ESSAYS IN INTERNATIONAL FINANCE

No. 131, December 1978

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RESERVE-CURRENCY PREFERENCES

OF CENTRAL BANKS

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H. ROBERT HELLER

AND

MALCOLM KNIGHT

H. Robert Heller is Vice President for International Economics at Bank of America's San Francisco World Headquarters. Prior to that, he was Chief of the Financial Studies Division of the International Monetary Fund in Washington. He is the author of numerous articles in economic journals and of several books, including International Monetary Economics, International Trade: Theory and Empirical Evidence, and The Economic System. Malcolm Knight has served on the faculties of the University of Toronto and the London School of Economics and Political Science. Since joining the International Monetary Fund in 1975, he has been engaged in economic research in the Financial Studies Division. He has written articles in the fields of macroeconomics and international finance.

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INTERNATIONAL FINANCE SECTION

CONTENTS

Introduction

Although foreign-exchange holdings constitute the major component of international reserves, there has been little analysis of the determinants of the currency composition of these holdings either for individual countries or for the world as a whole. The reason is easy to explain: while central banks regularly publish data on the aggregate amount of their foreign-exchange holdings, little information is available regarding the currency composition of their portfolios. The well-known studies of Kenen (1963), Hagemann (1969), and Makin (1971) examined the behavior of central banks with respect to the broader choice between gold, foreign exchange, and IMF assets, but data limitations prevented them from undertaking a detailed examination of the components of currency reserves. Furthermore, these studies were made in the institutional setting of a par value system and their relevance to current international monetary arrangements may therefore be somewhat limited.

The analysis of official foreign-exchange reserves in this essay is based on a set of data supplied to the International Monetary Fund on a regular basis by a large number of central monetary institutions. Certain general conclusions are drawn regarding the reserve-currency preferences of central banks, but care has been taken not to disclose the currency composition of the reserve portfolio held by any individual country.

A wide variety of factors is likely to influence a central bank's decisions about the total size of its international reserve holdings, the proportion of these reserves to be held in the form of foreign exchange, and the particular reserve currencies and other assets to include in its foreign-exchange portfolio. In addition to the economic considerations of safety, liquidity, risk aversion, and yield, political and institutional factors are likely to influence these decisions. In particular, international monetary arrangements are apt to play an important role. The adoption of more flexible exchange rates by a large number of countries, including virtually all nations whose currencies are held as foreign-exchange reserves, introduces a new source of variation in the relative values of international reserve assets, owing to more frequent exchange-rate changes. Thus it is hardly surprising that reserve-asset management has become more important for central bankers since the abandonment of the par value system.

1

And because the global stock of foreign-exchange reserves and its distribution among different currencies are the result of the decisions of individual central banks, reflecting intervention and portfolio policies, the reserve-asset preferences of these banks are important for the system as a whole.

This essay traces recent trends in the foreign-exchange composition of central banks' portfolios and analyzes the effect of exchange arrangements on official holdings of various currencies. It explores the determinants of the demand by central banks for individual reserve currencies, and it examines the special factors influencing their Eurodollar holdings.

Trends in Central-Bank Holdings of Foreign-Exchange Reserves

Before analyzing the determinants of currency reserves, it is useful to review recent trends in the foreign-exchange holdings of central banks. Table 1 presents the currency composition of foreign-exchange reserves held by the 76 countries included in our sample. (These data comprise a moving sample in the sense that they include some countries that did not report on all the dates indicated.) Total foreign-exchange holdings of the 76 countries increased from $35 billion at the end of 1970 to a peak of $116 billion at the end of 1976. These data can be compared with total foreign-exchange holdings by all countries, as reported in the IMF's *International Financial Statistics*, which amounted to $45 billion at the end of 1970 and to $176 billion at the end of 1976. Thus, 77 per cent of all foreign-exchange reserves were covered by our sample at the beginning of the period under study, and about 66 per cent at the end. The major reason for this decline in coverage is that several important OPEC countries are not included in our sample.

The dollar and sterling holdings of these 76 countries can be compared with the total liabilities to foreign official institutions, as reported by the United States and the United Kingdom. Table 2 shows that the total dollar holdings reported by the 76 countries are larger than the liabilities reported by the United States on all dates. In the case of the United Kingdom, the reporting countries show larger totals than the U.K. authorities up to 1974, but the tendency has been reversed since 1975. These divergences are due to two factors. On the one hand, the 76 reporting countries exclude some important holders of foreign-exchange reserves, as is evident from the comparison of the totals for the sample countries and the totals for all IMF member countries included in *International*

2

TABLE 1

CURRENCY COMPOSITION OF FOREIGN-EXCHANGE RESERVES,
76 REPORTING COUNTRIES, 1970-76

End of	Total	U.S. $[a]	£	DM	Francs	Other Reserve Currencies[b]	Other Assets[c]
In Billions of Dollars							
1970	$ 35.2	$28.7	$3.0	$0.7	$0.0	$ 1.9	$0.8
1971	66.4	52.1	5.0	2.0	0.3	4.1	3.0
1972	83.0	67.8	5.2	3.8	0.5	5.2	0.5
1973	95.1	75.8	4.7	6.2	0.6	7.5	0.3
1974	114.6	92.5	6.2	6.6	0.6	8.4	0.2
1975	106.7	85.6	3.6	6.7	1.1	9.2	0.5
1976	116.4	94.0	2.0	7.8	0.8	11.2	0.7
In Per Cent							
1970	100	81.5	8.6	2.1	0.1	5.5	2.2
1971	100	78.4	7.5	3.0	0.4	6.2	4.5
1972	100	81.7	6.3	4.6	0.5	6.3	0.6
1973	100	79.7	5.0	6.5	0.7	7.8	0.3
1974	100	80.7	5.4	5.8	0.5	7.3	0.2
1975	100	80.2	3.3	6.3	1.1	8.7	0.5
1976	100	80.8	1.7	6.7	0.7	9.6	0.6

[a] All dollar-denominated assets held by central monetary authorities of the 76 countries are included here, *whether or not they are liabilities of the United States.* In particular, this item includes all U.S. Treasury securities, whether marketable or nonmarketable, claims on other U.S. residents, IBRD and IDB dollar bonds or notes, dollar claims on the Bank for International Settlements, and other (e.g., Eurodollar) claims.

[b] The most important of these are Swiss francs, Japanese yen, and Dutch guilders, but full coverage is not available.

[c] The bulk of this item consists of U.S. Treasury securities issued to certain central banks in the late 1960s and denominated in the currency of the holder (Roosa bonds). As the table indicates, these assets reached their peak in 1971 and remained small thereafter. However, the item also includes small amounts of assets held by regional clearing unions, whatever their currency of denomination, and a very small residual error due to reporting anomalies.

Financial Statistics. On the other hand, the liabilities reported by each reserve center exclude official holdings of that country's currency in the offshore currency markets.

The data presented in Table 1 include certain countries that did not report their foreign-exchange holdings on all reporting dates. To make a more accurate comparison of time trends that is unmarred by changes in the composition of the sample, Table 3 presents the foreign-exchange holdings of the 53 central banks that reported to the IMF on all year-end

TABLE 2

DOLLAR AND STERLING FOREIGN-EXCHANGE RESERVES FOR 76 COUNTRIES AND U.S. AND U.K. LIABILITIES

(in billions of dollars)

End of	U.S. $		Pound	
	76 Reporting Countries	Liabilities Reported by U.S.	76 Reporting Countries	Liabilities Reported by U.K.
1970	28.7	23.8	3.0	2.5
1971	52.1	51.2	5.0	3.2
1972	67.8	61.5	5.2	3.6
1973	75.8	66.8	4.7	3.7
1974	92.5	76.8	6.2	4.6
1975	85.6	80.7	3.6	4.1
1976	94.0	91.9	2.0	2.6

SOURCES: Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin*; U.K. Central Statistical Office, *Financial Statistics*; and IMF.

