PRINCETON STUDIES IN INTERNATIONAL FINANCE
No. 53, March 1984

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Avraham Ben-Bassat

INTERNATIONAL FINANCE SECTION
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The author of this Study, Avraham Ben-Bassat, is Deputy Director of the Bank of Israel's Research Department and lecturer in economics at Tel-Aviv University. He has also lectured at the Hebrew University, Jerusalem. This paper, one of several on the reserve portfolios of central banks, was written in part while he was on leave at Stanford University. An earlier version was presented at the Ninth Annual Meeting of the European Finance Association held in Jerusalem in September 1982.

PETER B. KENEN, *Director*
*International Finance Section*

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**Library of Congress Cataloging in Publication Data**

Ben-Basset, Avraham.
Reserve-currency diversification and the substitution account.

(Princeton studies in international finance, ISSN 0081-8070; no. 53)
Includes bibliographical references.
1. Foreign exchange. I. Title. II. Title: Substitution account.
III. Series.
HG3851.B43 1984 332.4′5 84-581
ISBN 0-88165-225-3



Printed in the United States of America by Princeton University Press at Princeton, New Jersey.

International Standard Serial Number: 0081-8070
International Standard Book Number: 0-88165-225-3
Library of Congress Catalog Card Number: 84-581

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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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I have benefited from discussions of an earlier version of this paper at the Macroeconomics Seminar at Stanford University and at the IMF Research Department Seminar. I am especially grateful to John T. Cuddington, George M. von Furstenberg, Malcolm Knight, Ronald I. McKinnon, Zvi Sussman, and the late William White for their valuable comments, and to Barry Topf for research assistance.

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

$$U = U(M_1, M_2) , \tag{1}$$

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

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

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

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,

$\rho_i$ = 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):

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

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

$$\sum_i a_i = 1 ,$$

where $\sigma_i^2$ = 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 $\pi_i$ 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 ($\alpha_i$) can be computed as follows:

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

where $\alpha_{ij}$ 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.

TABLE 1

OPTIMAL AND ACTUAL CURRENCY COMPOSITION OF RESERVES, END OF 1976

*(in per cent)*

| | Semi-Industrialized and Developing Countries | | Industrialized Countries | | | |
|---|---|---|---|---|---|---|
| | | | Snake Countries | | Floaters | |
| | Optimal | Actual [a] | Optimal | Actual [a] | Optimal | Actual [a] |
| Dollar | 58.2 | 72.2 | 48.1 | 97.7 | 69.9 | 74.2 |
| Pound sterling | 2.0 | 2.5 | 0.1 | 0.02 | 1.9 | 2.5 |
| Deutsche mark | 12.5 | 10.0 | 8.2 | 1.3 | 11.3 | 8.2 |
| Other reserve currencies | 27.4 | 15.3 | 43.6 | 1.0 | 16.9 | 15.1 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Mean return [b] | 9.5 | 8.7 | 9.6 | 7.1 | 8.7 | 8.4 |
| Standard deviation [b] | 7.8 | 6.7 | 7.9 | 16.0 | 5.0 | 4.2 |

[a] From Heller and Knight (1978), Table 4.

[b] In terms of an import-currency basket weighted by the reserves of the countries in each group. The calculations are based on portfolio composition (optimal or actual) and the expected distribution of returns in 1972-76. The exact composition of the residual "Other reserve currencies" in the actual portfolios is not available. In the computation of risk and return for the actual portfolios, the residual was distributed among the other currencies in arbitrary but identical proportions for all three groups.

gation of the grouped 1976 data for the European currencies into individual currencies in 1980.[4] The Deutsche mark, Swiss franc, French franc, and Dutch guilder had similar distributions and were highly correlated (see Tables 4, 5, and 6 below). These currencies are to a large extent substitutes for one another, and it is probable that other factors, such as their role in international commerce and their tradability, influence the size of the actual holdings. Such factors can explain the relatively larger share of the Deutsche mark in the actual portfolio than would be expected from its distribution of returns alone. If these currencies are considered as a group, we find the gap between the optimal and actual portfolios in 1980 to be only 2 per cent (28 and 26 per cent respectively). It can also be seen that from 1976 until 1980 the gap for

[4] The breakdown is explained by the data available: the figures for 1980 are based on von Furstenberg (1981), who provides a more detailed currency breakdown than do Heller and Knight for 1976. Another source of data (see Group of 30, 1982) reveals trends identical to those presented here but indicates an even greater narrowing of the gap between optimal and actual portfolios for 1980.

TABLE 2

OPTIMAL AND ACTUAL CURRENCY COMPOSITION OF RESERVES, END OF 1980

*(in per cent)*

| | Semi-Industrialized and Developing Countries | | Industrialized Countries | | | |
|---|---|---|---|---|---|---|
| | | | Snake Countries | | Floaters | |
| | Optimal | Actual [a] | Optimal | Actual [a,b] | Optimal | Actual [a] |
| Dollar | 55 | 64 | 47 | 86 | 62 | 79 |
| Pound sterling | 11 | 5 | 15 | 1 | 10 | 1 |
| Deutsche mark | 9 | 19 | 11 | 7 | 9 | 11 |
| Swiss franc | 6 | 4 | 9 | 4 | 5 | 4 |
| French franc | 13 | 2 | 17 | 0 | 12 | 0 |
| Dutch guilder | . . . | 1 | . . . | 1 | . . . | 0 |
| Japanese yen | 8 | 5 | 1 | 1 | 2 | 5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean return [c] | 9.3 | 8.9 | 9.4 | 8.0 | 9.1 | 8.5 |
| Standard deviation [c] | 5.4 | 5.0 | 5.1 | 10.8 | 5.6 | 4.5 |

[a] Estimated by adjusting first-quarter 1980 data for each group as presented in von Furstenberg (1981) by the composition of world reserves at the end of 1980 as reported by the IMF Annual Report of 1981.

