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THE EVOLUTION OF RESERVE CURRENCY DIVERSIFICATION

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Contents

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1. Introduction*

In the late 1970s, when the US dollar was under strong pressure, reserve diversification in the form of a sharp shift on the part of central banks towards holding currencies other than the dollar in their foreign exchange reserves was believed to have been a contributing factor. Some viewed this development with concern, fearing that it might destabilise financial conditions in the international monetary system. This provoked the international debate of 1979 as to whether and how SDRs might be substituted for the "dollar overhang". When the dollar gained strength in the 1980s, however, the issue of reserve diversification lost much of its earlier interest. In addition to the recovery of the dollar on the exchange markets, other developments on the international monetary scene help to explain this loss of interest: firstly, the currency composition of aggregate foreign exchange reserves seems to have been relatively stable since 1980; secondly, there is a growing perception among researchers and practitioners alike that the impact of official reserve management on exchange rates has weakened with the rapid expansion of private portfolios and exchange transactions. The dollar began to depreciate once again in early 1985, but there has been no loss of confidence in the US currency comparable with what happened in the 1970s. Accordingly, concern about a "dollar overhang" in private or official circles has so far been less evident than was previously the case.

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The aim of this paper is to shed some light on the facts of reserve diversification since the early 1970s. Two points need to be made before we examine the available information on the subject. Firstly, the extent of diversification cannot be judged by looking at changes in the currency composition of global exchange reserves, since this is affected not only by changes in the currency composition of individual countries' reserves but also by other factors. For example, changes in the distribution across countries of total exchange reserves can affect the currency composition of global exchange reserves, since countries do not all hold identical baskets of reserve currencies. Thus, if the reserves of countries which tend to hold a high proportion of dollars in their portfolios increase more rapidly than those of countries which hold a smaller proportion of dollars, the share of the dollar in global exchange reserves will increase, and vice versa. Secondly, no information is available on the currency composition of most individual countries' exchange reserves, so that the discussion of diversification is limited to changes in the currency composition of the reserves of groups of countries.

Section 2 of this paper shows that, after adjusting for factors which affect the currency composition of global exchange reserves but which are unrelated to changes in countries' currency preferences, there was no large-scale diversification of reserves out of dollars into other currencies during the period under review *by groups of countries*. In the 1970s the adjusted proportion of dollar holdings in their foreign exchange reserves remained virtually unchanged, whereas in the early 1980s it showed a decline in some instances. In a statistical sense, therefore, reserve diversification occurred in the latter rather than in the earlier part of the period.

The absence of large-scale reserve diversification out of the dollar is perhaps surprising both in view of the increase in international trade and other transactions denominated in secondary reserve currencies, such as the Deutsche Mark and the Japanese yen, and also in the light of the potential gains to be realised from currency diversification in terms of return/risk in the portfolio management of floating currencies. This paradox is examined in Section 3, which

tentatively concludes that reserve diversification in a number of countries has been limited by the extent to which reserves are held as transactions balances. These findings are reviewed in Section 4 from the perspective of recent exchange rate developments and reserve conditions.

In this paper gold, SDRs and IMF reserve positions are not taken into account. ECUs created within the EMS, on the other hand, are treated as if they were gold and dollars, i.e. dollars swapped against ECUs are included in the dollar holdings of EMS member countries and gold swapped against ECUs is excluded from foreign exchange reserves. This treatment is consistent with the legal characteristic of the ECU whereby ownership of the reserve assets swapped against ECUs remains with the individual member countries.[1] As far as country groupings are concerned, the countries which report reserve data to the IMF are classified into industrial countries, oil-exporting developing countries and non-oil developing countries. Although this traditional distinction has recently become tenuous, it remained meaningful during most of the period under review.

[1] The characteristics of the ECU that are different from those of foreign currency reserves in terms of usability and yield are as follows. Firstly, official ECUs are created by and can be used between official holders within the European Monetary System. Non-member countries can buy and sell private ECUs in the markets, but the ECU private markets have been too thin for large-scale central bank operations. Secondly, even for EMS central banks it has been impossible to intervene in exchange markets using official ECU balances, because private and official ECUs are separated. Intervention within the EMS has been conducted largely in EMS member currencies and dollars, while ECUs swapped against dollar and gold reserves are used for the settlement of debts arising from interventions and other transfers. Thirdly, the ECU has only limited convertibility into currencies in these official transactions. ECUs can, without challenge, be used for the settlement of borrowing under the very short-term financing facility up to a certain limit. Apart from this, there was no guarantee during the period under review that ECUs would be accepted by member central banks. It was only after the introduction of the ECU mobilisation mechanism and the relaxation of acceptance limits in July 1985 that the scope of the ECU's convertibility was somewhat widened — see Micossi (1985) and Bank for International Settlements (1986). Finally, the dollars swapped against ECUs differ little from ordinary dollar holdings with respect to yields on reserve investments, because the conversion rate of dollar/ECU swaps is fixed throughout the swap period and each EMS central bank receives dollar interest rates from its preferred investment. Gold/ECU swaps are also carried out at a flat rate.

2. Trends in reserve diversification since the early 1970s

An overview of the currency composition of global foreign exchange reserves

The view seems to be widely held that there was a marked diversification out of the dollar into the Deutsche Mark, the Japanese yen and the Swiss franc in the 1970s, which was halted in the 1980s with the reversal of the decline in dollar exchange rates.[2] Table 1 shows the currency composition of foreign exchange reserves since the end of 1970. A cursory look at the table lends support to this view. In fact, the dollar's share in global foreign exchange reserves declined markedly from 77 per cent. at end-1970 to 67 per cent. at end-1980, when the declining trend virtually stopped. The pound sterling followed a similar trend; it represented more than 10 per cent. of global exchange reserves in 1970, but has accounted for no more than 3 per cent. since the mid-1970s. On the other hand, the share of the Deutsche Mark registered a substantial increase in the 1970s, followed by a modest decline in the 1980s. The Swiss franc showed a similar trend to the Deutsche Mark, but to a much smaller degree in terms of global reserve volumes — although not in relation to the Swiss domestic economy. The Japanese yen also increased its share in global foreign exchange reserves in the 1970s and, unlike the Deutsche Mark and the Swiss franc, has continued its advance in the 1980s.

Factors affecting the currency composition of global reserves

Changes in the currency composition of global foreign exchange reserves may result not only from individual countries' alteration of

[2] For example, Dini (1984) says: "In the first years of floating, with confidence in the dollar faltering as a result of accelerating inflation and expansionary policies in the United States, the demand for Deutsche Mark, Japanese yen and Swiss francs by official reserve holders increased substantially, fostering the development of a multicurrency reserve system. This tendency came to a halt in 1980, however, when the United States returned to sounder domestic policies and the dollar started to strengthen. Indeed, after falling by about ten percentage points during the seventies, the share of dollars in official foreign currency holdings has since recovered part of the lost ground, and now stands at about 70 per cent."

Table 1
Estimated currency composition of global foreign exchange reserves, 1970–84
(year-end figures, in percentages)

	1970	1972	1976	1980	1982	1983	1984
US dollar	77.2	78.6	76.6	67.2	68.4	68.5	65.8
Deutsche Mark	1.9	4.6	8.8	14.8	12.4	11.2	12.1
Japanese yen	–	0.1	2.1	4.3	4.6	4.7	5.4
Swiss franc	0.7	1.0	2.2	3.2	2.7	2.3	2.0
Pound sterling	10.4	7.1	1.9	2.9	2.4	2.6	2.8
French franc	1.1	0.9	1.6	1.7	1.3	1.1	1.0
Other currencies	8.7	7.7	6.8	5.9	8.2	9.6	10.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Improvements in data collection over the period covered by the table mean that the series are not wholly consistent over time.

their own reserve composition but also from other factors, which can be broadly classified as distribution effects and statistical inconsistencies. Distribution effects arise when a change occurs in the distribution of reserves between countries which have different currency preferences. For example, if a country which holds its reserves entirely in US dollars increases them by more than countries whose reserves include a proportion of other currencies, this change in reserve distribution results in a larger proportion of dollar assets in global reserves on an aggregate basis. On the other hand, if the growth rates of total foreign exchange reserves in individual countries are similar *or* if the currency compositions of their reserves are similar, distribution effects are negligible.[3] As far as statistical inconsistencies are concerned, not all the countries whose reserve holdings are included in the global aggregates report the currency composition of their foreign exchange reserves to the IMF. As a result, the currency composition of global reserves changes when there is a change in the coverage of the reporting countries. For example, when the coverage widens, the shares of identified currencies go up and that of "other currencies" falls,

because the reserves of countries whose composition is not reported are included in "other currencies".