TABLE 3

CURRENCY COMPOSITION OF FOREIGN-EXCHANGE RESERVES, CONSTANT SAMPLE OF 53 COUNTRIES, 1970-76*

End of	Total	U.S. $[a]	£	DM	Francs	Other Reserve Currencies[b]	Other Assets[c]
In Billions of U.S. Dollars							
1970	$ 33.4	$27.1	$3.0	$0.7	$0.0	$ 1.8	$0.7
1971	62.1	48.2	4.9	1.9	0.1	4.0	3.0
1972	76.4	61.9	5.0	3.6	0.3	5.1	0.5
1973	88.9	70.9	4.3	5.8	0.4	7.2	0.2
1974	106.3	85.9	5.7	6.0	0.4	8.1	0.2
1975	102.6	82.9	3.3	6.2	0.9	8.9	0.4
1976	109.6	89.3	1.7	7.2	0.6	10.5	0.3
In Per Cent							
1970	100	81.3	9.0	2.1	—	5.4	2.2
1971	100	77.6	7.9	3.1	0.2	6.5	4.8
1972	100	81.0	6.6	4.8	0.4	6.7	0.6
1973	100	79.7	4.9	6.5	0.5	8.1	0.3
1974	100	80.8	5.4	5.7	0.4	7.6	0.2
1975	100	80.8	3.2	6.1	0.9	8.6	0.4
1976	100	81.5	1.6	6.6	0.5	9.5	0.3

* For notes see Table 1.

dates between December 1970 and December 1976. The close correspondence between the totals in Tables 1 and 3 indicates that the countries which reported irregularly or for only part of the period hold relatively small amounts of exchange reserves, so that the two samples give virtually the same picture of trends in currency composition. Total foreign-exchange reserves of the 53 countries at the end of 1970 were $33 billion (compared with $35 billion for the entire sample) and amounted to $110 billion at the end of the period under review. The percentage distribution among currencies is virtually identical for the 53-country sample and the 76-country sample.

The composition of the official foreign-exchange reserves held by the 76-country sample during the period 1971-76 is depicted in Figure 1. The graph shows that the dollar component of foreign-exchange reserves has remained fairly stable, accounting for approximately 80 per cent of total holdings. The sterling component declined rather consistently over the period shown, while deutsche mark holdings increased. French franc reserves consistently accounted for 1 per cent or less of the total, leaving a residual of other reserve assets ranging between 5 and 11 per cent.

The data on the currency composition of foreign-exchange reserves held by countries adhering to different exchange-rate regimes are also of interest. They are described in detail in Figure 2 and presented in summary form in Table 4 for December 31, 1970, and December 31, 1976. The classification by exchange-rate regime is the one used by the IMF in its Annual Reports. Each country's exchange-rate regime on July 1, 1976, is used for classification purposes.

Independent floaters (Fig. 2a) hold approximately one-third of the total foreign-exchange reserves of the 76 countries included in the survey. Countries with floating exchange rates tend to hold a large proportion of their exchange reserves in the form of dollars, but there has been a persistent decline in the dollar component since 1970. For a brief period in 1974-75, the group held a substantial fraction of its foreign exchange in sterling, but virtually all these sterling reserves were accounted for by a single country that has sharply reduced its sterling holdings since then. Floaters have acquired larger holdings of deutsche marks during the period under consideration.

The *snake* countries, comprising Belgium-Luxembourg, Denmark, Germany, the Netherlands, Norway, and Sweden (Fig. 2b), are predominantly dollar holders. Even for 1970, the $904 million held in "other" currencies represents to a large extent U.S. liabilities in the form of "Roosa bonds," which are denominated in the holding country's own

5

FIGURE 1

CURRENCY COMPOSITION OF FOREIGN-EXCHANGE RESERVES,
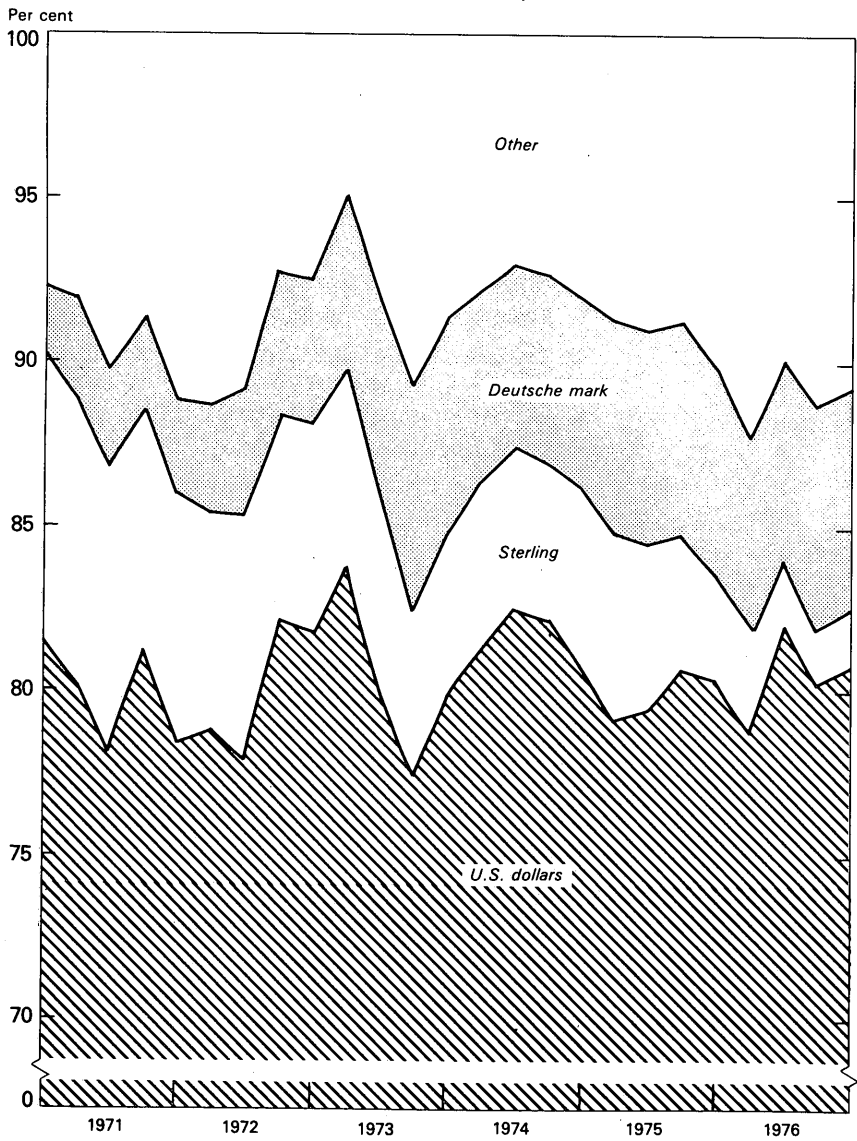76 REPORTING COUNTRIES, 1971-76

CURRENCY COMPOSITION OF FOREIGN-EXCHANGE RESERVES
BY EXCHANGE-RATE REGIME, 1970 AND 1976

Exchange Arrange-ments	Number of Countries	End of 1970				End of 1976			
		$	£	DM	Others	$	£	DM	Others
In Millions of Dollars									
Floaters	11	11,681	264	409	584	28,096	935	3,095	5,752
Snake	6	10,471	10	38	904	34,782	6	463	346
U.S. $ peggers	27	3,417	250	33	258	16,430	273	1,010	1,720
£ peggers	4	116	480	2	68	827	432	408	327
Basket peggers	21	2,476	2,034	173	740	12,377	332	2,671	4,248
In Per Cent									
Floaters	11	90.3	2.0	3.2	4.5	74.2	2.5	8.2	15.1
Snake	6	91.7	0.1	0.3	7.9	97.7	0.02	1.3	1.0
U.S. $ peggers	27	86.3	6.3	0.8	6.5	84.6	1.4	5.2	8.9
£ peggers	4	17.4	72.1	0.2	10.2	41.5	21.7	20.5	16.4
Basket peggers	21	45.6	37.5	3.2	13.6	63.1	1.7	13.6	21.6

currency. Half of these Roosa bonds were held by Germany and the other half by Switzerland.[1] In accordance with the Basle Agreement of April 10, 1972, limiting to working balances a snake country's holdings of the currencies of other members of the European Narrower Exchange Rate Margins Agreement, we find only insignificant holdings of currencies other than the dollar.

U.S. dollar peggers (Fig. 2c) reduced the dollar proportion in their portfolios considerably during the period of the dollar's decline from 1971 to 1973, only to rebuild their dollar holdings thereafter. The deutsche mark has replaced the pound sterling as the second most important currency held by this group of countries.

Sterling peggers (Fig. 2d) greatly reduced the sterling component of their reserves, while the dollar component of their portfolios increased. Holdings of deutsche mark and other currencies rose sharply.

[1] For data, see the *Federal Reserve Bulletin*. The U.S. liability data differ slightly from the asset data presented here because of valuation differences associated with exchange-rate changes.