[b] Value of ECUs issued against the dollar added to dollar holdings. ECUs issued against gold eliminated.

[c] In terms of an import-currency basket weighted by the reserves of the countries in each group. The calculations are based on portfolio composition (optimal or actual) and the expected distribution of returns in 1972-80.

the pound sterling increased considerably. The steep appreciation of the pound at the end of the period greatly increased its weight in the optimal portfolio. The countries studied did, in fact, adjust their portfolios to include a larger share of sterling, but not to the extent indicated by the distribution of returns. It is reasonable to assume that the central banks viewed the appreciation of sterling not as a trend but rather as a one-time adjustment to the improvement in Britain's balance of trade following the start of North Sea oil production.

The industrialized countries are considered as two separate groups (snake countries and floaters) because of the considerable differences found in their portfolio behavior. The countries belonging to the snake show an especially large gap between their actual aggregate reserve portfolio and the optimal portfolio computed for them in both 1976 and 1980.[5] In

[5] Since my concern is with the reserves of the group as a whole, I adopt the view here that ECUs issued against dollars are an investment in dollars.

fact, it appears that there is no connection between their actual holdings and the optimal portfolio—a result which bears out our hypothesis that profit and loss considerations are secondary for these countries. Even so, the snake countries did reduce the share of the dollar in their aggregate portfolio between 1976 and 1980, thereby reducing somewhat the difference between the actual and the optimal portfolios. These countries are constrained not only by considerations of international monetary stability but by mutual currency agreements. As participants in the European System of Narrower Exchange Rate Margins, they can hold working balances of other members' currencies but are prohibited from holding them as reserves. The agreements help to explain why the weight of the dollar in these countries' reserves is 40 to 50 percentage points above the optimal level.

A more surprising result is the striking similarity between the optimal and actual holdings of the other industrialized countries in 1976. Despite the interest these countries have in maintaining the stability of the international monetary system, profit and loss considerations evidently play an important role in their portfolio selections. This is apparent from an examination of the changes in their aggregate portfolio between 1970 and 1976 (see Chap. 7). Obviously, individual countries in the group may act like the snake countries in foreign-currency markets, but the lack of data for individual countries precludes clarification of this matter.

Between 1976 and 1980, the nonsnake industrialized countries increased the proportion of dollars in their portfolios, even though the shift in the distribution of returns would seem to have dictated an opposite course. I can offer no clear explanation of this change in trend, but it may in part have been related to the attitude of the floaters toward sterling. This currency was mainly responsible for the difference between the group's optimal and actual portfolios in 1980. Although sterling's share in the optimal portfolio rose appreciably between 1976 and 1980, it continued to decline in the group's actual holdings. It is reasonable to assume that, like the other groups, the floaters did not regard the improvement in the average return on sterling as a reflection of a change in trend (or indicative of future return on the pound). It should nevertheless be noted that the floaters' performance in 1980 ranked them between the group of developing and semi-industrialized countries and the snake countries—a less surprising result than that obtained for 1976 in view of the floaters' attitude toward the stability of the international monetary system. The differences between the 1976 and the 1980 findings may also reflect biases in the portfolio estimates for the various groups. It would therefore be preferable to draw conclusions on the basis of the results for both years.

Tables 1 and 2 also present the mean return and standard deviation of returns for the optimal and actual portfolios of the three groups. The results show clearly that in both years the snake countries held inefficient portfolios, with lower return and higher standard deviation than the optimal portfolio. This is not so clear with respect to the other two groups, whose portfolios had lower returns but also lower standard deviations than the optimal portfolios. Their portfolios may then have been optimal—if the central banks were more risk-averse. In order to test for optimality under the assumption of greater risk aversion, I compared mean returns on the actual portfolios with the returns obtained on the efficiency frontiers at the same standard deviation. In all cases except the floaters in 1976, a higher return could have been obtained at the same level of risk. In other words, the aggregate portfolio held by the floaters in 1976 was efficient, while their 1980 portfolio and the portfolios of the semi-industrialized countries in both years clearly were not.

## 4 FACTORS EXPLAINING THE OPTIMAL CURRENCY COMPOSITION OF RESERVES

### *Import Composition*

In the model presented here, the share of a currency in a country's optimal reserve portfolio varies directly with the currency's weight in that country's basket of import currencies; this is the result of hedging against unexpected changes in the exchange rates of import currencies. To demonstrate the importance of import composition in determining the desired portfolio of each country, I calculated the coefficient of correlation between each currency's weight in the optimal portfolio and in the import basket for a cross-section of countries. For 1976, for example, I obtained a coefficient of at least 90 per cent, significant at less than 1 per cent, for the dollar, pound sterling, Deutsche mark, and French franc (the correlation was strongest for the dollar: 0.97). No such correlation was found for the Swiss franc, whose weight was determined primarily by other factors. The results for 1980 were similar except for the mark and Swiss franc. The correlation coefficient rose in the case of the Swiss franc and declined in the case of the mark—changes primarily reflecting the high degree of substitution between the two currencies. The importance of the currency composition of imports in the actual reserve portfolio is confirmed by Heller and Knight (1978), but the method they use to examine the relationship and the way they explain its influence on portfolio selection are different.

### *Distribution of Returns*

Other factors, such as the rate of return on each currency, the variance of the returns, and the coefficient of correlation between them, also enter into the choice of portfolio. Analysis of these factors requires information on the distribution of returns in import-basket terms for each country separately. Such data were used to estimate the efficiency curves. Since it would be impractical to present all the data for each country, Table 4 presents only the returns and standard deviations for each currency during the periods 1972-76 and 1972-80 in terms of the weighted import basket of the 75 countries in the sample. (The import vectors are shown in Table 3.)

