is not merely of theoretical importance but of primary empirical importance.

ports" can be defined as an aggregate commodity of imports from different countries. The assumption usually required to justify this aggregation is that either relative prices or the relative volumes of the component commodities are constant. In our case, the uncertainty of the rates of return is the core of the problem and precludes the assumption of fixed relative prices. We are left with the assumption of constant relative volumes, in our case constant currency composition of imports. Although the stronger of the two, this assumption is nevertheless reasonably realistic in the short run. The investment horizon of foreign reserves is usually short, ranging from one month to at most one year. It is unlikely that substantial changes in the composition of imports would occur as a result of exchange-rate adjustments during so short a period. In fact, for most countries the annual changes in the composition of imports were very small, with negligible effects on the distribution of returns to the various currencies when measured in import-basket terms.

The optimal weights of currencies in the reserve portfolio (a_i) can be either positive or negative. A negative value means that the central bank should borrow in that currency and invest the proceeds in a different currency. The existing data for reserves indicate that central banks limit themselves to positive balances in the various currencies (see, for example, Heller and Knight, 1978, and the IMF Annual Report, 1981). This could follow from a separation between the management of foreign-currency reserves and the management of external debt. The separation is probably due to the fact that foreign debt is largely composed of relatively long-run obligations, while the investment horizon for reserves is typically rather short. Thus, at the beginning of the investment period the size and composition of the external debt are given and not subject to meaningful change. Since this Study deals with the composition of reserves, the solution of the model presented here is also limited to positive investments in foreign currencies ($a_i \geqslant 0$).

Although the optimal composition of external debt is not solved simultaneously in the model, it does, through the objective function, influence the solution to the optimal composition of the reserve portfolio. The optimal composition of reserves is dependent upon the basket of import currencies; since imports include the servicing of the external debt, the debt's composition will play a role in the solution. The lack of data on the currency composition of the external debt and its servicing for individual countries precluded the inclusion of this factor in the empirical analysis, as is explained in Chapter 3.

3 OPTIMAL VS. ACTUAL CURRENCY COMPOSITION OF RESERVES

Using the mean-variance model and measuring risk and return in import terms, I computed efficiency curves (representing the tradeoff between risk and return) and optimal portfolios for 75 countries. I calculated the import basket of each country on the basis of its imports of goods from the 12 leading exporting countries in 1976 and 1980.[1] The latter are 12 industrialized nations whose exports constitute about two-thirds of total world trade and whose currencies are freely tradable under floating rates of exchange. It is reasonable to assume that for these countries the currency of invoicing will generally be each country's own currency. As to imports from nonindustrialized countries (whose exports account for one-third of world trade), I assumed, as the best approximation, that the relevant numeraire is the U.S. dollar, for two reasons:

1. Since these countries have fixed exchange rates, the relevant currency is the one to which they peg their exchange rates. In many cases, it is the dollar.

2. Their principal exports consist of primary goods such as petroleum and raw materials, whose prices in the world market are determined in dollar terms.

The feasible-asset set in calculating the efficiency curves consisted only of investments in the six major reserve currencies—dollars, sterling, Deutsche marks, French francs, Swiss francs, and, for 1980, Japanese yen. In the mean-variance model, the efficiency curve is computed using the distribution of returns as the investor views them *ex ante*. I assumed that the distribution of returns derived from actual returns in the past constitutes a good indicator of investors' expectations regarding the future distribution of returns. Accordingly, the distribution of returns of each of the currencies at the end of 1976 and 1980 was calculated on the basis of the *ex post* monthly rate of return during the periods 1972-76

[1] The calculation was based on imports of goods only because country data were not available on the composition of imported services by country of origin. The composition of world trade in goods and services indicates, however, that if service imports had been taken into account, they would have increased the average weight of the United States by about 2 per cent and that of the United Kingdom by approximately 1 per cent, reducing the weights of Germany and Japan accordingly. Hence, the effect of the service component on the distribution of imports was relatively very small.