FIGURE 2

Currency Composition of Foreign-Exchange Reserves by Exchange-Rate Regime, 1971-76

Per cent
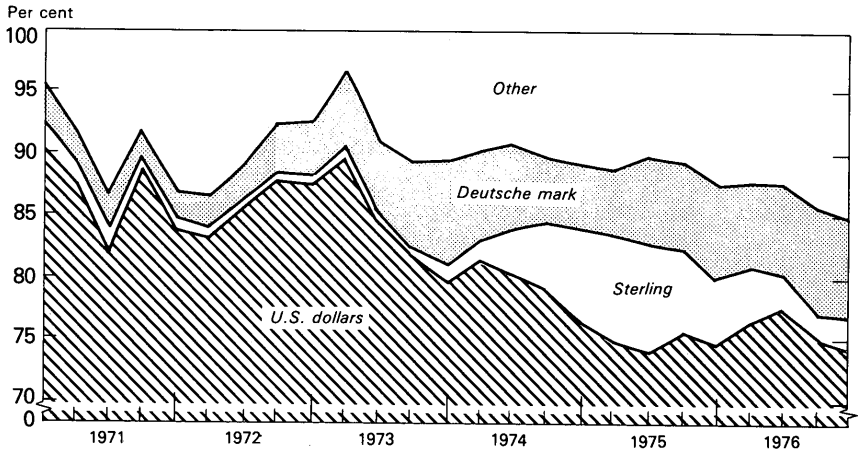
a. Independent Floaters

b. Snake Countries
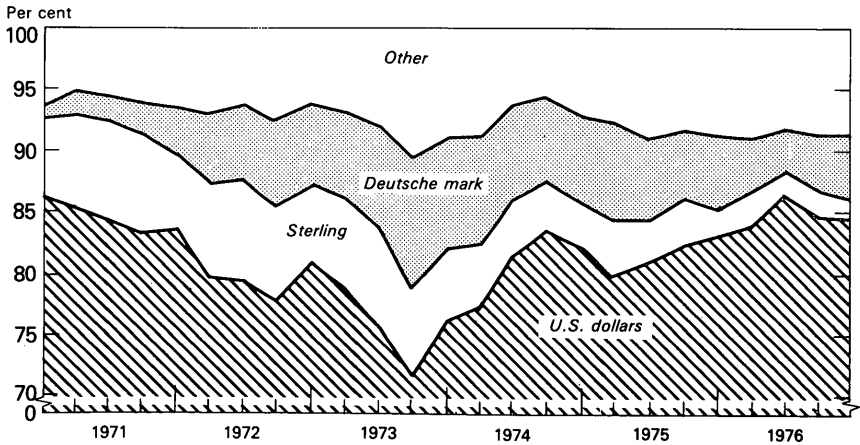
Per cent

c. Dollar Peggers

FIGURE 2 (*continued*)

Per cent

d. Sterling Peggers

Per cent

e. Basket Peggers
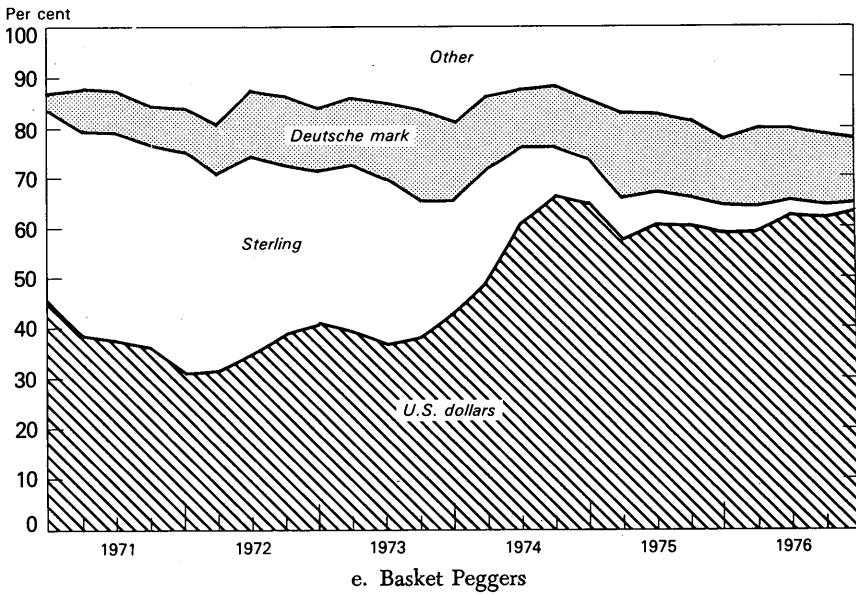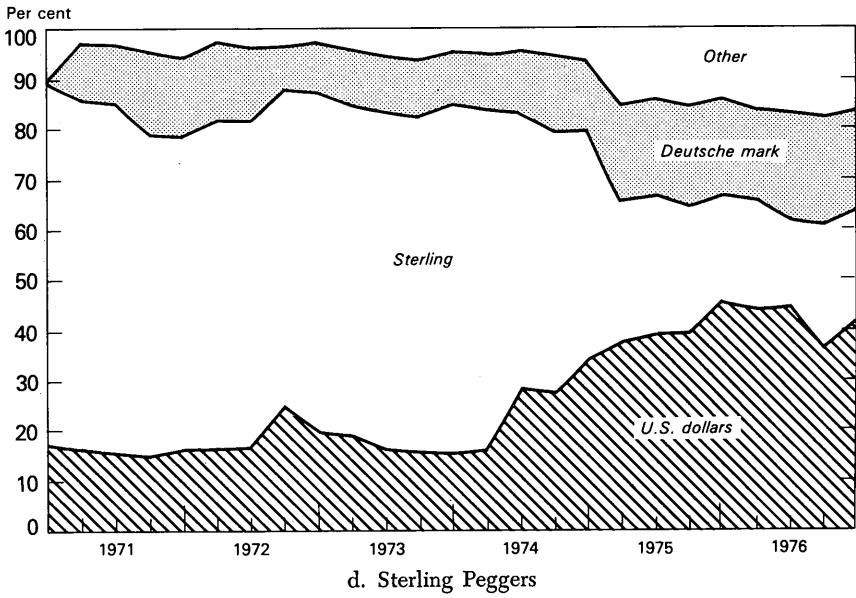
French franc peggers have traditionally held almost all their reserves in the form of French francs. The lowest share of French francs observed for this group during the period under review was 88 per cent. However, more than for most other groupings, the data are marred by incomplete reporting, so that franc peggers are omitted from both Figure 2 and Table 4.

Basket pegging (Fig. 2e), which includes SDR as well as "other" basket peggers, is a relatively new exchange-rate practice. Many former sterling peggers (Fig. 2d) have switched to the SDR or to a self-defined basket of currencies. The countries that pegged to a basket at the end of July 1976 had held a substantial proportion of their foreign-exchange reserves in pounds at the end of 1970, but had moved almost totally out of sterling by 1976. The decline in sterling holdings was reflected in a move into dollars and to a lesser degree into deutsche marks and other currencies.

Only two countries in our sample are classified as *crawlers*, that is, countries with currencies whose value is adjusted according to a set of indicators. Presenting the data for the two countries combined could reveal the foreign-exchange portfolio holdings of one country to the other, and consequently the data are omitted.

Perhaps the clearest impression given by Figure 2 is that since 1970 the currency composition of exchange reserves has varied widely both across countries and over time. Since central banks are free within certain constraints to determine the currency composition of their foreign-exchange portfolios on the basis of their own preferences, what factors influence their choice? The following sections address this question.

Factors Determining the Composition of Foreign-Exchange Reserves

It is clear that the portfolio-selection problem faced by a central bank is very different from that for an individual private transactor in the financial markets. The standard Markowitz-Tobin mean-variance analysis of portfolio selection assumes that an individual with given wealth can choose among a group of assets on the basis of their anticipated risks and returns. The individual first finds the combination of assets that minimizes the risk associated with each level of expected return (the efficient portfolio) and then chooses the portfolio that maximizes the expected utility of his wealth. Under certain assumptions about the form of the utility function and the probability distribution of anticipated returns, it

can be shown that the demand for each asset is homogeneous of degree 1 in wealth, with asset shares depending only on mean returns and on risk, as measured by the variances and covariances of returns.

These assumptions, however, do not appear to be particularly relevant to the problem of portfolio choice for central-bank holdings of foreign-exchange reserves. In the first place, central banks have broader objectives than simple portfolio optimization. Secondly, since the monetary authorities control the growth rates of domestic monetary aggregates, policies affecting the levels of the spot and forward exchange rates cannot be taken as exogenous. Therefore, such general considerations as a country's exchange arrangements and the structure of its trade and payments may be important determinants of its decision about how concentrated or diversified its foreign-exchange portfolio should be and what proportions should be held in each currency.