More specifically, the following sources of distribution effects and statistical inconsistencies since the early 1970s may be identified. Firstly, the foreign exchange holdings of the US authorities, which by definition consist of currencies other than the dollar, increased much more rapidly than those of other countries. The US exchange reserves rose from SDR 0.2 billion at the end of 1972 to SDR 6.8 billion at the end of 1984, while other countries' reserves expanded by 220 per cent. in SDR terms. This marked growth of US reserves automatically reduced the share of the dollar in global reserves and increased the shares of the Deutsche Mark and the yen, the currencies in which the US authorities accumulated foreign exchange reserves.

Secondly, the pattern of reserve growth in Germany and Japan differed from that in other countries during this period. In theory, these countries could hold non-dollar currencies, with, for example, Germany holding yen and Japan holding Deutsche Mark. In practice, however, their foreign exchange reserves seem to have been virtually all in dollars.[4] During the period under review, when reserve currencies floated against each other, the exchange reserve holdings of Germany and Japan did not increase as rapidly as those

[3] This can be shown as follows. The definitions of symbols are:
R_{ij}: country i's holdings of currency j,
R_i: country i's total foreign exchange reserves ($=\sum_j R_{ij}$),
W_{ij}: currency j's share in R_i ($=R_{ij}/R_i$),
$\bar{R}$: aggregate foreign exchange reserves of all countries ($=\sum_i R_i$),
α_i: country i's reserve share in $\bar{R}$ ($=R_i/\bar{R}$).
The aggregate holding of currency j is $\sum_i R_{ij}=\sum_i W_{ij}R_i=\sum_i W_{ij}\alpha_i\bar{R}$. Hence currency j's share in $\bar{R}$ is $W_j=\sum_i R_{ij}/\bar{R}=\sum_i W_{ij}\alpha_i$. A change in W_j is therefore
$\Delta W_j=\sum_i \Delta W_{ij}\alpha_i+\sum_i \Delta\alpha_i W_{ij}+\sum_i \Delta\alpha_i \Delta W_{ij}$ ... (*).
The first term on the right-hand side represents the effects arising from individual countries' changing of their own composition and the second term represents the distribution effects, the final term being a cross-effect. If α_i=const., then by definition there is no distribution effect. On the other hand, if all the countries have the same currency composition $\bar{W}_j$, i.e. $W_{ij}=\bar{W}_j$, the distribution effect is also zero, because $\sum_i \Delta\alpha_i . W_{ij}=\bar{W}_j \sum_i \Delta\alpha_i=0$ (note $\sum_i \alpha_i \equiv 1$).

of the rest of the world. Consequently, these two countries' reserve holding behaviour tended to reduce the share of dollar reserves in the global aggregate and to increase the shares of all the other currencies.

Thirdly, the patterns of reserve growth differed significantly between developing countries and industrial countries. As a result of the 1973 oil price hike, the foreign exchange reserves of oil-exporting developing countries expanded rapidly in the mid-1970s, while a number of non-oil developing countries accumulated considerable reserves through borrowing on the international capital markets in the late 1970s. Between end-1972 and end-1984 the combined exchange reserves of these two country groups quintupled in SDR terms, while those of industrial countries, excluding the three largest reserve centre countries, grew 2.7 times. Because the aggregate reserves of developing countries contained a lower proportion of dollars than those of industrial countries in the early 1970s, this difference in reserve growth also tended to contribute to the decline in the dollar share in global reserves.

Finally, as far as statistical inconsistencies are concerned, the foreign exchange reserves of those countries which do not report their currency composition increased by more than those for which a breakdown was available during this period. A highly significant example is Taiwan, whose reserves are estimated to have expanded by nearly $15 billion. The increase in unspecified reserve holdings automatically reduced the proportions of the dollar and other specified currencies in aggregate global reserves.

[4] As the Deutsche Mark and the yen represent the counterparts of private and official portfolio shifts out of and into the dollar, Germany and Japan have taken the main responsibility in exchange market interventions to influence dollar exchange rates. Under such circumstances, the inclusion of German and Japanese reserves in the global aggregates may mask underlying developments in the rest of the world. For example, if the Deutsche Bundesbank acquires dollars to neutralise dollar sales and Deutsche Mark purchases by other central banks, the global composition will under-represent the diversification attempts by the latter central banks. For further examples of how the currency composition of global reserves, including those of Germany and Japan, changes as a result of reserve shifts by other countries, see Kenen (1983).

The extent to which each of these distribution effects and statistical inconsistencies has contributed to changes in the currency composition of global foreign exchange reserves can be estimated statistically by the following procedure (for further details see Appendix 1). Firstly, the incidence of US reserve holdings can be estimated by comparing the currency composition of the aggregate reserves of all countries with that of reserves excluding US holdings.[5] Similarly, by comparing the currency composition of aggregate reserves with that of reserves excluding the holdings of countries not reporting a breakdown an estimate can be obtained of the effects of statistical inconsistencies.[6] Thirdly, the influence of German and Japanese reserves can be estimated by comparing the global currency composition of exchange reserves with that of all countries excluding Germany and Japan, on the assumption that these two countries have held only dollar reserves. Finally, the distribution effects arising from changes in shares of different groups of countries in total exchange reserves can be assessed by constructing the following hypothetical currency composition for the global aggregate (excluding the United States, Germany, Japan and countries not reporting a breakdown). Assuming that there have been no changes in the currency composition of reserve holdings within each of the three country groups (industrial countries, oil-exporting developing countries and non-oil developing countries) since the beginning of the period, the hypothetical amounts of individual currency holdings by each country group are calculated for the end of the period. These hypothetical amounts are then summed up to obtain a hypothetical composition of global reserves.

[5] In order to exclude US reserve holdings from the global total, US holdings of individual currencies have to be estimated. In this paper they are estimated by examining the United States' total foreign exchange holdings, its transactions with the IMF, annual exchange market interventions as disclosed in the Annual Reports of the Federal Reserve Board, the issuance of foreign currency bonds by the Treasury and other official transactions.

[6] The reserves of countries which do not report a full breakdown are estimated by subtracting the sum of reserves held by industrial countries, oil-exporting countries and non-oil developing countries from global exchange reserves.

By comparing this hypothetical composition with the actual composition of global reserves at the beginning of the period, one can estimate the effect of distributional changes *between* country groups.

The estimate obtained by applying this procedure to the period between end-1972 and end-1984 is shown in Table 2, in which the first and second factors are combined under the heading "US and statistical effects" because both are rougher estimates than the third and fourth factors, viz. "German and Japanese effects" and "Other distribution effects". The difference between the sum of the four factors and the actual change in the currency composition of global reserves is termed "net diversification". This "net diversification" consists of the effects of two different factors affecting the composition of global exchange reserves. One is changes in the currency composition of individual countries' reserves and the other is distributional changes *within* each country group. Since there are no published data on the currency composition of individual countries' reserves, the contributions of these two effects cannot be separated.

As mentioned earlier, however, distribution effects are negligible if patterns of reserve growth are similar across countries or if the currency composition of reserve holdings is similar. Since the growth patterns of individual countries' total reserves are known, the following inferences can be made as to the importance of distribution effects within country groups. Firstly, distributional effects within the group of oil-exporting developing countries seem to have been relatively small. The reported shares of individual countries in this group's aggregate foreign exchange reserves did not change much during the period under review, with the exception of that of Libya.[7] As far as non-oil developing countries are concerned, however, distribution effects may have been larger, since there were a number of significant changes in countries' relative holdings of foreign exchange reserves within this group. For example, the People's Republic of China was not a member of the IMF before 1980, but at the end of 1984 it was the group's largest reserve

Table 2
Changes in the currency composition of global foreign exchange reserves, end-1972 to end-1984

Items	US dollar	Deutsche Mark	Japanese yen	Pound sterling	Swiss franc	French franc	Others
	in percentages						
Composition							
at end-1972	78.6	4.6	0.1	7.1	1.0	0.9	7.7
at end-1984	65.8	12.1	5.4	2.8	2.0	1.0	10.9
Changes in shares	−12.8	7.5	5.3	− 4.3	1.0	0.1	3.2
of which:							
US + statistical effects[1]	− 4.2	0.3	0.3	− 0.1	− 0.1	− 0.1	3.9
German + Japanese effects[2]	− 3.8	− 0.2	− 0.9	2.8	−	0.1	1.9
Other distribution effects[3]	− 3.6	0.8	− 0.1	1.0	−	0.4	1.5
Net diversification[4] .	− 1.2	6.6	6.0	− 8.0	1.0	− 0.3	− 4.1
Memorandum item:							
Net diversification in sub-periods[5]							
end-1972–76	*3.4*	*4.8*	*2.6*	*−10.0*	*1.4*	*0.3*	*− 2.5*
end-1976–79	*− 2.6*	*3.5*	*0.8*	*−*	*−*	*− 0.3*	*− 1.4*
end-1979–84	*− 3.5*	*− 1.2*	*2.4*	*1.1*	*−*	*− 0.2*	*1.4*

[1] The estimated effects of US reserve changes plus the effects of statistical inconsistencies in connection with the reserve holdings of countries not reporting a currency breakdown.
[2] The effects of changes in German and Japanese reserves, which are assumed to consist entirely of dollars.
[3] The effects arising from changes in reserve distribution between three groups of countries: industrial countries (excluding the United States, Germany and Japan), oil-exporting developing countries and non-oil developing countries.
[4] The effects arising from changes in currency composition within each of the three country groups. This item includes the effects of distributional changes within each group and changes in the currency composition of individual countries' reserves.
[5] Owing to the existence of cross-terms and to rounding, the figures for the three sub-periods do not necessarily add up to the figures for the whole period.
For further details see Appendix 1.

holder,[8] while reserve growth in most European developing countries was very modest between the early 1970s and the mid-1980s. The distribution effects within the group of industrial countries may also have been significant, as will be discussed in rather more detail in the following sub-section.