TABLE 3

WEIGHTED IMPORT VECTOR OF 75 COUNTRIES,[a] 1976 AND 1980

*(in per cent)*

| *Country of Origin* | *1976* | *1980* | *New SDR* [b] |
|---|---|---|---|
| Belgium | 3.2 | 3.6 | . . . |
| Canada | 1.5 | 1.4 | . . . |
| Denmark | 0.8 | 0.9 | . . . |
| France | 5.9 | 6.2 | 13.0 |
| Germany | 10.4 | 9.7 | 19.0 |
| Italy | 5.3 | 5.8 | . . . |
| Japan | 8.4 | 6.9 | 13.0 |
| Netherlands | 4.1 | 4.2 | . . . |
| Sweden | 1.8 | 1.8 | . . . |
| Switzerland | 1.9 | 2.1 | . . . |
| U.K. | 6.2 | 6.2 | 13.0 |
| U.S. and others [c] | 50.5 | 51.2 | 42.0 |
| Total | 100.0 | 100.0 | 100.0 |

[a] The import vector of each country was weighted by the level of its foreign-exchange reserves.

[b] Revised definition of the SDR from January 1981.

[c] Imports from the group of "other countries" are assumed to have been paid for in dollars.

SOURCES: Foreign reserves, from *International Financial Statistics*, IMF, various issues. Imports by country of origin from *Direction of Trade*, IMF, various issues.

Although these distributions do not represent the actual distribution for any individual country, they illustrate the relative returns and variances of the currencies and thereby help to clarify the results obtained for the aggregate optimal portfolios. According to Table 4, for example, in 1972-76 sterling showed a far lower rate of return than the other currencies and a fairly high standard deviation. Its weight in the efficient portfolio in 1976 was therefore significantly smaller than its weight in the import baskets of the various countries; in most cases it was not represented at all. On the other hand, the dollar and particularly the Swiss franc had a larger weight in the efficient portfolio than in the import basket. The dollar had a relatively low rate of return, but its standard deviation was the lowest of all the currencies considered, while the Swiss franc had both the highest rate of return and the highest standard deviation. Another factor determining the optimal composition was the high negative correlation between the rate of return on the dollar

TABLE 4

MEAN AND STANDARD DEVIATION OF MONTHLY RATES OF RETURN ON SELECTED CURRENCIES, 1972-76 AND 1972-80

*(in per cent, annualized)*

| | Nominal | | | | Real | |
|---|---|---|---|---|---|---|
| | *1972-76* [a] | | *1972-80* [b] | | *1972-80* [c] | |
| | *Mean* | *Standard Deviation* | *Mean* | *Standard Deviation* | *Mean* | *Standard Deviation* |
| Dollar | 7.3 | 13.4 | 7.9 | 13.3 | −3.6 | 13.5 |
| Pound sterling | 3.5 | 24.1 | 10.5 | 25.9 | −1.4 | 25.6 |
| Deutsche mark | 12.0 | 29.1 | 10.8 | 29.1 | −1.8 | 30.2 |
| Swiss franc | 13.7 | 31.6 | 11.9 | 37.5 | −0.6 | 38.8 |
| French franc | 11.0 | 28.2 | 11.3 | 26.3 | −1.3 | 28.0 |
| Dutch guilder | 12.3 | 29.0 | 11.1 | 28.0 | −1.5 | 29.0 |
| Japanese yen | 4.8 | 24.5 | 8.3 | 33.8 | −3.5 | 35.5 |
| SDR [d] | 7.4 | 3.4 | 8.5 | 3.9 | −3.5 | 7.2 |
| Inflation rate | 12.1 | 8.0 | 12.0 | 7.2 | . . | . . |

[a] In terms of the world import-weighted currency basket in 1976 (see Table 3).
[b] In terms of the world import-weighted currency basket in 1980 (see Table 3).
[c] As in footnote b, deflated by the monthly change in the World Wholesale Price Index, *International Financial Statistics Supplement* on price statistics, No. 2, 1981.
[d] Based on a simulation of the performance of an asset identical to the SDR as composed since January 1981, including exchange-rate changes and the full combined interest rate.

and the rate of return on the European currencies in both 1972-76 and 1972-80 (see Tables 5 and 6). This negative correlation significantly reduced the overall variance of returns by creating a portfolio consisting primarily of the dollar on the one hand and the European currencies on the other.

TABLE 5

CORRELATION COEFFICIENTS BETWEEN RETURNS ON SELECTED CURRENCIES, 1972-76 [a]

| | *Dollar* | *Pound Sterling* | *Deutsche Mark* | *Swiss Franc* | *French Franc* | *Japanese Yen* |
|---|---|---|---|---|---|---|
| Pound sterling | −0.278 | | | | | |
| Deutsche mark | −0.717 | 0.028 | | | | |
| Swiss franc | −0.629 | −0.036 | 0.751 | | | |
| French franc | −0.675 | 0.212 | 0.575 | 0.640 | | |
| Japanese yen | −0.527 | −0.042 | 0.162 | 0.240 | 0.133 | |
| SDR [b] | −0.069 | 0.606 | 0.233 | 0.174 | 0.366 | −0.006 |

[a] In terms of the world import-weighted currency basket in 1976 (see Table 3).
[b] See Table 4, footnote d.