While countries with relatively small foreign-exchange reserves can readily swap one currency for another in order to optimize their holdings, some countries with very large holdings could not do so without significantly affecting exchange rates. To take a hypothetical example, the Deutsche Bundesbank could not convert a substantial portion of its U.S. dollars into, say, Swiss francs without causing a large change in the rate of exchange between these two currencies. Thus the currency composition of a large country's reserves is basically the outcome of its choice of intervention currency. If this choice is constrained by transactions costs, by agreement (as in the case of the countries in the European snake), or by other factors, the currency composition of reserves may be largely a consequence of the volume of past intervention, and the scope for optimization may be quite limited. However, it is reasonable to assume that all but a few of the countries included in our sample are small enough that they are relatively free to hold foreign-exchange portfolios that reflect their preferences.

In choosing the composition of its foreign-exchange portfolio, a central bank must seek an optimal tradeoff between two competing objectives. On the one hand, transactions costs are incurred in exchanging one currency for another, and the possibility of economies of scale in asset-exchange costs gives a central bank an incentive to concentrate its holdings in a single foreign currency. On the other hand, the risks involved in holding a single reserve asset act as an inducement to portfolio diversification. The most important of these risks arise from uncertainty about future movements in exchange rates between the currencies in which reserve assets are denominated.

In an international monetary system that permits exchange-rate changes, there are no foreign-exchange reserve assets that have capital certainty in terms of the home currency. Thus in the current system of managed floating by the main reserve countries, there are risks associated with holding exchange reserves denominated in any currency. Since central banks are averse to risk, it seems reasonable to suppose that minimization of exchange risk will be a consideration in their decisions about which foreign currencies to hold as reserves.

A country that pegs to a single currency can eliminate exchange risk by holding its foreign-exchange reserves in the currency to which it pegs. It may be argued that such an approach to exchange risk should be regarded as irrelevant by central banks because it guarantees capital certainty only in terms of the central bank's nominal balance sheet, rather than in terms of the real consumption stream of domestic residents. However, most central banks exhibit a strong aversion to exchange losses. This aversion is grounded in past experience of exchange losses during times of international monetary instability, which on occasion forced central banks to approach their governments for supplemental capital appropriations. Needless to say, such a request is highly embarrassing for a central bank. Furthermore, there is the central bank's desire to act as an example of prudence to the private banking system. A country that pegs to a composite basket can reduce the exchange risk on its reserves by distributing its holdings across different currencies according to the weights in the basket. A floating-rate country can do so by diversifying its portfolio according to the weights in some effective (e.g., import-weighted) exchange-rate index.

Intervention in the foreign-exchange market is another factor that influences the relationship between exchange arrangements and reserve-currency holdings. For example, we might expect countries that peg their currencies to the U.S. dollar to hold on average a higher proportion of their exchange reserves in dollars than countries that do not peg to the dollar. As a first step in analyzing foreign-exchange portfolio selection by central banks, we tested this hypothesis for each of the four major reserve currencies using the data provided by our 76-country sample. First, the ratio of dollar to total foreign-exchange holdings at the end of June was calculated for each country for the years between 1973 and 1976. The 76 countries were divided into two samples according to whether or not they pegged their exchange rate to the dollar on that date. Countries were categorized according to the IMF classification of their exchange arrangements on the nearest available date (July of each

12

year). The size of the subsamples varied between periods as countries switched from one exchange regime to another, and the overall sample size was reduced when a few countries did not report on certain dates. The means of the dollar ratios in each sample were calculated and tested for equality for each of the four mid-year dates. The same tests were then carried out for holdings of sterling, French francs, and deutsche marks. The results are presented in Table 5.

The first striking feature of the mean tests reported in Table 5 is the extent to which the demand for dollar assets on the part of countries that peg their exchange rates to the dollar increased relative to that of non–dollar peggers from 1973 to 1976. In each of the four years, dollar peggers held a higher ratio of dollars to total foreign-exchange reserves. But in mid-1973 the difference between the mean holdings of dollar peggers and those of other countries was not statistically significant except at the 54 per cent level. By 1974 these mean holdings were significantly different from the other means at the 24 per cent level, and by 1975 they were significantly different even at the 0.3 per cent level. These results are all the more surprising when it is noted that, on average, even countries that did not peg to the dollar increased their holdings of dollar assets during this period. Thus the mean tests in section 1 of Table 5 are consistent with the view that the desire of dollar peggers to hold their foreign-exchange reserves in dollar-denominated assets has become more pronounced since 1973 as the structure of the international monetary system has evolved, particularly with regard to the degree of exchange-rate flexibility.

This change in the difference in preferences between peggers and non-peggers is much less pronounced for other currencies, so that holdings at the latest date, June 1976, may be taken as representative. In the case of sterling, average holdings of the reserve currency by the countries that peg to it were significantly higher on that date than those of other countries. For example, the average country that pegged to sterling at the end of June 1976 held 41 per cent of its foreign-exchange reserves in sterling, as compared with an average of 5 per cent for other countries; and these ratios are different from each other at the 5 per cent significance level. Similarly, the average French franc pegger held 87 per cent of its currency reserves in francs as compared with 1.2 per cent for others, a difference that is significant at the 2.4 per cent level.

The results are rather different in the case of deutsche mark holdings by countries that are members of the European System of Narrower Exchange Rate Margins. Since Germany is the largest country in the snake,

13

TABLE 5

TESTS OF THE RELATIONSHIP BETWEEN CENTRAL-BANK HOLDINGS OF
RESERVE CURRENCIES AND EXCHANGE ARRANGEMENTS FOR 76 COUNTRIES, 1973-76

Ratio to Total Foreign-Exchange Reserves of	Mid-1973		Mid-1974		Mid-1975		Mid-1976	
	Number of Countries	Sample Mean of Currency Ratio	Number of Countries	Sample Mean of Currency Ratio	Number of Countries	Sample Mean of Currency Ratio	Number of Countries	Sample Mean of Currency Ratio
1. U.S. $ holdings:								
$ peggers	39	0.502	41	0.568	31	0.684	26	0.785
Other countries	27	0.444	33	0.475	43	0.482	44	0.593
	66	(0.540)	74	(0.236)	74	(0.003)	70	(0.001)
2. Sterling holdings:								
£ peggers	7	0.725	8	0.631	8	0.480	4	0.414
Other countries	59	0.155	66	0.135	66	0.080	66	0.049
	66	(0.000)	74	(0.001)	74	(0.005)	70	(0.050)
3. Franc holdings:								
Franc peggers	3	1.000	3	0.810	5	0.854	3	0.866
Other countries	63	0.026	71	0.018	69	0.014	67	0.012
	66	(0.000)	74	(0.053)	74	(0.001)	70	(0.024)
4. DM holdings:								
Snake countries	6	0.020	5	0.016	5	0.032	5	0.030
Other countries	59	0.143	68	0.133	68	0.127	64	0.103
	65	(0.000)	73	(0.000)	73	(0.005)	69	(0.047)

NOTE: Numbers in parentheses are the significance levels of the probabilities of committing a type 1 error in testing the null hypothesis that the two sample means being compared are the same.

it might be expected that the deutsche mark holdings of other snake countries would be substantial. Instead, the average snake country holds a significantly *smaller* ratio of deutsche marks than do other countries. This is directly attributable to the agreement restricting the right of participating central banks to hold European currencies other than working balances, while providing for obligatory intervention in the currencies of the participating countries financed by automatic credit provisions unlimited in amount but not duration (Deutsche Bundesbank, 1976).

The results presented in Table 5 for the reserve-currency holdings of various groups are particularly striking when compared with a similar test on the entire foreign-exchange component of international reserves. In general, the less flexible a country's exchange rate and the more its macroeconomic policies are devoted to the attainment of such domestic goals as high employment or rapid economic growth, the greater will be its use of reserves. Since a country's holdings of reserve currencies are highly liquid, we might postulate that countries that have pegged exchange rates will tend to hold a higher ratio of foreign exchange to total reserves than countries that are floating. A mean test of this hypothesis was made for the same group of 76 countries used in the previous experiment. Germany was excluded and all other snake countries were included in the 67 countries pegged to a currency or a basket of currencies. There were 8 floaters. The average pegger held 82 per cent of its international reserves in foreign exchange, while the average floater held only 77 per cent, but this difference was not statistically significant except at the 51 per cent level. Tests for other dates yielded similar conclusions.

To summarize, the tests in this section indicate that there is indeed a relationship between exchange arrangements and currency holdings. Countries that peg to the dollar, sterling, and the French franc tend to hold more of these currencies than do others. In the case of the dollar, these preferences have become more pronounced over time. Snake countries hold significantly *fewer* deutsche marks than others, owing to an explicit agreement. These results confirm the importance of exchange-risk reduction and the "intervention motive" in a central bank's choice of reserve currencies.