All the estimates in Table 2 are made on the basis of the currency composition calculated at current exchange rates. Thus, "net diversification" and other factors are influenced by valuation effects arising from exchange rate changes. The implications of exchange rate effects for reserve currency diversification will also be discussed in the following sub-section.

Net diversification: end-1972 to end-1984

One of the most noteworthy aspects of the changes in the currency composition of global reserve holdings revealed in the above table is that a significant part of the overall decline in the share of the dollar between end-1972 and end-1984 is accounted for by factors other than those commonly associated with reserve diversification by individual countries. Of a 12.8 percentage point drop in the dollar share, 4.2 percentage points are directly attributable to the effect of US reserve holdings and statistical inconsistencies, resulting from the larger reserve accumulation in the United States and countries not reporting a breakdown than in other countries. The slower-than-average growth of German and Japanese reserves accounts for a 3.8

[7] Libya's share in the foreign exchange reserves of oil-exporting developing countries fell by 25 percentage points between end-1972 and end-1984. However, even if the proportion of a particular currency, say the US dollar, in Libya's reserves had differed from that in the rest of the group by as much as 20 percentage points, the decline in Libya's share in the country group would have caused a distribution effect of no more than a half percentage point on a global basis. This can be shown as follows. Let country 1 be Libya and country 2 the others in the group in equation (*) in footnote 3. The distribution effect is $\sum_i \Delta\alpha_i.W_{ij}=\Delta\alpha_1 W_{1j}-\Delta\alpha_1 W_{2j}$. Let β be the difference between currency j's share in Libya's reserves and in those of the rest of the group. The distribution effect will be $\Delta\alpha_1 W_{1j}-\Delta\alpha_1(W_{1j}-\beta)=\Delta\alpha_1.\beta$. Suppose $\beta=0.2$, i.e. Libya's holdings of currency j are 20 per cent. higher than the average. The decline in Libya's share in the reserves of oil-exporting developing countries between end-1972 and end-1984 was 25 percentage points. Therefore, $\Delta\alpha_1\beta=(0.2)(0.25)=0.05$, i.e. 5 per cent. The effect on global reserves would have been approximately 0.5 per cent., since the total foreign exchange reserves of oil-exporting developing countries accounted for one-tenth of global reserves at end-1972.

[8] China's share in the total foreign exchange reserves of non-oil developing countries went up from zero at end-1972 to 18 per cent. at end-1984. This reserve growth alone may have caused a distribution effect of 0.7 percentage points, supposing the proportion of a particular currency in China's reserves differed from that in the rest of the group by 20 percentage points.

percentage point decline in the dollar share. The other distributional effects are responsible for an additional decline of 3.6 percentage points, which reflects the faster reserve expansion in developing countries than in industrial countries (excluding the United States, Germany and Japan). Leaving these factors aside, "net diversification" accounts for a drop of only 1 percentage point in the dollar share in global exchange reserves during the period under review.

On balance, the share of the Deutsche Mark has been much less affected by these rather special factors. Its overall increase by 7 percentage points to 12 per cent. at the end of 1984 broadly matches the increase due to "net diversification" of exchange holdings, whereas the effects of German and Japanese reserve holdings partly offset those of other distributional changes and statistical inconsistencies. The same applies to Swiss franc reserves, whose overall increase of 1 percentage point represents "net diversification". The rise in the yen's share in global reserves, on the other hand, is understated to the extent that the effect of "net diversification" was partly masked by changes in German and Japanese reserves, still held virtually exclusively in dollars despite a rapid increase in yen reserves in other countries.

The overall change in sterling reserves is also understated, but in the opposite direction. Since the foreign exchange reserves of countries holding larger proportions of sterling in their portfolios grew faster than those of other countries, including Germany and Japan, sterling reserves would have increased somewhat on a global basis during this period, had it not been for shifts out of that currency within each group of countries. The net effect of this shift out of sterling is estimated to have been an 8 percentage point drop in global sterling reserves. This marked diversification out of sterling reserves may, to a certain extent, be attributed to the fact that several countries within the traditional sterling area which had been dissuaded from reserve currency switching under the fixed exchange rate system became less constrained under the flexible exchange rate system, and sterling balances were converted into other currencies.

A breakdown of the period of currency floating into three sub-periods, the dividing lines being drawn at the end of 1976 and the end of 1979, shows that "net diversification" out of the dollar occurred in the first half of the 1980s rather than in the mid and late 1970s. Between end-1972 and end-1976 there was even an increase in the share of dollar reserves due to "net diversification", amounting to 3 percentage points. The shares of the Deutsche Mark and the yen also rose, by 5 and 3 percentage points respectively. On the other hand, there was a pronounced diversification out of sterling reserves, corresponding to 10 percentage points.

Between end-1976 and end-1979 there was, indeed, some diversification out of the dollar into the Deutsche Mark, as indicated by the 2½ percentage point fall in the dollar share and the 3½ percentage point rise in the DM share. However, these changes in currency composition are largely accounted for by the depreciation of the dollar against the Deutsche Mark on the exchange markets. In the sense that central banks accepted the changes in reserve composition due to exchange rate movements, the diversification in this period may be viewed as "passive" diversification. Another noteworthy development in this period is that diversification out of sterling virtually stopped.

Developments in "net diversification" between end-1979 and end-1984 contrast markedly with those in the two preceding periods. For one thing, there was a more significant shift out of the dollar in the first half of the 1980s. In this period the dollar share fell by 3½ percentage points, while the yen and sterling shares rose by 2½ and 1 percentage points respectively. Moreover, this diversification out of the dollar took place despite a rapid appreciation of the dollar against other reserve currencies. Unlike developments in the late 1970s, therefore, the "net diversification" in this period resulted from an intentional, or at least conscious, modification of reserve composition on the part of holders. The recovery of the sterling share is also remarkable in view of the fact that sterling depreciated more sharply than any other reserve currency in this period. On the other hand, the small decline in the DM share was due, to a

significant extent, to the depreciation of the Deutsche Mark on the exchange markets.

These details of the net changes in global currency holdings may be supplemented by an examination of their regional breakdown. Table 3 shows the volume of changes in currency holdings accounted for by "net diversification" and/or intra-group shifts in industrial countries, oil-exporting developing countries and non-oil developing countries. In the period from end-1972 to end-1976, substantial shifts out of sterling were recorded in all the country groups. In the industrial countries dollar, DM and yen reserves increased as a counterpart of the decline in sterling reserves, while dollar reserves rose considerably in the non-oil developing countries. In the oil-exporting developing countries, on the other hand, dollar reserves fell somewhat, together with sterling reserves, these declines being offset by increases in all the other currencies.

In the period from end-1976 to end-1979 there was no further diversification out of sterling in any country group. Although the table shows a net shift out of sterling by SDR 1 billion in the industrial countries, this was entirely accounted for by a substantial accumulation of foreign exchange — non-sterling — reserves by the United Kingdom. As far as dollar reserves are concerned, however, the oil-exporting and non-oil developing countries reduced their dollar holdings by SDR 2 and 3 billion respectively, while in the industrial countries dollar reserves continued to increase.