TABLE 6

CORRELATION COEFFICIENTS BETWEEN RETURNS ON SELECTED CURRENCIES, 1972-80 [a]

| | *Dollar* | *Pound Sterling* | *Deutsche Mark* | *Swiss Franc* | *French Franc* | *Dutch Guilder* | *Japanese Yen* |
|---|---|---|---|---|---|---|---|
| Pound sterling | −0.336 | | | | | | |
| Deutsche mark | −0.772 | 0.124 | | | | | |
| Swiss franc | −0.730 | 0.129 | 0.787 | | | | |
| French franc | −0.746 | 0.215 | 0.676 | 0.659 | | | |
| Dutch guilder | −0.740 | 0.130 | 0.888 | 0.695 | 0.666 | | |
| Japanese yen | −0.367 | 0.076 | 0.071 | 0.204 | 0.174 | 0.047 | |
| SDR [b] | −0.081 | 0.594 | −0.019 | −0.030 | 0.126 | −0.087 | 0.339 |

[a] In terms of the world import-weighted currency basket in 1980 (see Table 3).
[b] See Table 4, footnote d.

## 5 THE EFFECT OF EXCHANGE-RATE REGIME

Heller and Knight (1978) claim that a country's exchange-rate regime exerts an important influence on the composition of its reserves. In their opinion, if a country pegs its currency to another currency it will hold more of the latter than other countries do. They cite two possible reasons: First, intervention in foreign-exchange markets is usually executed in the currency to which the exchange rate is pegged, a reasonable proposition. Second, holding the currency to which the exchange rate is pegged will reduce exchange-rate risk. The implication of the second argument is that the correct numeraire for measuring risk and return of a central bank's portfolio is the currency to which its own currency is pegged. From a strictly accounting standpoint, this argument might be justified. The economically correct numeraire, however, is not the currency to which a currency is formally pegged (although that can influence the composition of the portfolio) but rather the currency of invoicing of the goods that the country consumes.

The actual effect of the type of exchange-rate regime on the composition of reserves can be evaluated by applying the model presented here. Within the mean-variance framework, the type of regime could influence portfolio decisions of the central banks (other than floaters) by affecting the relative returns and variance through the terms in which they are expressed. Table 7 compares the actual portfolio for 1976 with the optimal portfolio defined in two ways: in terms of the currency to which the country pegs and in terms of its import basket.[1] For dollar peggers, the actual weight of the dollar (85 per cent) was less than in the optimal portfolio expressed in dollar terms (97 per cent) but greater than in the optimal portfolio expressed in import-basket terms (60 per cent). Thus, the share of the dollar in the reserves of dollar peggers was affected by the choice of exchange-rate regime as well as by the composition of imports.

In the group of sterling peggers, however, it appears that the pegging of their currency did not affect the share of sterling in their reserves. In 1976, their sterling holdings were 58 percentage points lower than in

[1] The effect of the exchange-rate regime is examined only for 1976 because data on reserve composition by exchange-rate regime are not available for subsequent years.

TABLE 7

OPTIMAL CURRENCY COMPOSITION OF RESERVES FROM DIFFERENT VIEWPOINTS, AND ACTUAL COMPOSITION, END OF 1976

*(in per cent)*

| | *Dollar Peggers* | | | *Sterling Peggers* | | | *Basket Peggers* | |
|---|---|---|---|---|---|---|---|---|
| | *Optimal in Dollar Terms* | *Optimal in Import Terms* | *Actual* [a] | *Optimal in Sterling Terms* | *Optimal in Import Terms* | *Actual* [a] | *Optimal in Import Terms* | *Actual* [a] |
| Dollar | 96.9 | 59.6 | 84.6 | 5.7 | 35.8 | 41.5 | 55.1 | 63.1 |
| Pound sterling | — | 1.0 | 1.4 | 79.8 | 42.6 | 21.7 | 0.3 | 1.7 |
| Deutsche mark | 0.2 | 10.9 | 5.2 | 1.4 | 9.0 | 20.5 | 15.4 | 13.6 |
| Other reserve currencies | 2.9 | 28.6 | 8.9 | 13.1 | 12.6 | 16.4 | 29.2 | 21.6 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[a] From Heller and Knight (1978), Table 4.

the optimal portfolio in sterling terms and indeed lower than called for by the optimal portfolio expressed in import-basket terms. Overall, it appears that actual reserves were more similar to the optimal portfolio in import-basket terms. But these results should be interpreted with caution, since the sample contains only four countries in this category, one of which is dominant.

For the third group, basket peggers, I assume that their currencies are linked to their import-weighted baskets, and therefore only one optimal portfolio is presented for them in Table 7. The optimal and actual portfolios for this group were very close, and the similarity between them was greater than for all nonfloating groups. Heller (1978) finds that basket peggers are characterized by more openness in their economies than other peggers (as evidenced by high import-GNP ratios). It might be reasonable to assume, therefore, that the very experience with and sensitivity to exchange-rate fluctuations that led them to adopt the import-basket concept in their exchange-rate regime exerted greater influence on their reserve-portfolio selection than for other pegging countries. This could explain why the similarity between optimal and actual portfolios was closer for this group than for the other peggers.

# 6 THE WEALTH-DISTRIBUTION EFFECT

We have seen that the optimal composition of foreign-exchange reserves is a function of both the composition of each country's imports and the distribution of returns on the various currencies. When the aggregate reserves of all the countries are considered, however, the optimal composition of world foreign-currency reserves can change, even without any change in the objective function or in the distribution of returns, as a result of changes in the distribution of total world reserves among countries.

Since the optimal composition of a country's reserves is a function of the composition of its import basket, and since each country's import basket is unique, its optimal reserve portfolio will also be unique. The movement of reserves between countries, or even the accumulation of reserves at different rates by different countries, will thus change the optimal composition of overall world reserves. This can be seen from equation (6) above. Changes in $\alpha_i$, the optimal weight of currency $i$ in total world reserves, may result from changes in $w_j$, the weight of country $j$ in total reserves, even when $\alpha_{ij}$ remains constant. This argument is analogous in some respects to Grubel's (1968) contention that capital movements between countries can begin even without a change in relative interest rates, as a result of differences in rates of growth in national income and wealth or of differences in initial capital.