Determinants of Central-Bank Demand for Individual Reserve Currencies: Regression Analysis

The simple tests performed above indicate that exchange arrangements are a significant factor in a central bank's decision about what currencies

15

to hold in its foreign-exchange portfolio, but the data also show that few central banks keep their exchange reserves entirely in the currency to which they peg. We will now broaden the analysis somewhat to include other variables among the determinants of the foreign-exchange portfolio and use regression techniques to allow for the simultaneous influences of several factors. We will argue that, in addition to the exchange-rate-regime variable discussed previously, the percentage of trade carried on with each reserve-center country is an important factor determining the asset composition of a central bank's foreign-exchange portfolio.

Our hypothesis is that a country's holdings of a particular reserve currency will be a positive function of its trade with that reserve center. This hypothesis is analogous to Swoboda's (1968, pp. 5-11) argument that private transactors' efforts to minimize transactions costs will induce them to concentrate their foreign-exchange holdings in a small number of "vehicle currencies." It can easily be justified on the basis of the central bank's concern to intervene in the foreign-exchange market to finance residual imbalances. For example, an increase in a country's net exports to Germany that are invoiced in marks will increase the deutsche mark earnings of domestic residents. To the extent that private transactors transfer their receipts back into the domestic currency, the authorities' exchange-stabilization operations will cause them to acquire deutsche marks. Conversely, a central bank must be prepared to sell deutsche marks from its reserves and buy domestic currency whenever an increase in private demand for imports from Germany induces an excess demand for deutsche marks on the foreign-exchange market at the existing exchange rate. This implies that when a country's residents are heavily engaged in trade with a particular reserve-currency country, the central bank has a further motive for holding that currency. Whatever a country's exchange arrangements, it seems likely that official holdings of a particular reserve currency, in our example the deutsche mark, will be a larger proportion of its exchange reserves as the importance of trade with Germany increases. Furthermore, since the major reserve currencies are substitutes for one another, a country's holdings of reserve currency A will be *negatively* related to its trade with reserve centers B, C, etc. Thus, we assume that a country's demand for each reserve currency depends on variables representing its trade with each of the four major reserve-currency countries. The trade variables are defined as:

$$T_{ij} = (E_{ij} + I_{ij})/(E_i + I_i) \, ,$$

where E and I refer to exports and imports and the subscripts are i for

16

the home country and j for the reserve-currency countries, that is, $j =$ the United States, the United Kingdom, France, and Germany.

In addition to trade in goods and services, capital transactions between residents of a particular country and those of a reserve center are likely to be important determinants of that country's holdings of each reserve currency. The absence of reliable data on bilateral capital flows makes it impossible to test this hypothesis in our regression analysis. However, to the extent that current-account transactions between a country and a reserve center are financed by credits extended by residents of the exporting country, capital flows between the two countries may be correlated with trade flows, so that the absence of variables representing bilateral capital movements may not be as serious an omission as it appears to be at first. This point is reinforced by the fact that many countries impose controls on capital flows that do not finance current-account transactions.

It was noted that members of the European System of Narrower Exchange Rate Margins have committed themselves to limit their holdings of the other snake countries' currencies. This implies that snake countries hold more dollars and less of other reserve currencies than we would expect on the basis of their trade with the reserve centers and their exchange arrangements. Thus, in addition to the variables discussed above, a dummy variable for the snake countries is included in all regressions. This variable is expected to have a positive coefficient in the regression for the dollar and a negative coefficient in the other regressions.

It might be argued that considerations of the risk and return on any reserve currency relative to others will act as yet another influence on the portfolio decisions of a central bank. But at any given moment the relative returns on all reserve currencies are the same for all holders. Consequently, the use of cross-section data obviates the need to take into account these two potentially important factors.

To summarize, we estimated 5 cross-section regressions on a sample of 55 countries in which the endogenous variables were the ratios of holdings of each major reserve currency (dollars, sterling, deutsche marks, French francs, and other reserve currencies) to the total foreign-exchange portfolio. Because of reporting coverage, the sample size varied slightly. The 6 explanatory variables are the exchange-rate regime, the 4 variables representing trade with each reserve center, and a dummy for the members of the European System of Narrower Exchange Rate Margins.

The equations, estimated by ordinary-least-squares methods, are given in Table 6. Both the standard regression coefficients and the Beta coeffi-

TABLE 6

DETERMINANTS OF CENTRAL-BANK HOLDINGS OF RESERVE CURRENCIES, CROSS-SECTION REGRESSION ANALYSIS FOR 1975

Ratio to Total Foreign-Exchange Reserves of	Parameter	Constant	Exchange-Rate Regime[a]	Trade Share with				Snake Country Dummy	$\bar{R}^2$	S.E.E.	F-Ratio (Degrees of Freedom)
				U.S.	U.K.	France	Germany				
U.S. $	Regression	0.662	0.0006	0.603	−0.945	−1.195	−0.464	0.514	0.61	0.19	17.02
		(6.92)	(0.10)	(2.88)	(3.38)	(4.34)	(1.01)	(5.40)			(6,56)
	Beta coefficient	—	0.001	0.29	−0.32	−0.44	−0.09	0.49			
Sterling	Regression	0.076	0.252	−0.123	0.743	−0.077	−0.236	−0.096	0.43	0.17	8.35
		(1.02)	(2.91)	(0.67)	(2.59)	(0.36)	(0.58)	(1.20)			(6,53)
	Beta coefficient	—	0.37	−0.08	0.35	−0.04	−0.07	−0.13			
Franc	Regression	0.028	0.742	−0.051	−0.063	0.252	−0.155	−0.022	0.92	0.07	111.89
		(0.88)	(13.19)	(0.66)	(0.48)	(1.77)	(0.88)	(0.58)			(6,48)
	Beta coefficient	—	0.84	−0.03	−0.03	0.12	−0.03	−0.02			
DM	Regression	0.075	—	−0.203	0.023*	−0.066	1.174	−0.250	0.23	0.13	4.37
		(1.20)		(1.38)	(0.12)	(0.36)	(3.36)	(3.43)			(5,53)
	Beta coefficient	—	—	−0.21	0.02	−0.05	0.49	−0.46			
Other reserve currencies	Regression	0.102	0.070	−0.151	−0.013	−0.254	0.203*	−0.081	0.35	0.07	6.00
		(3.43)	(2.87)	(2.03)	(0.14)	(3.03)	(1.29)	(2.48)			(6,50)
	Beta coefficient	—	0.34	−0.29	−0.02	−0.37	0.16	−0.31			

[a] In the dollar regression, this dummy is unity for all dollar peggers and zero otherwise. The dummies for sterling and French franc peggers have analogous definitions. In the regression for "Other reserve currencies," the dummy is unity for countries that peg to the SDR or some other basket and zero otherwise.

NOTE: Numbers in parentheses are t-ratios.

cients are presented. Since the Beta coefficients give the contribution of the standard error of each independent variable to the standard error of the dependent variable, they are a useful indicator of the relative importance of each explanatory variable as a determinant of the ratio of a particular currency to total foreign-exchange reserves.

In each regression, the exchange-rate-regime variable is expected to enter with a positive sign. In the regression for reserve currency A, for example, the trade share of each country with country A should have a positive effect, while the trade shares with the other reserve centers should be negative. The expected sign of the dummy representing the snake countries should be positive in the dollar equation and negative in the others. Estimated coefficients that violate their *a priori* sign restriction are marked with an asterisk.

The coefficients of determination adjusted for degrees of freedom range from 0.23 in the case of the deutsche mark to 0.92 for the French franc. The *F*-ratios indicate that all five regression equations are significant. Of the 35 estimated parameters, all but two are consistent with their *a priori* sign restrictions, although only about half the coefficients are significant. Except in the case of the U.S. dollar, the variable representing the exchange-rate regime is significant at the 1 per cent level, and the dummy for the snake countries is significant at this level in three of the five equations. In connection with the trade ratios, we find that in the equations for the four individual reserve currencies, the coefficient of the "own trade ratio" (i.e., the coefficient of holdings of currency A with respect to trade with country A) is significant with the correct sign at the 1 per cent level except in the case of the French franc (where it is significant only at the 10 per cent level). For holdings of "other reserve currencies," two of the four trade ratios are significant with the correct (i.e., negative) sign at the 5 per cent level. These are reasonably satisfactory results for cross-section data.