Developments in individual country groups in the period from end-1979 to end-1984 can be summarised as follows. Firstly, there was a partial recovery of sterling holdings in the industrial countries and non-oil developing countries despite negative valuation effects due to the depreciation of sterling. Secondly, there were no additional increases in DM and yen reserves of the oil-exporting and non-oil developing countries. A decrease in their DM holdings and a minor change in yen holdings reflected to a large extent the marked depreciation of the Deutsche Mark and relative stability of the yen on the exchange markets. Finally, there was some shift out of dollar reserves in the industrial countries despite these exchange

Table 3
Details of net diversifications, end-1972 to end-1984[1, 2]

	US dollar	Deutsche Mark	Japanese yen	Pound sterling	Swiss franc	French franc	Others
	in billions of SDRs						
Industrial countries[3]							
end-1972–76	*1*	*3*	*2*	*– 3*	*0*	*0*	*– 3*
end-1976–79	*1*	*3*	*– 1*	*– 1*	*0*	*0*	*– 2*
end-1979–84	*–12*	*5*	*5*	*1*	*1*	*0*	*0*
end-1972–84	– 9	16	8	– 6	1	1	– 9
Oil-exporting developing countries							
end-1972–76	*– 1*	*3*	*1*	*– 6*	*1*	*1*	*2*
end-1976–79	*– 2*	*2*	*1*	*0*	*0*	*0*	*0*
end-1979–84	*– 1*	*– 3*	*0*	*0*	*0*	*0*	*4*
end-1972–84	– 4	2	2	– 7	1	0	6
Non-oil developing countries							
end-1972–76	*5*	*0*	*1*	*– 4*	*1*	*– 1*	*– 2*
end-1976–79	*– 3*	*2*	*2*	*0*	*0*	*0*	*– 1*
end-1979–84	*5*	*– 5*	*1*	*1*	*– 1*	*0*	*– 1*
end-1972–84	11	– 1	5	– 6	1	– 2	– 8
All countries[4, 5]							
end-1972–76	*4*	*6*	*3*	*–13*	*2*	*0*	*– 3*
end-1976–79	*– 4*	*6*	*2*	*0*	*0*	*0*	*– 3*
end-1979–84	*– 8*	*– 3*	*6*	*3*	*0*	*– 1*	*2*
end-1972–84	– 3	16	15	–20	3	– 1	–10

[1] The figures for each country group indicate the differences between actual currency holdings at the end of each sub-period and hypothetical holdings assuming that the currency composition remained the same as at the end of the year preceding the period under review.
[2] Owing to the existence of cross-terms, the shifts during the three sub-periods do not add up to the shifts during the period combined.
[3] Excluding the United States, Germany and Japan.
[4] Excluding the United States, Germany and Japan and countries whose currency compositions are unavailable.
[5] These figures are not necessarily equal to the sum of country groups' figures owing to rounding.

rate developments. At the end of 1984 the dollar holdings of the industrial countries (excluding the United States, Germany and Japan) were SDR 12 billion less than they would have been if the currency composition of their reserves had remained the same as

five years earlier, while their DM and yen reserves were each SDR 5 billion higher.

To sum up, as far as dollar reserves are concerned, the picture of reserve diversification presented by the statistics which show the decline of the dollar share in global reserves has been exaggerated by factors other than countries' attempts to change reserve currency composition. When adjustment is made for such factors, only a limited degree of diversification out of dollar assets can be observed in two instances since the early 1970s. One was the diversification carried out by the oil-exporting and non-oil developing countries in the late 1970s; however, this diversification may have resulted directly from the valuation effects of the depreciation of the dollar against other reserve currencies. The other was the diversification observed in the reserves of the industrial countries in the first half of the 1980s. In this case the estimated degree of diversification, which is larger than in the first case mentioned, may understate the shift out of dollar reserves to the extent that it was partly offset by the valuation effects of the appreciation of the dollar on the exchange markets. As far as sterling reserves are concerned, on the other hand, there was a rapid diversification out of sterling into dollar, DM and yen reserves in all the country groups in the mid-1970s, but this came to a halt in the late 1970s and was followed by a partial recovery in the 1980s.

Certain reservations should be expressed with regard to this summary of findings. Firstly, since the effects of distributional changes on the currency composition of global reserves are estimated on the basis of country groups rather than individual countries, the "net diversification" may have resulted from changes in the distribution of reserves within a country group. For example, between end-1979 and end-1984, when some reserve diversification took place in the industrial country group, Norway and Australia accumulated considerable amounts of foreign exchange reserves. As a result, the combined share of these countries within the group (excluding the United States, Germany and Japan) went up by 11 percentage points during this period. On the other hand, the

reserves of the United Kingdom fell, resulting in a 12½ percentage point decline in the United Kingdom's share within the group. Since no other industrial country saw a change in its share by more than 2½ percentage points, distributional effects within this country group should have been concentrated on the effects of the changes in the reserve shares of these three countries. If Australia and Norway had held proportionally fewer dollar reserves than the United Kingdom, the "net diversification" out of the dollar in the 1980s estimated above on the basis of the industrial country group would be an overestimate.[9]

Secondly, these "net" changes in the currency composition of country groups' reserves do not necessarily represent "gross" changes in each country group. In other words, the "net" changes may have resulted from two different directions of diversification: taking, for example, the diversification in the 1980s, some countries diversified their reserve holdings out of the dollar into the Deutsche Mark and others out of the Deutsche Mark into yen and sterling.

Finally, the currency diversification discussed here concerns only those official holdings of foreign exchange that are classified and reported to the IMF as reserve assets. As will be mentioned later in this paper, some central banks are known to hold official external assets in addition to their reported foreign exchange reserves. It is possible that these central banks have changed the currency composition of other external assets in quite a different way from that in which they have managed their foreign exchange reserves.

3. Theory and reality of reserve diversification

A trend towards currency diversification of official reserves, or, more broadly speaking, towards a multi-currency reserve system,

[9] Even if the proportion of dollars in Norwegian and Australian reserves was 20 per cent. less than that in UK reserves, the "net diversification" of SDR 12 billion in Table 3 is overestimated by no more than SDR 2½ billion.

has often been suggested as being a natural or even an inevitable evolution for several reasons. Firstly, there seems to have been faster long-run growth in the Japanese and German economies in terms of production and international trade than in that of the United States; to this extent it is often said that the world economy is becoming more "polycentric".[10] Secondly, reflecting this at least in part, exchange rate arrangements in a number of countries have also changed from de facto pegging to the dollar to various kinds of arrangement in which dollar exchange rates are relatively less important. Thirdly, the adoption of a floating exchange rate regime in major countries is believed to have given additional momentum to reserve diversification. It is argued that under floating rates there is a large potential gain to be derived from diversified currency holdings in terms of portfolio return/risk and that there is hardly any practical constraint on countries aiming their reserve management at such a gain. Increased depth in foreign exchange markets also appeared to support this trend by reducing the advantages of using a common vehicle currency in international transactions. On the other hand, there are reasons to believe that certain factors may have tended to check potential moves towards currency diversification, such as the inertia due to conservatism and the predominant role that the US dollar has continued to play in international financial transactions. This section sets against this background the main finding of the previous section, viz. an absence of marked reserve diversification out of the US dollar, except for some build-up of reserves in other currencies by industrial countries during the early 1980s.

Trends in international trade

The linkage between the changing relative sizes of the economies of reserve currency countries and the extent to which their currencies are held in the reserves of other countries may be

[10] See Bernstein (1982) and Kindleberger (1985).

expressed by the following hypothesis. International trade in manufactured goods tends to be denominated in the sellers' currencies.[11] As exports of manufactured goods of countries other than the United States grew relative to US exports and to other countries' exports of primary products priced in dollars, private transactions in the non-dollar currencies increased. Accordingly, central banks found it convenient to hold these currencies for the purpose of intervening in the exchange markets or, in countries with exchange controls, in order to be able to supply them to residents against domestic currency.[12]

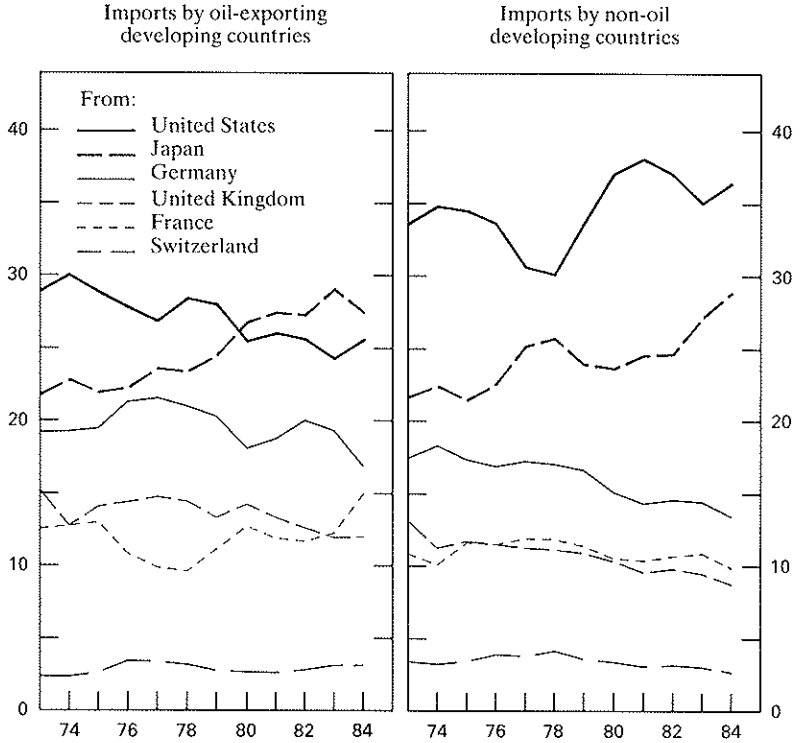
Despite the intuitive appeal of this argument, it is not confirmed by actual developments in the currency composition of reserves. Graph 1 shows the relative supply shares of six reserve currency countries in imports of developing countries. As far as imports of oil-exporting countries are concerned, the relative share of the United States showed a steady decline from the early 1970s onwards, while that of Japan grew markedly. The share of imports from other countries remained fairly stable. On the other hand, the US share in imports of non-oil developing countries increased in the early 1980s, following a fall in the 1970s. The Japanese share went up steadily in the 1970s and early 1980s, while the other countries' shares dropped.