and 1972-80, respectively. The monthly rate of return consists of three components: the interest rate on short-term deposits in the international money market at the beginning of the month, the rate of change during the month in the nominal effective exchange rate of the currency in relation to the import currency basket, and the average world rate of inflation. But, like many other researchers who have dealt with international investment portfolios, I used the nominal rate of return alone. That is to say, the rate of return was calculated as a function of only the first two components. Ignoring the rate of inflation is justified when the fluctuations in the returns stem mainly from unexpected fluctuations in the rates of exchange while the rate of inflation is relatively stable (see Kouri and de Macedo, 1978, p. 125). This was actually one of the outstanding characteristics of the 1970s, the period investigated here (see, for example, Dornbusch, 1980, pp. 147-148, and de Macedo, 1982, p. 79). Comparison of the distributions of nominal returns and real returns in terms of the world import basket reveals great similarity from 1972 to 1980. Table 4 below shows that the standard deviation of the nominal rate of return of the various currencies was almost identical to that of the real rate of return. The covariance matrices of the nominal and real rates of return are also very similar, although slightly less so than the variances. Thus, while using the real distribution of returns for each country would have been a more precise solution, using the nominal returns was a very good approximation, and both distributions yield very similar optimal portfolios for the period studied.

The resulting efficiency curve represents all possible optimal risk-return combinations. Each such combination is the result of a different composition of assets, all of them efficient; the choice among them should be based on investors' preferences with regard to risk and return. In the absence of information concerning the utility function of central banks, Sharp's (1964) and Lintner's (1965) market model (CAPM) was used to determine the composition of risk-bearing assets in the portfolios of central banks. According to this theory, the optimal portfolio of risky assets is determined by the point of tangency between the efficiency curve and the straight line whose intercept is the riskless rate of return. When the objective function is defined in terms of a single currency, the rate of interest on treasury bills in that currency is generally taken as the riskless-asset rate. Since, in our case, the objective function is a basket of currencies, I used the weighted average of interest rates on treasury bills in these currencies. The portfolios obtained by this procedure all represented a relatively low risk-return combination.[2]

I then weighted the optimal reserve combination of each country by its actual total foreign-currency holdings in order to obtain the aggregate optimal reserve holdings for all the countries together. In the same way, I computed optimal reserve holdings for the semi-industrialized and developing countries as one group, the snake countries as another group, and other industrial countries with floating exchange rates (floaters) as a third group. That is to say, the optimal weight of currency i in the aggregate portfolio of a group of m countries (α_i) can be computed as follows:

$$\alpha_i = \sum_{j=1}^{m} \alpha_{ij} w_j , \tag{6}$$

where $\alpha_{i\,j}$ is the proportion of currency i in the portfolio of country j and w_j is the weight of country j in the total reserves of group m.

Tables 1 and 2 compare optimal and actual currency composition of reserves for the three groups of countries mentioned above. A number of observations can be made from the results. First, the 1976 data in Table 1 show that the actual and optimal portfolios are similar for the semi-industrialized and developing countries.[3] They are not identical because risk and return, while central, are not the sole determinants of reserve composition. Institutional and other factors, such as the performance of the portfolio managers, may explain the difference.

From 1976 to 1980, the semi-industrialized and developing countries reduced the share of the dollar in their foreign-currency reserves, thereby narrowing the gap between their optimal and actual portfolios. It appears that the opposite occurred with the share of European currencies; however, the apparent widening of the gap was actually due to the disaggre-

[2] Since the computer program that generates the efficiency frontier cannot compute an infinite number of points, the exact location of the optimal portfolio is not always identified. This can cause inaccuracies of up to 2 per cent in the weight of the dollar, the principal currency in the optimal set.

[3] Note that in the work of Heller and Knight (1978), the source of the 1976 data, countries were grouped not by level of development but by type of exchange regime: 11 countries with floating rates, 6 participants in the European snake, and 52 countries with fixed exchange rates. This grouping is comparable to the level-of-development grouping employed by the IMF, which defines the first two groups as the industrialized countries.