In an attempt to measure the practical significance of this phenomenon, I examined the effect of variations in the intercountry distribution of world reserves from 1972 to 1980 on the overall optimal reserve portfolio for those years, assuming no change in the distribution of returns. During this period, the energy crisis caused major shifts in the distribution of reserves among countries. For example, from 1972 to 1976, the reserves of the oil-exporting countries grew almost sixfold and those of developing countries in Asia and South America by 83 per cent, while those of the industrialized countries grew by only 16 per cent. In 1976-80, there were further significant variations, and even a change in trend: reserves grew fastest in the industrialized countries and most slowly in the oil-exporting group.

The optimal portfolio for each country was computed on the basis of the distribution of foreign-currency returns from 1972 to 1980 (see Chapter 3). The optimal composition of world reserves at the end of 1980 was then calculated by weighting the optimal portfolio of each country by its reserves in 1972, 1976, 1980. Table 8 demonstrates that the shift in the intercountry distribution of reserves from 1972 to 1980 could by itself reduce the weight of the dollar in the optimal world currency portfolio by 8 percentage points.

TABLE 8

THE WEALTH-DISTRIBUTION EFFECT ON THE OPTIMAL CURRENCY COMPOSITION OF RESERVES FOR 75 COUNTRIES, END OF 1980

*(in per cent)*

| | *Optimal Composition, 1980* [a] | | |
|---|---|---|---|
| | *1972 Weights* | *1976 Weights* | *1980 Weights* |
| Dollar | 61 | 57 | 53 |
| Pound sterling | 11 | 11 | 13 |
| Deutsche mark | 6 | 7 | 9 |
| Swiss franc | 7 | 6 | 7 |
| French franc | 12 | 14 | 15 |
| Japanese yen | 3 | 5 | 4 |
| Total | 100 | 100 | 100 |

[a] The optimal reserve composition of each country in 1980 weighted by its foreign-exchange reserves in 1972, 1976, and 1980.

The importance of changes in the intercountry distribution of reserves is not restricted to optimal portfolios. The data on actual portfolios also show significant intercountry variance in reserve composition. Thus a change in the intercountry distribution of reserves can lead to a change in the composition of the world currency portfolio.

# 7 THE ADJUSTMENT PROCESS

Several other factors that were not accounted for in the mean-variance portfolio model help to explain the gap between the optimal and actual composition of international reserves. For example, currency agreements, foreign-exchange regimes, and other institutional factors undoubtedly influence the composition of reserve portfolios. Since these factors are fairly stable over time, however, they can explain differences in reserve composition among countries but not changes over time. But it is precisely the changes in reserve composition over time that are of vital importance to international monetary stability. These changes are mainly caused by variations in exchange rates and interest rates.

The shift from fixed to floating exchange rates and the resulting changes in the distribution of returns set in motion an adjustment process that apparently has not yet been completed. Thus, it would seem that the observed gap between optimal and actual portfolio composition is partly explained by the dynamic nature of portfolio selection. While the adjustment process is the subject of much current research and a rigorous analysis is not yet feasible, a survey of data on central banks for the period 1970-80 could elucidate some important points. Accordingly, I first analyze the changes that occurred in the central banks' portfolios between 1970 and 1976, and then examine developments between 1976 and 1980.

The aggregate portfolios for all central banks show only slight changes from 1970 to 1976 in response to shifts in the distribution of returns (see Table 9). But changes in the different groups of central banks were sometimes in opposite directions, and aggregation of the data hides these changes. When the aggregate portfolios are decomposed into data for smaller groups, significant variations are revealed.

One of the principal developments in the international money market in the 1970s was the weakening of the dollar and the pound sterling, and there was a general tendency to adjust the share of these currencies in most of the groups' portfolios. The deviant behavior of the snake countries is attributable to the currency agreement they are party to, which severely limits their ability to hold European currencies as reserves. The other groups, even if resisting market trends in the short run, apparently

TABLE 9

ACTUAL CURRENCY COMPOSITION OF RESERVES BY EXCHANGE-RATE REGIME, END OF 1972, 1976, AND 1980

*(in per cent)*

| | *Semi-Industrialized and Developing Countries* | | | | *Industrialized Countries* | | |
|---|---|---|---|---|---|---|---|
| | *Dollar Peggers* | *Sterling Peggers* | *Basket Peggers* | *All Peggers* | *Snake Countries* | *Floaters* | *Total* |
| 1970: [a] | | | | | | | |
| Dollar | 86.3 | 17.4 | 45.6 | 59.3 | 91.7 | 90.3 | 81.8 |
| Pound sterling | 6.3 | 72.1 | 37.5 | 27.7 | 0.1 | 2.0 | 8.8 |
| Deutsche mark | 0.8 | 0.2 | 3.2 | 2.3 | 0.3 | 3.2 | 1.9 |
| Others | 6.5 | 10.2 | 13.6 | 10.7 | 7.9 | 4.5 | 7.4 |
| 1976: [a] | | | | | | | |
| Dollar | 84.6 | 41.5 | 63.1 | 71.9 | 97.7 | 74.2 | 80.8 |
| Pound sterling | 1.4 | 21.7 | 1.7 | 2.7 | . . . | 2.5 | 1.7 |
| Deutsche mark | 5.2 | 20.5 | 13.6 | 10.0 | 1.3 | 8.2 | 6.7 |
| Others | 8.9 | 16.4 | 21.6 | 15.4 | 1.0 | 15.1 | 10.8 |
| 1980: [b] | | | | | | | |
| Dollar | | | | 64.0 | 86.0 | 79.0 | 74.7 |
| Pound sterling | | | | 5.0 | 1.0 | 1.0 | 2.8 |
| Deutsche mark | | | | 19.0 | 7.0 | 11.0 | 13.2 |
| Others | | | | 12.0 | 6.0 | 9.0 | 9.3 |

[a] SOURCE: Heller and Knight (1978), Table 4.