When considering the regression results, it is important to keep the dimensions of the variables in mind. As the dependent variable is defined in percentage terms, the constant term shows the proportion of their foreign-exchange reserves that countries would hold in the reserve currency indicated independently of the factors explicitly included in the equation. Only the constant terms for the U.S. dollar and "other" currencies are significant, but both are highly so. They indicate that, on average, the countries in our sample tend to hold 66 per cent of their foreign-exchange reserves in dollars and 10 per cent in "other" currencies, independently of their trading patterns and exchange arrangements.

19

The coefficients for the other three reserve currencies are very small and are not significantly different from zero.

Since the variable representing the exchange-rate regime is a (0,1) dummy (see footnote a to Table 6), its parameter indicates the proportion of holdings of currency A resulting from the fact that a given country pegs its exchange rate to A. For example, the fact that a country pegs its currency to the French franc is estimated to add 74 percentage points to its proportionate holdings of French francs, and sterling peggers tend to hold 25 per cent more in sterling than do other countries. The fact that a country is a dollar pegger does not seem to have much influence on its holdings of dollars. Our results show that countries hold dollars irrespective of whether they are dollar peggers or not. This conclusion is strengthened by the existence of a significant constant term in the dollar equation.

Turning to the trade variable, we find that a 1 per cent increase in the proportion of trade with the United States will lead to a 0.6 per cent increase in the fraction of foreign-exchange reserves that is held in the form of dollars. Similarly, an increase in the trade ratio with the reserve-center country is in all cases associated with an increase in the reserves held in that country's currency. These results are in each case significant at the 1 per cent level, except for French franc peggers, where the results are significant at the 10 per cent level.

Also relevant is the finding that a country's holdings of a particular reserve currency are negatively related to the share of its trade with other reserve-currency countries. For instance, the first equation of Table 6 shows that a 1 per cent increase in trade with the United Kingdom as a share of total trade will reduce a country's dollar reserve ratio (as a percentage of total foreign-exchange reserves) by 0.95 per cent. Similarly, higher trade shares with France or Germany will also lead to a lower dollar-reserve ratio. In our five estimated equations in Table 6, 13 of these 15 "substitution" effects of trade shares on demand for reserve currencies have the expected negative sign.

Finally, a (0,1) dummy representing membership in the European System of Narrower Exchange Rate Margins shows that snake countries hold significantly higher dollar reserves and less of other reserve currencies. This is in accordance with the agreement on reserve-asset holdings among these countries.

Which variables are relatively more important in holdings of each currency? This question can be answered by examining the relative sizes of the Beta coefficients in each equation. These coefficients reflect the relative importance of the factors motivating the holding of the four major

reserve currencies. In the case of the dollar, the most widely used currency, trade with the reserve center and snake membership are much more important than the exchange-rate regime. In the case of sterling, trade and the exchange-rate regime are of roughly equal importance, while in the case of franc holdings, the dominant influence is the fact that the country pegs its exchange rate to that currency. In the case of deutsche mark holdings, we find the strong negative relation between snake membership and mark holdings that is the result of the Basle agreement.

Other factors, such as the degree of openness of a country's economy with respect to trade and financial factors, the structure of its foreign-trade sector, and perhaps even the level of its GNP, may also play a role in the country's reserve-management policy. We attempted to represent each country's openness on current account by the ratio of its trade (imports plus exports) to GDP and on capital account by the ratio of the absolute value of commercial-bank foreign assets to the domestic money stock. When these variables were entered in the equations, we found that approximately half the coefficients associated with them were not significantly different from zero. Their absolute value was in all cases very small relative to those of the exchange-rate regime and trade with the reserve center, and we therefore concluded that these factors are of secondary importance in the portfolio decision. Furthermore, examination of the residuals from the regression lines indicates that many of the largest residuals are due to the fact that countries having recently changed their exchange-rate regimes (e.g., from a single currency to the SDR or some other basket) were still holding large balances of the currency to which they used to peg. This is at least *prima facie* evidence that our determinants of reserve-currency preferences are likely to become even more important empirically in the future, as countries settle into optimal exchange arrangements and adjust their reserve-currency portfolios accordingly, provided that the optimal exchange arrangements do not vary over time.

Since trade patterns change only slowly and each country's exchange arrangements are under the control of its national authorities, it is tempting to conclude from our empirical analysis that the central-bank demand for reserve currencies is a stable function of a small number of variables that do not vary much. But such a conclusion would be precipitous. We have already noted that our use of cross-section data prevents us from analyzing the interest sensitivity of central-bank demands for reserve assets. Thus our regression results do not tell us how holding patterns

might change over time as expected yields on reserve currencies change. Some limited evidence on this question is presented below. What we can say, however, is that the central-bank demand for foreign exchange is stable in the sense that *at given interest rates* holdings are determined primarily by each country's exchange arrangements and by its trade with reserve-currency countries.

Eurocurrency Holdings of Central Banks

Between 1970 and 1976, the total identified Eurocurrency holdings of central banks rose from SDR 10.9 billion to SDR 52.9 billion, and the proportion of total reserves held in the Euromarket jumped from 12 to 23 per cent (IMF, *Annual Report 1977*, Tables 10 and 14). During the five-year period, the ratio of Eurocurrency deposits to total official holdings of foreign exchange increased from 24 to 33 per cent. A substantial proportion of official holdings in the Eurocurrency market takes the form of deposits made by central banks with the Bank for International Settlements. Holdings of dollar-denominated assets made up at least 85 per cent of official Eurocurrency deposits in all years except 1973, when they made up 81.6 per cent.

The fact that central monetary authorities hold a significant proportion of their foreign-exchange reserves as deposits in the Eurocurrency markets raises a number of important issues for international monetary analysis and policy. On the one hand, some central banks find Eurocurrency deposits attractive because their yield is generally higher than that of the official liabilities of reserve-currency countries. On the other hand, it is widely recognized that whenever central banks deposit reserve accruals in the Euromarket, the effect on Eurocurrency aggregates is analogous to that of an open-market purchase of securities by the authorities in a domestic monetary system. Williamson (1977) notes that if country A, which holds its reserves in the United States, has a deficit with country B, which holds its reserves in the Euromarket, official monetary movements between the two will inject funds into the Euromarket, giving rise to an expansion of deposits and loans. Furthermore, these injections take place without any change in the net external liabilities of the reserve center in whose currency the deposits are denominated. During the deliberations of the Committee on Reform of the International Monetary System (the Committee of Twenty), a proposal was made to limit placement of reserves in the Eurocurrency market by central monetary institutions, but agreement was never reached (see IMF, 1974).

In view of the significance of central-bank Eurodollar deposits, this

section attempts to analyze the factors that determine these holdings. In constructing our series for central-bank Eurodollar holdings, we have followed the practice of successive IMF Annual Reports in regarding central banks' dollar deposits at the Bank for International Settlements as part of their identified Eurodollar holdings. The existing data are incomplete both across countries and over time, but we have been able to obtain a consistent quarterly time series for the holdings of a group of 37 central banks during the period Q4 1967 to Q2 1976. This group includes 11 developed and 26 developing countries. At the end of 1975, the group held approximately 55 per cent of the total identified Eurodollar holdings of central monetary authorities. Figure 3 presents the proportion of the total dollar-denominated reserves of these central banks that is held in Eurodollars (left-hand scale) together with the differential between the Eurodollar interest rate and the market yield on U.S. Treasury bills (right-hand scale).