These findings are supplemented by an examination of the imports of developing countries from all foreign countries. On this basis, too, the US share in oil-exporting countries' imports declined steadily between the early 1970s and the mid-1980s, while that of Japan increased. The share of the EEC countries remained virtually unchanged between 1974 and 1979 but fell markedly thereafter. The counterpart of this fall was to be found in the share of developing countries, which went up from 17 to 23 per cent. between 1979 and 1984, after showing fluctuations but no secular trend in the previous seven years. Assuming that most trade flows between developing countries are denominated in dollars, the rise in these countries'

[11] See Grassman (1973) and Table 3 in Kenen (1983).
[12] See Aliber (1982).

Graph 1

Relative shares of exporters in developing countries' imports*



Source: IMF Direction of Trade.

* The relative shares are calculated in relation to aggregate imports from these six countries.

share in oil-exporting countries' imports can be said to have offset the decline in trade conducted in US dollars due to the decline in the US share between the late 1970s and the mid-1980s. As far as imports by non-oil developing countries are concerned, the results obtained in Graph 1 do not change materially. The US share showed

a sharp decline between the early and mid-1970s, followed by a recovery. The Japanese share increased and the share of EEC countries fell throughout the period between the early 1970s and the mid-1980s. Since foreign trade within the group of non-oil developing countries expanded substantially during the decade ending in 1984, however, the increase in the Japanese share is less pronounced and the decline of the EEC share more pronounced on this basis than is suggested in Graph 1. Between 1975 and 1984 the share of non-oil developing countries in imports of other countries in the same group went up from 15 to 22 per cent., while the share of oil-exporting developing countries fluctuated between 12 and 16 per cent. Assuming, again, that a substantial part of trade in this country group is denominated in dollars, these increases and the aforementioned recovery of the US share should have contributed to a relative increase in dollar-denominated imports to non-oil developing countries since the late 1970s.

Comparing these changes with those in the currency composition of reserves in developing countries, there are only a few instances in which they are similar. Firstly, between the early and late 1970s there was a certain degree of diversification out of dollar reserves in oil-exporting developing countries while the US share in their imports declined. Secondly, between end-1979 and end-1984 the dollar share in these countries' reserves scarcely changed. Meanwhile, imports from the United States showed a relative decline, which may have been offset, in terms of dollar-denominated imports, by increases in imports from other developing countries. Thirdly, in the 1970s both oil-exporting and non-oil developing countries increased their yen reserves as their imports from Japan increased in relation to those from other countries.

These instances apart, the changes in the distribution of developing countries' imports contrast sharply with the developments in the currency composition of their reserves. As far as oil-exporting countries are concerned, the German and UK shares in their imports hardly changed between 1972 and 1979, when the Deutsche Mark share in their reserve portfolio increased and the

sterling share fell significantly. In the 1980s the yen's reserve share showed no increase despite a continued rise in the Japanese share in imports by these countries. As for the non-oil developing countries, the contrast between reserve and import developments is even sharper. Firstly, in the mid-1970s, when there was a marked reserve diversification out of sterling into the dollar, the US share in their imports fell significantly while the decline in the UK share was more modest. Secondly, the rise in the Japanese share in imports accelerated in the period after 1979, when the rise in the yen share in reserves slowed down. Finally, despite a marked turn-round of the US share in these countries' imports in the late 1970s, the dollar share in their reserves went up in both the mid-1970s and the early 1980s. When the shares of imports from oil-exporting and non-oil developing countries are added to the US share, taking account of the fact that they are largely dollar-denominated, the combined share fluctuated widely without any clear trend in the 1970s, and then increased in the early 1980s. In addition to these discrepancies between reserve composition and import distribution in the developing countries, the fact that in the industrial countries (excluding the United States, Japan and Germany), where DM reserves have recently increased, foreign trade with EEC countries has not expanded more than trade with other regions also runs counter to the hypothesis of a linkage between international trade and reserve holdings.[13] Of course, such a simple comparison is lacking in statistical precision, but the discrepancies suggested by this comparison seem too large to be attributable to the lack of rigour in statistical treatment alone.[14]

One explanation for the lack of correlation between the changes in patterns of international trade and those in reserve composition may be that the shares of currencies used for trade invoicing have

[13] The average share of imports supplied by EEC countries in total imports by industrial countries (excluding the United States, Germany and Japan) between 1973 and 1979 was 45.7 per cent., while that between 1979 and 1984 was 45.9 per cent. Furthermore, there was no increasing trend within the latter period, when reserve diversification took place.

changed significantly, so that increases in a reserve currency country's trade have not necessarily resulted in a larger proportion of trade being denominated in its currency.[15] In this connection, the Group of Thirty (1985) received interesting replies from large international corporations to its questions regarding the currencies used for invoicing, noting that companies have become more flexible in denominating sales in different currencies in the 1980s in order to accommodate customers, whereas in the 1970s there was a preference for denominating exports in domestic currency.[16] Although this finding has an extremely important implication for the choice of an invoicing currency and may necessitate a re-examination of earlier theories about it,[17] there seems to be no

[14] For example, the aggregate figures do not necessarily reflect the precise relationship between the reserve holdings and import composition of individual countries, since reserve/import ratios differ across countries. However, this discrepancy does not seem to give rise to any serious problem in interpreting the aggregated figures. For one thing, despite differences in reserve/import ratios across countries, the ratios have, on balance, moved in the same direction. In addition, the differences in reserve/import ratios in fact only slightly affect the relative shares of exporting countries. For example, the relative share of each reserve currency country in the aggregated imports of the twelve largest reserve holders (China, Brazil, Singapore, Mexico, India, Malaysia, Israel, Korea, Chile, Hungary, Thailand and Peru), which accounted for 74 per cent. of the total foreign exchange reserves of non-oil developing countries, does not differ significantly from that of the weighted average taking account of relative reserve holdings. The shares of the United States, Japan, Germany, the United Kingdom, France and Switzerland in the twelve countries' aggregate imports in 1984 were 41, 36, 10, 6, 4 and 2 per cent. respectively, while the weighted averages taking account of reserve holdings would work out at 42, 32, 12, 7, 5 and 3 per cent. respectively.

[15] This paper does not discuss the level or proportion of a currency used for international trade. It is well known that the US dollar has been used much more extensively in Japanese exports than in those of other large industrial countries, which might have contributed to a much smaller percentage share of the Japanese yen in global reserves than in imports during the whole period under review. However, the argument about levels does not account for the difference in directions of changes in reserve composition and international trade in that period.

[16] Increasing intra-company trade across borders by large international firms, as suggested by Little (1985), may have contributed to greater consideration of the currency of invoicing as part of marketing strategy. The development of efficient hedging devices such as futures and options may also have played a part.

[17] Magee and Rao (1980) and Melvin and Klein (1983) argue that the choice depends on expectations of the intertemporal stability of cash flows. In view of the Group of Thirty's finding, the invoicing issue has to be reviewed in the context of comprehensive corporate planning which integrates marketing and financial decision-making.

statistical evidence yet to indicate that invoicing in yen declined in the 1980s to counter the growth in imports by developing countries from Japan or that dollar invoicing in intra-industrial country trade declined in relation to DM invoicing in the same period so as to decrease dollar-denominated trade and to increase DM-denominated trade in this area. Rather, the incomplete statistics suggest that since the early 1970s the share of dollar invoicing in exports from major European countries has been relatively stable, while that of yen invoicing has increased, at least as far as exports from Japan are concerned.[18] In conclusion, central banks' decisions as to currency holdings do not appear to have merely reflected the underlying use of currencies in international trade. Therefore, even if the world economy is becoming "polycentric" in this limited sense, which is open to question, it is not a sufficient condition for currency diversification in official reserves.