[b] See Table 2, footnotes a and b. From 1977 on, no classification of the data by exchange-rate regime was published, and so only aggregate analysis was possible.

adjusted their portfolios to trends in market returns in the long run. Both the floaters and the dollar peggers substituted the Deutsche mark and other European currencies for the dollar and sterling. The reaction of sterling and basket peggers was more complex, however. At the beginning of the period, sterling represented a high proportion of their reserves (72 and 38 per cent respectively). In response to the steep downward trend of sterling against other currencies, including the dollar, central banks of these groups sharply reduced its weight in their portfolios. Sterling was replaced by other reserve currencies, including the dollar (although the weight of the dollar grew at a relatively slower rate). The rise of the dollar in these countries' portfolios was a consequence of its complementarity to the pound sterling and the Deutsche mark (and to all other European currencies). The rate of return on the dollar was negatively correlated with the rates of return on all the European currencies, especially the Deutsche mark (−0.72; see Table 5 above).[1] Thus, substitution in a portfolio that was based mainly on sterling should have been made through the mark and the dollar, despite the relatively lower return on the dollar, because combining the two currencies reduced the total risk.

It should be noted that from 1968 to 1974 the decline in the share of sterling was tempered somewhat by the Basel agreements between the Bank of England and other sterling-area central banks (see Bank of England, 1974, pp. 169-171, and Tew, 1977, pp. 136-138). According to these agreements, the Bank of England guaranteed an agreed dollar value for the sterling reserves of central banks if the banks maintained a given level of reserves in sterling. These agreements were renewed periodically, and new levels were set for the dollar value and the minimum share of sterling reserves in each bank's portfolio. The last of these agreements expired in 1974; since then, the level of sterling reserves has been influenced by market factors only.

The adjustment out of sterling probably came to an end by the beginning of 1977, after the pound had undergone a drastic and continuous depreciation from 1970 to 1976 that almost excluded it from central banks' portfolios. At that point, the dollar could benefit very little from a further reduction in sterling. Moreover, the beginning of oil production from the North Sea in 1977 reversed the trend of the sterling exchange rate, while, for various reasons, the dollar continued to depreciate. From that point on, the dollar's share in total reserves declined much more rapidly than in the first half of the decade. From the end of 1976 to the end of 1980, it fell by 6 percentage points (see Table 9). A survey of this period reveals also that the developing and semi-industrialized countries continued to adjust their portfolios faster than the industrialized countries. The weight of the dollar declined during this period by 8 percentage points in the former group but by only 3 points in the industrialized countries. It is interesting to note that between 1976 and 1980 the snake countries began to reduce the share of their dollar holdings, in contrast to the increase in other industrialized nations (see Table 9 and footnote 5 in Chapter 3).

[1] The correlation coefficients were calculated in terms of the world import-currency basket. The same ranking is obtained for other numeraires, but the values of the coefficients are different.

# 8 APPLYING THE MODEL TO THE SUBSTITUTION-ACCOUNT PROPOSAL

The quantitative data in Table 2 above support an assumption basic to the substitution-account proposal, namely that a gap exists between the optimal and actual composition of foreign-currency reserves, and the crux of the problem is the weight of the dollar in reserve portfolios. Once it has been decided in principle to set up a substitution account, a number of questions still remain, some of which can be answered by the model and findings described in this Study. The conclusions presented here are not final policy recommendations, because the creation of a substitution account would require up-to-date information and further research, especially with respect to the composition of reserves in individual countries. These data are confidential, so that such an analysis can be undertaken only by the IMF. Nevertheless, I can illustrate the usefulness for substitution-account planning of the model presented here and of the analysis of actual central-bank behavior.

*Optimal Size of the Substitution Account*

One of the major problems faced by planners of the substitution account was the determination of its optimal size. The principal proposal calls for allowing deposits up to a maximum of SDR 50 billion, although there was also support for limiting them to SDR 35 billion.

The findings presented in Table 2 above make possible a preliminary estimate of the demand for participation in the substitution account under prevailing conditions in the foreign-currency market. The drop in demand for the dollar can be estimated by multiplying the difference (in percentage points) between the optimal and the actual weights of the dollar in total reserves by the total amount of reserves. If $\alpha_{ij}^*$ represents the optimal weight of currency $i$ in the reserve portfolio of group $j$, and $\alpha_{ij}$ the actual weight of currency $i$ in the reserve portfolio of group $j$, then the change in demand by group $j$ for currency $i$ is given by

$$\Delta D_{ij} = (\alpha_{ij}^* - \alpha_{ij})R_j \,. \tag{7}$$

Table 10 presents estimates of the decline in demand for the dollar that would result if all countries in the sample moved from their actual

TABLE 10

EXPECTED DECLINE IN DEMAND FOR DOLLARS, END OF 1980 [a]

| | Semi-Industrialized and Developing Countries | Industrialized Countries | | Total |
|---|---|---|---|---|
| | | Snake Countries | Floaters | |
| Total foreign exchange (billions of SDRs) | 114.50 | 88.70 | 61.10 | 264.30 |
| Optimal dollar proportion [b] | 55% | 47% | 62% | |
| Actual dollar proportion [b] | 64% | 86% | 79% | |
| Potential decline in demand for dollars (billions of SDRs) | 10.30 | 34.60 | 10.40 | 55.30 |

[a] For the 75 countries in the sample, representing 90 per cent of total world reserves.
[b] See Table 2.

to their optimal 1980 portfolios. The potential reduction in demand for the dollar is shown to be approximately SDR 55 billion, assuming that the distribution of returns of the various currencies remained unchanged.[1]