It is important to emphasize at the outset that Eurodollar portfolio

FIGURE 3

PROPORTION OF OFFICIAL DOLLAR RESERVES HELD IN EURODEPOSITS AND YIELD DIFFERENTIAL BETWEEN EURODOLLAR DEPOSITS AND U.S. TREASURY BILLS, CONSTANT SAMPLE OF 37 COUNTRIES, 1967-76
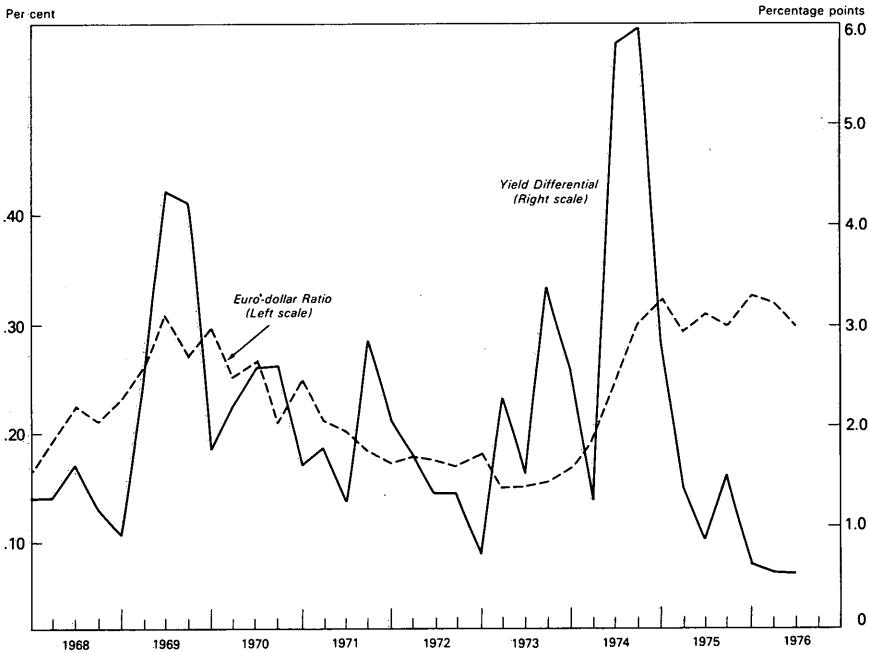
behavior differs widely from one central bank to another. Thus the data in Figure 3 are only suggestive of certain broad trends and cannot be considered representative of any individual central monetary institution. Despite this caveat, the trends in Figure 3 are interesting. After rising to a peak of nearly 30 per cent in 1969, Eurodollar holdings gradually declined to just over 15 per cent in the first quarter of 1973. They then rose sharply to over 30 per cent in 1975.

The interest differential also varied considerably during the period. This differential is sometimes very large, considering that both Eurodollars and Treasury bills are short-term assets with similar characteristics. It is due mainly to the restrictions on capital exports by U.S. residents that were introduced in 1965 and were in force for most of the period. These included the Foreign Direct Investment Program, the Voluntary Foreign Credit Restraint Program, and the Interest Equalization Tax. From 1967 until 1975, there appears to have been some correlation between the proportion of dollar reserves held in Eurodollars and the interest differential in favor of these assets. In 1975, the interest differential declined precipitously and remained stable at around 60 basis points throughout 1976. This fundamental shift in the equilibrium relationship between the two rates may have been at least partly due to the removal of restrictions on foreign lending by U.S. residents. Those restrictions were lifted in the first quarter of 1974, but during the next three quarters the Euromarkets were disturbed by the failure of a commercial bank in Europe and questions about the solvency of others. Thus the effect of the abolition of capital controls on the interest differential is not apparent until 1975.

Once a central bank has decided how much of its foreign-exchange portfolio should be in dollars, it can choose between claims on U.S. residents (typically U.S. Treasury bills) and Eurodollar deposits. In making this portfolio decision, do central banks respond to changes in the relative yields on the two assets? This is, of course, a much narrower aspect of portfolio selection than the division of exchange reserves among different currencies, but it is interesting for two reasons. First, since Treasury bills and Eurodollar deposits are short-term securities, there is virtually no risk of capital loss due to interest-rate changes. Second, the fact that the two assets are denominated in the same currency means that the choice between them does not involve an assessment of exchange risk. This permits an empirical analysis of central-bank portfolio choice in the absence of the two most common types of risk associated with international asset holdings.

A small partial-adjustment model, which is described in the Appendix, yields the conclusion that the aggregate demand for Eurodollars by the 37 central banks included in our sample *is* responsive to changes in interest-rate differentials. Our estimates for the interest elasticity lie between 1.4 and 1.9, depending on whether the elasticity is evaluated at the mean of the Eurodollar rate or of the U.S. Treasury bill rate.

We have already noted that there are cross-country differences in the reserve-portfolio behavior of central banks. Do the responses of central banks in the developed countries differ from those of less developed countries? There is good reason to expect such a difference. In 1971, concern over the expansionary effects of official placements of reserves in the Euromarkets induced the central banks of the Group of Ten industrialized countries (G-10) to agree that for the time being they would limit their reserve placements in the Euromarket (see Williamson, 1977, p. 156). Williamson observes, "the G-10 lead was not, however, followed by the developing countries, which were not only attracted by the higher yields available in the Euromarkets, but, insofar as they were conscious of the result, welcomed the fact that additional deposits expanded the lending potential of the market, to which they were increasingly turning as borrowers." This observation suggests the presence of systematic differences in Eurodollar portfolio behavior as between developed and developing countries. If developing countries deposit a higher proportion of their reserve gains in the Euromarket, we would expect our equation to show a higher elasticity of Eurodeposits with respect to their total dollar holdings. Furthermore, since a higher proportion of the reserves of developing countries would be placed in the Euromarket whatever the size of the Euro-U.S. yield differential (so long as it is positive), the developed countries might be expected to have a more elastic response to changes in relative yields.

As a simple test of these hypotheses, we split our sample into two subgroups, the central banks in the 11 developed countries (7 of which are members of the G-10), and those in the 26 developing countries. The estimates are presented in the Appendix.

A comparison of the results suggests that there are considerable differences in behavior between the two groups of central banks. The scale elasticity for the holdings of developing countries is much larger (2.1) than that for the developed countries (0.5). The estimated interest parameter is roughly the same size for each group but is significant only in the case of the developed countries. The parameter representing the speed of portfolio adjustment is not significantly different from zero for

the developing countries, whereas for the developed group it is very significant and indicates a mean time lag of adjustment of just over three months.

These results are consistent with our hypothesis that central banks in the developing countries tend to redeposit a certain proportion of their reserve accruals in the Euromarket regardless of the exact size of the current yield differential. By contrast, central banks in the developed countries have tended to limit placements in the Euromarkets as their reserves have grown, but they appear to exercise close management of their foreign-exchange portfolios: their Eurodollar holdings are sensitive to changes in relative yields and are adjusted very quickly in response to such changes.

Any general conclusion about the Eurodollar portfolio behavior of central banks must be regarded as tentative. Our findings refer only to a particular group, and for obvious reasons we do not present regression results for individual countries. Nevertheless, the empirical work in the Appendix tentatively confirms two hypotheses, that placements in the Eurodollar market are responsive to yield differentials and that there is a systematic difference between the Eurodollar portfolio behavior of developed and less developed countries. In view of the known expansionary effects of central-bank placements on the size of the Eurocurrency markets, these findings are important for the determination of the volume and composition of the stock of international liquidity.

Conclusions

The main feature that distinguishes the new international monetary system from the Bretton Woods regime is the increased degree of exchange-rate flexibility, especially among the major reserve currencies. As recent contributions to international monetary theory emphasize, exchange rates are determined by the demand for and supply of assets denominated in different currencies, and these demands and supplies arise from the interaction of the various market participants. This makes decisions on the size and composition of foreign-exchange balances more complicated for both private transactors and central banks.

This essay has dealt with the question of central banks' demand for various reserve currencies. We first presented new data on the currency composition of the foreign-exchange holdings of central banks. Among the 76 central banks covered, the dollar component of international reserves has remained relatively stable at approximately 80 per cent during

the period 1970-76. Sterling has declined in importance during this period, and its place as the second most important reserve currency has been taken by the deutsche mark.

Two factors were found to be of importance in a central bank's selection of its foreign-exchange portfolio: the country's exchange-rate regime and the pattern of its international trade. Countries hold a significantly greater proportion of their exchange reserves in the currency to which they peg. The desire to minimize exchange risk and the need to hold intervention balances are both important factors in this decision. There are two exceptions to this finding: first, countries tend to hold a high proportion of dollars whether they are dollar peggers or not. Second, the snake countries, in accordance with the European System of Narrower Exchange Rate Margins, tend to hold dollars almost exclusively. Countries hold a higher percentage of the currencies of those reserve centers that are their important trading partners. Furthermore, our results indicate that as a country's trade share with a reserve center increases, it will hold less of the other reserve currencies.

While the question of the interest sensitivity of holdings of the various reserve currencies was not analyzed, we presented evidence pertaining to reserve holdings in U.S. Treasury bills and Eurodollars. We found that central banks as a group are sensitive to interest differentials between these two markets. As compared with industrial countries, the developing countries tend to deposit a higher proportion of reserve accruals in the Eurodollar market regardless of the size of the interest differential.

Over the coming years, changes in the demand for individual currencies will have significant effects on exchange-rate trends. While our analysis of central-bank demand for reserve currencies is not exhaustive, it pinpoints some of the factors that influence this important decision.

APPENDIX

Central-Bank Demand for Eurodollars

A central bank's behavior with respect to its dollar portfolio may be described by a simple partial-adjustment system. The equilibrium demand for Eurodollar deposits, ED^d, may be specified in semilogarithmic form as

$$ln \, ED^d = a_0 + a_1 \, (r_E - r_S) + a_2 \, ln \, TD \, , \tag{1}$$

where ED = Eurodollar holdings of central banks

a_1 = interest-rate coefficient

r_E = three-month Eurodollar deposit rate in London

r_S = market rate on 90-day U.S. Treasury bills[1]

a_2 = elasticity of Eurodollar deposits with respect to total dollar reserves

TD = total dollar holdings of central banks.