From the standpoint of some central banks' reserve management, capital transactions are a more important factor. They outweigh trade in goods and services in many countries. Shocks to a country's balance of payments which ultimately require its central bank to absorb or inject foreign exchange are often caused by sudden capital inflows or outflows. Even when a shock is triggered by a large fluctuation in the current account, the ultimate magnitude of the shock crucially depends on the behaviour of private capital flows, whether stabilising or destabilising. Such relationships between international capital flows and reserve management will be discussed later in this paper in connection with factors checking the move towards diversification.

Exchange rate arrangements: actual practice and stated intentions

Since March 1973, when major currencies started to float against the US dollar, many countries have changed their exchange rate arrangement. Virtually no industrial country's currency has been pegged to the dollar since the advent of the floating system, while a

[18] See Kenen (1983) and Taguchi (1982).

number of European currencies have been linked formally or informally to the Deutsche Mark. Developing countries have also modified exchange rate arrangements significantly, although the process took place more slowly. By the end of 1985 the number of developing countries pegging their currency to the dollar had dropped to 31 out of 128. All the developing countries that abandoned pegging to the dollar adopted pegging to a composite of currencies or managed floating with or without a specific indicator.

Countries' formal exchange rate arrangements, however, do not necessarily represent their actual management of exchange rates to maintain stability vis-à-vis reserve currencies. For example, a country may peg its currency to a basket of major currencies in which the dollar carries a significant weight. In this case the country may be viewed as pegging to the dollar de facto in the sense that its exchange rate is stable in terms of the US dollar. An opposite case is a country which pegs its currency to the dollar but changes its parity so frequently that its exchange rate against the dollar fluctuates just like that of a floating currency. In this sub-section, we shall first examine changes in actual exchange rate management in developing countries since the early 1970s and then consider whether these changes have been followed by analogous changes in the currency composition of reserves. We shall go on to discuss such relationships in industrial countries.

Table 4 shows the formal exchange rate arrangements and exchange rate stability in terms of the US dollar, the Deutsche Mark and sterling of the twenty largest reserve holders among developing countries. At the end of 1984 these countries accounted for more than 75 per cent. of the aggregate foreign exchange reserves of developing countries. It is not surprising that four out of five currencies officially pegged to the dollar[19] showed relative stability in dollar terms in the April 1973–December 1979 period, and three

[19] This category includes countries which permit wider flexibility than is the case for currencies pegged formally to the dollar according to the IMF definition. For the IMF classification, see the IMF International Financial Statistics and its Annual Reports.

Table 4
Exchange rate arrangements and management in twenty developing countries[1, 2]

	Relatively stable in terms of [3]				
	US dollar	Deutsche Mark	pound sterling	none	total
	number of countries				
Pegged to the US dollar					
Apr. 73–Dec. 79	4	0	0	1	5
Jan. 80–Mar. 86	3	0	0	1	4
Pegged to a composite unit					
Apr. 73–Dec. 79	4	2	0	0	6
Jan. 80–Mar. 86	3	0	0	4	7
Floating with indicators					
Apr. 73–Dec. 79	0	0	0	2	2
Jan. 80–Mar. 86	0	0	0	3	3
Other managed floating					
Apr. 73–Dec. 79	3	0	0	4	7
Jan. 80–Mar. 86	0	0	0	6	6
Total					
Apr. 73–Dec. 79	11	2	0	7	20
Jan. 80–Mar. 86	6	0	0	14	20

[1] The twenty countries covered are China, Saudi Arabia, Brazil, Singapore, Venezuela, Mexico, India, Indonesia, Iran, Kuwait, Malaysia, Libya, Israel, Korea, Chile, Hungary, the United Arab Emirates, Thailand, Peru and Nigeria. These countries accounted for 76 per cent. of the aggregate foreign exchange reserves of developing countries at the end of 1984.
[2] Exchange rate arrangements for the April 1973–December 1979 period and the January 1980–March 1986 period are taken to be those at June 1979 and June 1985 respectively. China and Hungary, which were not IMF members in the earlier period, are assumed to have adopted the same exchange rate arrangement in both periods.
[3] Relative stability in terms of a single currency is defined by a lower coefficient of variation in that currency than in the other two at the 1 per cent. significance level.

out of four in the January 1980–March 1986 period. An exception among those pegging their currencies to the dollar in the former period was Korea; its currency did fluctuate less widely in dollar terms than in DM or sterling terms but the difference between the degree of its stability in relation to the dollar and sterling was not statistically significant. The exception in the latter period was Venezuela, whose currency depreciated sharply against all major

currencies. It is also noteworthy that in 1973–79 and 1980–86 four and three currencies[20] respectively which were pegged to a self-defined currency composite[21] showed marked stability against the dollar. In this sense, these currencies have been more closely linked to the dollar than some of the currencies formally pegged to it.

Looking at changes in exchange rate movements in the 20 countries between 1973–79 and 1980–86, the number of currencies which showed marked stability vis-à-vis the dollar decreased from eleven to six. In three instances this was due to a dramatic depreciation of these currencies against all the reserve currencies, as noted above in the case of Venezuela. In addition, while two currencies[22] had been stable in DM terms in 1973–79, none were in 1980–86. A common thread in these changes in currency linkage was a trend away from pegging to a single currency. However, this table masks an important development in the relative stability of countries' exchange rates. In addition to the countries which changed from linking their currencies to the dollar, there were also a few which, while continuing to follow their earlier practice, showed a less strong linkage to the dollar within their chosen group of currencies in the second period. Table 5 shows the relative stability of exchange rates of ten large reserve holders in the developing world vis-à-vis the dollar, the Deutsche Mark and sterling. For example, the Chinese yuan had been stable against the US dollar, albeit to a slightly lesser extent than against the Deutsche Mark, in 1973–79. In 1980–86, however, it registered much wider fluctuations against the dollar than against any other major currency. Similarly, the Indian rupee, which had been linked to

[20] The four countries concerned in the former period were Singapore, Kuwait, Malaysia and Thailand; those in the latter period were the same countries with the exception of Thailand, whose currency recorded greater stability in dollar terms than in DM terms only to a statistically insignificant degree.

[21] Of the twenty countries Iran was the only one to peg its currency to the SDR, a ready-made composite, and this only in the latter period. Despite the large weight of the dollar in the SDR basket, however, the Iranian rial fluctuated less widely against the Deutsche Mark than against the dollar.

[22] Those of China, which took the place of Taiwan in the IMF in 1980, and Hungary, which joined the IMF in 1982.

Table 5
Coefficients of variation of selected developing countries' currencies

	April 1973–Dec. 1979			Jan. 1980–March 1986		
	vis-à-vis			vis-à-vis		
	US dollar	Deutsche Mark	pound sterling	US dollar	Deutsche Mark	pound sterling
Pegged to composite unit						
China	0.09	0.05**	0.15	0.23	0.14*	0.12*
Singapore	0.05**	0.09	0.13	0.02**	0.15	0.20
Kuwait	0.03**	0.11	0.14	0.04**	0.12	0.18
Indicators or other managed floating						
Brazil	0.46	0.53	0.40	1.13	1.02	1.00
Mexico	0.29	0.38	0.25*	0.83	0.74	0.69
India	0.06**	0.13	0.09	0.16	0.08*	0.08*
Indonesia	0.14*	0.23	0.20	0.24	0.16*	0.13*
Pegged to the US dollar						
Saudi Arabia	0.03**	0.11	0.14	0.03*	0.14	0.19
Venezuela	0.01**	0.13	0.13	0.24	0.20	0.19
Libya	0.00**	0.13	0.13	0.00**	0.16	0.22

Note: Figures marked * are lower than one of the other two coefficients at the 1 per cent. significance level; those marked ** are lower than both other coefficients at the same significance level.

sterling before March 1973, showed relative stability against the dollar and sterling in 1973–79. In 1980–86 its fluctuations against the dollar were significantly greater than those against the Deutsche Mark and sterling. Combining the findings in Tables 4 and 5, it seems that exchange rate arrangements in large developing countries have changed to the extent that their currencies have become less closely linked to the US dollar in practice as well as in terms of stated intention.