Note that, by definition, a decline in demand for dollars of SDR 55 billion implies an equivalent rise in demand for other currencies, although not necessarily for the SDR-denominated asset offered by the substitution account. Since the SDR is itself a basket that includes the dollar, a portfolio adjustment involving a shift from the dollar to the SDR would presumably be larger than an adjustment not involving the SDR. To determine the potential demand for the SDR, its properties as a proposed investment must be defined and then included as a feasible asset in the model. I assumed that the asset to be offered was identical in composition to the SDR as it was defined in January 1981 (the basket of five currencies shown in Table 3 above) and would pay the full combined market interest rate on these currencies. To evaluate the SDR's investment performance, I computed changes between 1972 and 1980 in the exchange rate of the SDR in relation to the weighted world import basket, as well as the full combined interest rate. Table 4 above shows a standard deviation of returns on the SDR of 3.9 per cent. It is lower

[1] If the data on actual reserve composition reported by the Group of 30 (1982) are used, the gap between optimal and actual holdings is smaller. Nevertheless, the potential decline in demand for the dollar is still a sizable SDR 42 billion.

than that of any individual currency because the SDR is a diversified investment whose composition is correlated with the proportions of the five main currencies in the weighted world import vector. The mean return on the SDR was 8.5 per cent, which was lower than for any other currency except the dollar.

The rate of return on the SDR as defined above deviates from an exact linear combination of the returns on the five currencies that comprise the SDR, partly because of differences in interest rates. The calculation of the returns on each of the feasible currencies used Euromarket interest rates, while the rates for the five-currency SDR basket are the national interest rates now used by the IMF to calculate the interest rate of the SDR (see also von Furstenberg, 1981). The national interest rates differ from the Euromarket rates.

If the asset introduced is an exact linear combination, it will not be necessary to re-estimate the model. The maximum demand of central banks for the SDR can be calculated by using the weight of the dollar in the SDR, as long as the conversion does not produce negative weights for any of the other currencies. Since the weight of the dollar in the SDR is 42 per cent and the gap between its optimal and actual weight is SDR 55 billion (see Table 10), to eliminate the excess supply of dollars it would be necessary to convert dollars into SDRs in the amount of SDR 95 billion: 55/(1 − 0.42). After this change, the SDR would constitute about 36 per cent of the portfolio of all the central banks taken together.

If the definition of the SDR described above is used instead of the exact linear combination of returns, the efficiency curve and the optimal portfolio for all central banks taken together will have to be recalculated with the SDR included in the feasible asset set. Including the SDR in the model will change the optimal portfolio: the SDR will account for only 18 per cent of the portfolio, and demand for it will amount to SDR 48 billion. Converting 18 per cent of the actual portfolio from dollars into SDRs will close only half the gap between the optimal and actual weights of the dollar in the portfolio, since the SDR has a dollar component of 42 per cent.

It will thus be seen that the proposal to convert dollars into SDRs could reduce or even completely close the gap between the optimal and actual weight of the dollar. But since the SDR is an arbitrary combination of the feasible currencies and differs from the optimal portfolio combination, the introduction of the SDR cannot close the gaps between the optimal and actual weights of all the other currencies. In fact, it even somewhat widens the gap in some of the currencies.

The goal of the substitution account is to enable central banks to adjust their portfolios outside the market mechanism in order to avoid the risk inherent in wider fluctuations in exchange rates and to speed up the adjustment process. Nevertheless, the substitution account should limit conversion of dollars to SDRs to the volume that would have been converted through the market. Any attempt by a large number of countries to change the currency composition of their portfolios via the market would probably change current and expected exchange rates and balance-of-payments accounts, so that the actual flight from the dollar would be less than the initial excess demand. Therefore, the substitution account should be smaller than the total demand of the central banks.

The model used here to measure demand for different currencies is appropriate to a single relatively small country whose distribution of returns is determined exogenously. In order to estimate the appropriate size of the substitution account more accurately, it would be necessary to build a model that described the market mechanism as a whole. Such a model would need to include both the supply of foreign currencies and the relationship between the distribution of their returns and changes in the demand for them (by both central banks and the private sector). It could be used to determine the dimensions of the problem more precisely. Note, however, that the model employed here provides an upper bound for the move from the dollar to other currencies.

*Beneficiaries of the Substitution Account*

Another important problem that arose in planning the substitution account was to determine who would cover the capital losses and who would benefit from any capital gains that might be earned. Kenen (1981) mentions that the main obstacle to reaching an agreement on the substitution account by the Interim Committee, when it met in Hamburg in April 1980, was the question of capital value, also known as the question of financial balance. Kenen estimated the magnitude of the problem by simulation, assuming that the substitution account was introduced in 1964 and discontinued in 1978. He showed that depositors in the account derived a positive net benefit in comparison with investment of reserves in dollars. He assumed that the United States would bear this cost alone, while the Interim Committee at its Belgrade meeting proposed that costs and benefits be fairly shared by all parties concerned.

It is difficult to evaluate the relative benefits that would accrue to participants in the substitution account, as it is envisioned today. A dynamic model is needed in order to describe the market mechanism and the market solution, that is, the currency composition that would result from the attempt of the various countries to adjust their portfolios via the market. Furthermore, information is needed about the actual composition of reserves held by each country. Each country's attitude toward profit and loss, and thus the potential benefit to it inherent in the proposal, can be evaluated only by comparing optimal and actual portfolios at the country level. It is possible, however, to give a preliminary answer on an aggregate level as to the relative benefit that would accrue to the industrialized countries as opposed to the rest of the world. I have investigated the relative benefit that would be derived from the substitution account by each of the groups, using as a measure the gap between the weight of the dollar in the optimal and the actual portfolios. This method estimates the improvement in performance not only by the rate of return but also by the degree of risk, since the optimal portfolio is determined by a combination of these two variables.