Central banks are assumed to adjust their holdings of Eurodollar deposits in response to their excess demand for these assets:

$$\frac{d}{dt} \, ln \, ED = b \, (ln \, ED^d - ln \, ED) \, , \tag{2}$$

where d/dt denotes the time derivative and b is the adjustment coefficient. Substituting (1) into (2) gives

$$\frac{d}{dt} \, ln \, ED = ba_0 + ba_1(r_E - r_S) + ba_2 \, ln \, TD - b \, ln \, ED \, , \tag{3}$$

for which a discrete approximation is[2]

$$\Delta \, ln \, ED = ba_0 + ba_1 M(r_E - r_S) + ba_2 \, M \, ln \, TD - bM \, ln \, ED \, , \tag{4}$$

where, with L the lag operator, $\Delta = 1 - L$, $M = \frac{1}{2}(1 + L)$.

In order to take account of the shift in the normal level of the interest differential that resulted from the removal of U.S. capital controls, we include a dummy variable (z), which is zero until Q4 1974 and unity

[1] In the estimation work below, the time series for both interest rates were obtained from the Bank of England *Quarterly Bulletin*.

[2] See Wymer (1972). Wymer has shown that if the errors in (3) are serially uncorrelated and (3) contains stock variables only, the errors in the discrete approximation (4) will also be serially uncorrelated.

thereafter. The coefficient of the dummy variable is c. Transforming (4) into levels and adding this variable gives

$$ln\ ED = \frac{ba_0}{1+0.5b} + \frac{ba_1}{1+0.5b}\ M\ (r_E - r_S) + \frac{ba_2}{1+0.5b}\ M\ ln\ TD$$
$$+ \frac{1-0.5b}{1+0.5b}\ L\ ln\ ED + c\ z\ . \tag{5}$$

Since the over-identifying restrictions must be imposed on (5) in order to obtain estimates of the behavioral parameters, this equation was estimated using nonlinear least-squares methods for the full group of 37 countries. The numbers in parenthesis are the t-ratios of the estimated parameters:

$$b\ =\ \ \ 0.366 \qquad\qquad a_2 =\ \ \ 0.887$$
$$(2.00) \qquad\qquad\qquad (8.57)$$
$$a_0 = -0.753 \qquad\qquad c\ =\ \ \ 0.163$$
$$(0.73) \qquad\qquad\qquad (1.38)$$
$$a_1 =\ \ \ 0.248$$
$$(3.17)$$
$$\bar{R}^2 =\ \ \ 0.99 \qquad \text{S.E.E.} = 0.091 \qquad \text{D.W.} = 2.05$$

This equation is well determined. The adjustment parameter (b), the interest-rate coefficient (a_1), and the elasticity of Eurodollar deposits with respect to total dollar reserves (a_2) are all significant with the correct sign at the 5 per cent level, and the explanatory power of the regression is high. The estimated adjustment coefficient indicates that, as a group, the 37 central banks included in the sample adjusted their Eurodollar holdings with a mean time lag of less than three quarters. Since our discrete-time approximation (5) is subject to the same over-identifying restrictions as (2), the adjustment parameter b must be greater than 0 but need not be less than 1. The mean time lag of the response (the time required for central banks to complete about 63 per cent of the portfolio adjustment resulting from a change in one of the predetermined variables) is equal to $1/b$.

Given our semilogarithmic specification, the demand function (1) has variable interest elasticities that are defined for any interest rate r as:

$$\epsilon_r = \frac{\partial\ ln\ ED^d}{\partial\ ln\ r} = a_1 \cdot r\ .$$

29

The estimated interest elasticities, calculated at the means of the time series for each interest rate, $\bar{r}_E$ and $\bar{r}_S$, are

$$\epsilon_{r_E} = a_1 \cdot \bar{r}_E = 1.93$$
$$\epsilon_{r_S} = a_1 \cdot \bar{r}_S = 1.44 \, .$$

The corresponding results for the subgroups of 11 developed and 26 developing countries are given in Table A-1.

TABLE A-1

ESTIMATED CENTRAL-BANK DEMAND FOR EURODOLLARS
BY SUBGROUP, Q1 1968 TO Q3 1976

Parameter	Group of 11 Developed Countries	Group of 26 Less Developed Countries
b	0.964 (2.56)	0.153 (1.66)
a_0	2.632 (5.03)	−9.704 (2.48)
a_1	0.153 (3.76)	0.125 (0.57)
a_2	0.529 (9.62)	2.063 (4.23)
c	0.382 (2.85)	−0.248 (2.16)
$\bar{R}^2$	0.94	0.99
$D.W.$	2.26	2.01
$S.E.E.$	0.13	0.11

30

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The International Finance Section publishes at irregular intervals papers in four series: ESSAYS IN INTERNATIONAL FINANCE, PRINCETON STUDIES IN INTERNATIONAL FINANCE, SPECIAL PAPERS IN INTERNATIONAL ECONOMICS, and REPRINTS IN INTERNATIONAL FINANCE. ESSAYS and STUDIES are confined to subjects in international finance. SPECIAL PAPERS are surveys of the literature suitable for courses in colleges and universities.

An ESSAY should be a lucid exposition of a theme, accessible not only to the professional economist but to other interested readers. It should therefore avoid technical terms, should eschew mathematics and statistical tables (except when essential for an understanding of the text), and should rarely have footnotes.

A STUDY or SPECIAL PAPER may be more technical. It may include statistics and algebra and may have many footnotes. STUDIES and SPECIAL PAPERS may also be longer than ESSAYS; indeed, these two series are meant to accommodate manuscripts too long for journal articles and too short for books.

To facilitate prompt evaluation, please submit three copies of your manuscript. Retain one for your files. The manuscript should be typed on one side of 8½ by 11 strong white paper. All material should be double-spaced—text, excerpts, footnotes, tables, references, and figure legends. For more complete guidance, prospective contributors should send for the Section's style guide before preparing their manuscripts.

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Department of Economics, Dickinson Hall
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Princeton, New Jersey 08540

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List of Publications

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102. Constantine Michalopoulos, *Payments Arrangements for Less Developed Countries: The Role of Foreign Assistance.* (Nov. 1973)
103. John H. Makin, *Capital Flows and Exchange-Rate Flexibility in the Post-Bretton Woods Era.* (Feb. 1974)
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118. Alexandre Kafka, *The International Monetary Fund: Reform without Reconstruction?* (Oct. 1976)
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120. George N. Halm, *Jamaica and the Par-Value System.* (March 1977)
121. Marina v. N. Whitman, *Sustaining the International Economic System: Issues for U.S. Policy.* (June 1977)

[1] Some earlier issues are still available from the Section. For a complete list of publications, write to the Section.

122. Otmar Emminger, *The D-Mark in the Conflict between Internal and External Equilibrium, 1948-75.* (June 1977)
123. Robert M. Stern, Charles F. Schwartz, Robert Triffin, Edward M. Bernstein, and Walther Lederer, *The Presentation of the Balance of Payments: A Symposium.* (Aug. 1977)
124. Harry G. Johnson, *Money, Balance-of-Payments Theory, and the International Monetary Problem.* (Nov. 1977)
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131. H. Robert Heller and Malcolm Knight, *Reserve-Currency Preferences of Central Banks.* (Dec. 1978)

PRINCETON STUDIES IN INTERNATIONAL FINANCE

26. Klaus Friedrich, *A Quantitative Framework for the Euro-Dollar System.* (Oct. 1970)
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*11. Edward Tower and Thomas D. Willett, *The Theory of Optimum Currency Areas and Exchange-Rate Flexibility*. (May 1976)
12. Ronald W. Jones, *"Two-ness" in Trade Theory: Costs and Benefits*. (April 1977)

REPRINTS IN INTERNATIONAL FINANCE

13. Benjamin J. Cohen, *Sterling and the City*. [Reprinted from *The Banker*, Vol. 120 (Feb. 1970)]
14. Fritz Machlup, *On Terms, Concepts, Theories and Strategies in the Discussions of Greater Flexibility of Exchange Rates*. [Reprinted from *Banca Nazionale del Lavoro Quarterly Review*, No. 92 (March 1970)]
15. Benjamin J. Cohen, *The Benefits and Costs of Sterling*. [Reprinted from *Euro-money*, Vol. 1, Nos. 4 and 11 (Sept. 1969 and April 1970)]
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