It might have been expected that these changes in countries' exchange rate arrangements would have been reflected in their reserve management with respect to currency composition. Firstly, a central bank may find it convenient for intervention purposes to hold foreign exchange reserves in a currency with which its own currency is linked. Also, central banks which have an obligation to provide foreign currencies for legitimate requirements under

exchange control regimes may want to provide, and thus hold in advance, such currencies in order to attain the desired exchange rate against the target currency directly. In fact, Heller and Knight (1978) find in their cross-section analysis that a country's exchange rate arrangement is an important determinant of the currency composition of its reserves. Secondly, reserve management based on portfolio considerations, which will be discussed in the following sub-section, is also related to exchange rate arrangements. Although the choice of a numeraire against which to stabilise the domestic currency under a given exchange rate arrangement can differ from that of a price deflator for calculating real returns on portfolio investment, these two are positively related.[23] Moreover, the relative stability of the domestic currency in terms of one reserve currency depends on the correlation between reserve currencies,[24] which is a key element in estimating the efficient portfolio.

In view of the changes in exchange rate arrangements in large developing countries between 1973–79 and 1980–86, it would not be surprising if there had been reserve diversification out of the dollar in these countries. The fact that the currency composition of their reserves has been stable does not confirm this expectation. The "polycentric" world economy in terms of exchange rate arrangements has, therefore, not been fully reflected in the currency composition of these countries' reserves.

As far as industrial countries are concerned, however, the recent increases in non-dollar currency reserves are not difficult to explain. It is well known that nominal exchange rates between the currencies

[23] For the distinction between the composition of the pegging currency and that of international trade, see Edison and Vardal (1985).

[24] This could be shown as follows. Let the domestic exchange rates against the dollar and the Deutsche Mark be DLX (=DL/X) and DMX (=DM/X) respectively. The exchange rate of the Deutsche Mark against the dollar is ML (=DM/DL). The relationship between the three rates is ln(DMX)=ln(DLX)+ln(ML). Hence, Var(lnDMX)−Var(lnDLX)=Var(lnML)+Cov(lnDLX,lnML). The relative stability of a currency in terms of one other currency can be broken down into the volatility of the DM/dollar rate and covariance between the DM/dollar and dollar/domestic exchange rates, both of which serve as a basis for the variance-covariance matrix in the efficient portfolio exercise in the following sub-section.

Table 6
Correlations between selected EMS countries
(Figures in the triangles above 1 for inflation rates, those in the triangles below 1 for output)

	Germany	France	Italy	Netherlands	Belgium
	correlation coefficients during the pre-EMS period				
Germany	1.00	0.77	0.38	0.82	0.84
France	*0.42*	1.00	0.61	0.62	0.82
Italy	*−0.22*	*0.53*	1.00	0.55	0.63
Netherlands	*0.13*	*0.03*	*0.35*	1.00	0.97
Belgium	*0.14*	*0.47*	*0.44*	*0.65*	1.00
	correlation coefficients during the EMS period				
Germany	1.00	0.92	0.87	0.92	0.60
France	*0.42*	1.00	0.89	0.93	0.54
Italy	*0.10*	*−0.27*	1.00	0.84	0.52
Netherlands	*0.36*	*0.38*	*−0.55*	1.00	0.45
Belgium	*0.42*	*0.27*	*0.32*	*0.13*	1.00
Memorandum item:	correlation coefficients with US inflation rates				
pre-EMS period	0.60	0.85	0.27	0.31	0.54
EMS period	0.78	0.82	0.84	0.88	0.13

Note: The correlation coefficients for inflation rates are calculated from twelve-month changes in monthly consumer prices, those for output from twelve-month changes in monthly industrial production. The calculations are based on data for March 1973 to March 1979 for the pre-EMS period, while the EMS period covers April 1979 to August 1985. Since no correlation with lagged variables is higher than simultaneous correlation (except for the insignificant correlation between Italian and German industrial production), all the correlations in the table are simultaneous.

of EMS countries, which are for the most part major industrial countries, have shown increased stability compared with the pre-EMS period. Moreover, as shown in Table 6, there has been a heightened correlation between EMS countries' inflation rates since the inception of the EMS. In addition to this correlation between inflation rates, there has even been progress towards convergence in inflation performance.[25] All this suggests that EMS countries have become more strongly committed to exchange rate stability and less reluctant to accept its constraint on domestic policy than they were

[25] See BIS (1986).

earlier. Under these circumstances, increased holding of other member currencies or their close substitutes is complementary to their exchange rate management. Intervention in EMS currencies is an effective way of influencing the domestic currency rate against the target currency within the EMS exchange rate mechanism. Moreover, in the light of actual exchange rate developments between 1980 and 1984, characterised by a strengthening of the dollar against EMS currencies, purchases of Deutsche Mark rather than dollars by central banks at a time when they augmented reserves tended to mitigate downward pressures on the dollar exchange rates of EMS currencies.

Floating exchange rates and portfolio management

The adoption of floating exchange rates has allegedly widened the scope for reserve management by central banks.[26] Central banks no longer have to use or accumulate reserves in order to stabilise exchange rates within a predetermined band, so it is argued that they are in theory at liberty to determine the level and composition of the reserves they hold. The expansion of international capital markets in the 1970s also lessened constraints on reserve management even for countries whose currencies are still pegged to a foreign currency. At least in the short run such countries can acquire reserves simply by borrowing, unless their creditworthiness on the international capital markets is significantly impaired. Given all these factors, it is not surprising to find arguments supporting the view that the techniques of "efficient" portfolio management can be applied to official reserve management.[27]

It is a well known fact that in circumstances where real exchange rates are subject to wide swings benefits may be reaped from holding a portfolio with a diversified currency composition. When returns on investment in various currencies are imperfectly correlated, the expected return on a diversified portfolio can be raised at the same

[26] See Wallich (1983), Romberg (1985) and Chapter 4 of the Group of Ten (1985).
[27] See de Macedo (1982).

level of risk as that on a single currency portfolio (or the risk can be reduced for the same expected return) by combining assets denominated in different currencies. If this facet is exploited, the "optimum" portfolio à la Markowitz, i.e. the portfolio that offers the ideal combination of expected return and risk for the holder, depending on his risk aversion and expenditure pattern, can be chosen from the "efficient" set of portfolios which is constructed so as to attain the lowest risk of fluctuation of real returns at each level of expected return. A number of theoretical studies of "efficient" portfolio management in an international context have focused on these aspects.[28]

Examples of the application of portfolio techniques to reserve management can be found in Ben-Bassat (1984) and Jager and de Jong (1984) covering a wide sample of countries. Working from their findings, these two studies extend their analysis to a discussion of the maximum size of an account on which SDRs should be substituted for official dollar holdings. Although their technical assumptions, such as the price deflator for evaluating real returns on reserve investment and the sample period for calculating returns on investment, are somewhat different, the techniques employed are basically the same, as is also the estimated maximum size of a substitution account.

An experiment based on techniques of "efficient" portfolio management has been carried out in this paper with respect to industrial countries (excluding the United States, Germany and Japan), where some diversification took place in the first half of the 1980s. The "optimum" portfolio calculated here is the one which generates the minimum risk for a holder, defined as the minimum variance of real returns on portfolio investment. In other words, it is assumed that central banks hold foreign currencies in such a way

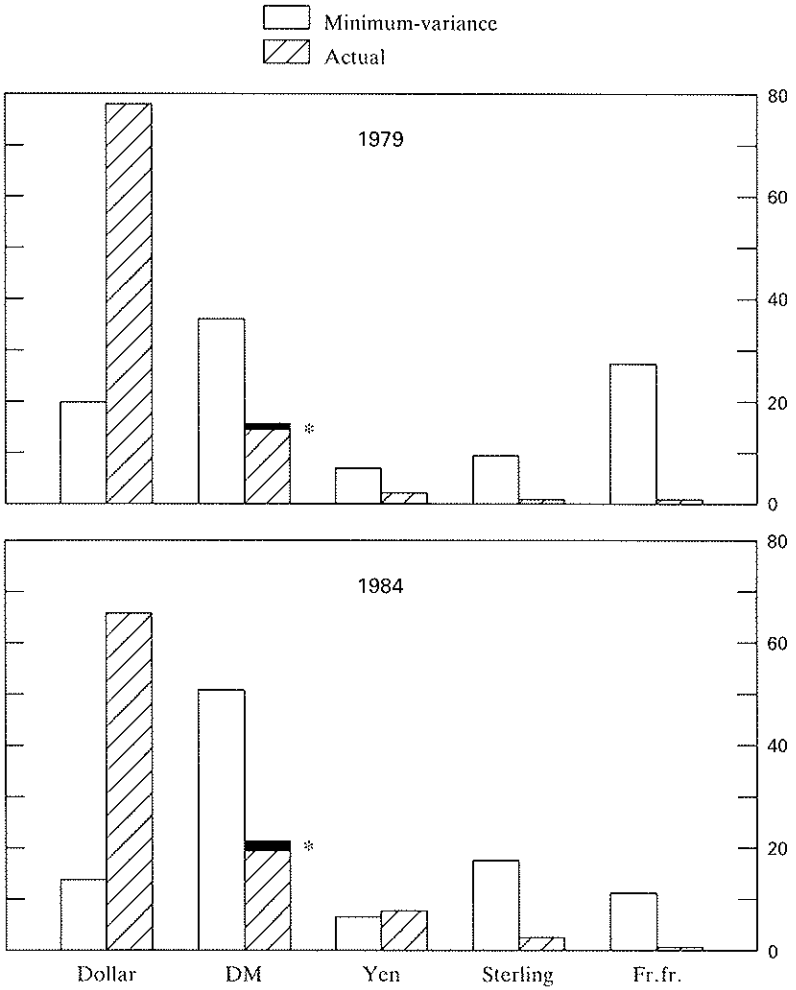
[28] For theoretical frameworks of international portfolio management, see Solnik (1973), Kouri and de Macedo (1978) and de Macedo (1982). Applications of the theory to private investors are found in von Furstenberg (1981) and Levy and Sarnat (1975). For a critical examination of the assumptions underlying the international portfolio theory, see Adler and Dumas (1983).