In terms of portfolio performance, the industrialized countries would be the principal beneficiaries of the substitution account. As can be seen in Table 10 above, the snake countries would show the greatest improvement in risk-return performance. There are two reasons. First, the gap between the optimal and actual weights of the dollar is largest in their portfolios. Second, the average level of reserves per country is much higher in this group than for the semi-industrialized and developing countries.

In light of the agreement prohibiting snake members from holding more than working balances of other members' currencies, would they realize these potential profits by participating in the substitution account? The degree of participation in such an account depends on a number of factors in addition to risk-return performance, especially its liquidity characteristics. An SDR-denominated asset will be more attractive if it serves as a means of payment between monetary authorities and, most important, if it is widely used in the private sector (see Group of 30, 1980, and Kenen, 1983).

The degree to which the ECU is used by the European Monetary

System (EMS) can be instructive in this regard. While the EMS is more limited in scope and the ECU has a different currency composition, the idea behind the EMS is similar to that behind the substitution account. From the inception of the EMS in March 1979 until the end of 1980, EMS countries converted SDR 10 billion from dollars to ECUs, thereby reducing the dollar component of their foreign-exchange portfolio by 12 percentage points. (The conversion of gold into ECUs was even greater.) If the proposed asset has liquidity characteristics similar to those of the ECU, it is reasonable to assume that it will be preferred by the snake countries. First, as a global agreement, the substitution account will have a much more stabilizing effect on exchange rates than any limited regional arrangement. Since such stability is the account's primary goal, the countries most interested in international monetary stability could be expected to join. In addition, the proposed SDR-denominated asset would undoubtedly be used more widely than the ECU, thereby providing greater liquidity. With the improved performance of their portfolios resulting from participation in the substitution account, the snake countries could be expected to relax the current limitations on holding other members' currencies in their reserve portfolios.

The other industrialized countries—the floaters—would also benefit considerably from the proposed fund, although to a lesser extent than the snake countries. But the developing and semi-industrialized countries would have little interest in the proposed substitution account. These differences are reflected in the reduction of the potential demand for the dollar per country in the sample—by SDR 4.94 billion for the snake countries, by SDR 1.3 billion for the other industrialized countries, and by only SDR 170 million for the semi-industrialized and developing group. It should be borne in mind that there is considerable variance within the groups and further research on an individual country level is required.

Von Furstenberg (1981) examined the problem from a different angle, and his findings support this conclusion. He compared the performance of the actual portfolios held at the beginning of 1980 by the various groups of countries with an investment in new SDRs, on the assumption that the return on each of the currencies was determined by changes in exchange and interest rates from 1973 to 1980. He found that for the snake and other industrialized countries returns on the actual portfolios fell short of what might have been earned on new SDRs by approximately 10 per cent of their total reserve holdings, while the developing and semi-industrialized countries had negligible shortfalls.

No less important than the financial costs and benefits, and perhaps even more important, as Kenen claims (1981, p. 425), would be the stabilizing influence of the substitution account on the international monetary system. The principal beneficiaries would again be the industrialized countries, since they have a much greater interest in international monetary stability than has the rest of the world.

## 9 CONCLUSIONS

This study focuses primarily on the gap that exists between the optimal and actual reserve portfolios of different groups of countries classified by level of development and type of exchange-rate regime. My hypothesis that risk and return considerations are relatively weak in the reserve-portfolio management of the industrialized countries was found to be most applicable to members of the snake group. In this group, there was almost no observed relationship between their actual holdings and their optimal portfolios in 1976 and 1980. By contrast, in the other industrialized countries there was great similarity between optimal and actual portfolios in 1976, although in 1980 the gap between them widened somewhat. Nevertheless, the portfolio performance of the floaters remained far superior to that of the snake countries. In the group of developing and semi-industrialized nations, there was a relatively high degree of similarity between the optimal and actual portfolios in 1976, and the similarity was even closer in 1980. It was especially close for countries that peg their exchange rate to a basket of currencies, and much less so for countries that peg their exchange rate to the dollar or sterling. For the dollar peggers, this finding is partly explained by the type of exchange-rate regime. Remaining differences between optimal and actual portfolios for the various groups may have been the result of differences between the *ex ante* distribution of returns as viewed by central banks and as implied by the model presented here.

It was also shown that considerable changes in aggregate demand for various currencies could occur even without changes in the distribution of returns or in the objective function. Since each country has a different optimal portfolio, a shift in the world distribution of reserves among countries is sufficient to cause a change in the aggregate demand for each currency.

The model developed in this study and the findings about central-bank behavior were used to analyze a number of questions arising from the IMF's proposal to establish a substitution account—a proposal intended to reduce speculative movements in the exchange rates of major currencies by substituting SDRs for a large proportion of the dollar reserves. Solutions to some of the problems were suggested. Comparison of the optimal and actual portfolios for the three groups of countries examined made it possible to estimate the potential demand for the substitution account and to evaluate the relative benefits that would accrue to each of the groups. In view of the gap between optimal portfolios and actual holdings at the end of 1980, the substitution account should be smaller than the central banks' aggregate demand, which presumably would amount to either SDR 48 or 95 billion, depending on how the SDR was defined. The findings indicate that the demand for participation in the substitution account would come primarily from the industrialized countries, especially the snake group. The industrialized countries would be the principal beneficiaries of the plan for two reasons: they have a greater interest in the stability of the international monetary system than do the semi-industrialized and developing countries, and the proposal would enable them to make significant improvements in the risk and return performance of their reserve portfolios.

A number of other important questions require further research. Especially in need of investigation are the stabilizing role of central banks, optimal vs. actual portfolio composition for individual countries, and the dynamics of foreign-exchange markets.

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ISBN 0-88165-225-3