that they minimise the risks of losses on their currency holdings rather than aim at higher returns with higher risks. In order to compare the currency composition of the "optimum" portfolio with changes in actual currency composition, two "optimum" portfolios, 1979 and 1984 portfolios, have been constructed, the first on the basis of the exchange rates and consumer prices in the 1974–79 period, the second on the basis of those in the 1979–84 period, i.e. covering two six-year periods which overlap in 1979. These two periods differ markedly as far as both dollar exchange rate movements and price developments are concerned. The specification and the technical assumptions are described in Appendix 2.

Graph 2 shows the currency compositions of the "optimum" portfolio of these countries on an aggregate basis (unshaded bars) and the actual currency composition of their reserves (shaded bars) at end-1979 and end-1984. The main findings can be summarised as follows. Firstly, the "optimum" proportion of dollar holdings is far below actual holdings in both the 1979 and the 1984 reserve portfolios. On the other hand, the proportion of DM reserves in the actual reserve portfolio is much lower than that in the "optimum" portfolio. The same is true of sterling and French franc reserves. The large shares of European currencies in the "optimum" portfolio are attributable to the fact that the industrial countries examined here, with the exception of Canada and Australia, have closer economic ties with Germany, the United Kingdom and France than with the United States. Most of the large reserve holders participate in the EMS, and hence their exchange rates are linked to the Deutsche Mark. Other European countries have adopted exchange rate arrangements under which their currencies have been kept more stable against the Deutsche Mark than against the dollar, reflecting their closer trade relationships with EMS countries. Because of these exchange rate arrangements, domestic inflation also tends to be more influenced by that in the large European countries. As far as the proportion of yen is concerned, the gap between the actual and the "optimum" portfolio is not large. The yen has a relatively

Graph 2

Comparison between the actual and minimum-variance reserve compositions of industrial countries (excluding the United States, Germany and Japan)



* Represents the share of the Swiss franc.

small share in the latter portfolio not only because these countries' economic bonds with Japan are less strong but also because the yen fluctuated less widely against the Deutsche Mark than against the dollar, so that the marginal benefit of holding yen assets in addition to Deutsche Mark for risk-reducing purposes is relatively small.

If we discard the assumption of risk-minimising behaviour on the part of central banks and admit risk-taking, i.e. maximising the expected return on portfolio at the expense of higher risk, the results will of course be different. However, in order to increase the dollar proportion in the "optimum" portfolio to the actual level, we have to assume that these central banks are tolerant of risk to an unrealistically high degree.[29]

As far as the changes between 1979 and 1984 are concerned, actual developments were in the same direction as those suggested by the "efficient" portfolio exercise. The dollar proportion in the "optimum" portfolio declined by 6 percentage points to 14 per cent., while in actual fact it dropped by 12 percentage points to 66 per cent. The Deutsche Mark proportion increased by 15 percentage points to 50 per cent. in the "optimum" portfolio, while in reality it rose by 6 percentage points to about 20 per cent. Similarly, the sterling share more than doubled in both portfolios. The direction of the changes in the French franc proportions in the two portfolios coincided, although the franc comprised less than 1 per cent. of actual foreign reserves. The Japanese yen is an exception. While there was little change in the yen share in the "optimum" portfolio, its share in the actual portfolio trebled.

In sum, as far as industrial countries are concerned, the currency composition obtained in this minimum-risk portfolio experiment is not totally consistent with the actual composition, although the direction, but not the extent, of changes between 1979 and 1984 is roughly in accord. There are two possible reasons for this

[29] In order to obtain a dollar proportion approaching the 80 per cent. in the 1984 portfolio, the degree of relative risk aversion as defined in Appendix 2 would have to be as low as 0.5, whereas risk-minimising behaviour would take on positive infinite values.

inconclusive result: mis-specification of the portfolio model or the absence of systematic portfolio considerations in actual reserve management. As regards the first factor, the model defined here is not the only model that could be applied to a central bank which tries to minimise portfolio risks. For example, central banks may be using a different numeraire to evaluate real returns on portfolio, although this is not very likely to obtain results very different from those in this paper because of the relatively high correlation between different price indices in a country. Mis-specification is more likely to stem from the assumption that central banks, in trying to minimise portfolio risk, take as their basis the expectation that past correlations between exchange rates will hold good in the future. In point of fact, when exchange rates were clearly out of line from a central bank's viewpoint it is quite possible that the central bank in question may have changed its reserve portfolio accordingly. Another cause of mis-specification is the lack of any dynamic adjustment process in this model. The comparison between the "optimum" and actual composition is made in static terms with respect to the end-1979 and end-1984 reserve portfolios. However, adjustments geared towards achieving the "optimum" composition may have been made very slowly. If this is the case, then the diversification in the first half of the 1980s can be interpreted as a movement to fill out the gap between the actual and "optimum" currency compositions already indicated in the late 1970s. (For further discussion of possible sources of mis-specification, see Appendix 2.)

On the other hand, the reason why the actual and "optimum" composition did not systematically correspond may be the absence of systematic portfolio considerations covering all the foreign exchange reserves of a country. For example, central banks may have taken countries' trade and other economic relationships with reserve centre countries into consideration in their reserve management, which may have resulted in a spurious correlation between the directions of changes in the "optimum" and actual currency composition. Alternatively, central banks may have

managed only part of their reserves in accordance with a portfolio model similar to the one in this paper, while applying other criteria to a significantly larger part. These other criteria will be discussed further in the following sub-section.

As far as developing countries are concerned, Ben-Bassat (1984), working on a model similar to the one used in this paper, finds that there was a relatively high degree of similarity between the "optimum" and actual portfolios. There is, therefore, certain presumptive evidence that these countries may decide on the currency composition of their reserves on the basis of portfolio considerations. However, whether this is a mere coincidence or not is still an open question. For one thing, the actual dollar proportion was still significantly higher than that in Ben-Bassat's "optimum" portfolio. In addition, the distribution among non-dollar currencies seems to have been out of line with what the model suggests in that the Deutsche Mark and the yen were preferred to sterling and the French franc in the actual portfolio of a number of countries.[30]

Transactions balances, liquidity and inertia

This paper has so far focused on the currency composition of reserves and no explicit mention has been made of its relationship to the levels of reserves. An implicit assumption has been that central banks' decisions regarding the currency composition of reserves are independent of the reserve level. A number of economic studies in fact treat these two aspects separately, arguing that the optimum level of reserves depends on the variability of external payments while the optimum composition depends on currency preferences.[31] Where this assumption of separability does not hold good, however, reserve diversification can be constrained by the levels of reserves.

[30] Muehring (1984) estimates that Deutsche Mark, Japanese yen and other non-dollar currencies were held in roughly equal proportions in the investment portfolio of the Saudi Arabian Monetary Agency in August 1984, whereas the risk-minimising portfolio constructed using data for 1981–84 under the procedure adopted in this paper includes sterling and the French franc but not Deutsche Mark or yen.

[31] See Ben-Bassat (1984), for example.

In general, international reserves fulfil the following basic functions for central banks. They are a buffer stock which a central bank mobilises whenever it is found desirable to fill a gap between the private demand for and supply of foreign currencies at a given exchange rate. And they are a store of national wealth. In addition to these basic functions, gross reserves also serve, in the case of indebted countries, as collateral or as a "sweetener" for external borrowing. The assumption of separability between level and composition reflects the separability of these functions, provided that the foreign exchange markets and financial markets in which reserves are placed are perfectly efficient, i.e. that conversion from one currency to another at the precise moment of need is possible without cost or self-damaging price effects. In practice, however, there are a number of constraints on rapid conversion. Firstly, a currency conversion operation involves a cost at least equal to the offer/bid spread. Secondly, not all reserve currencies offer the same range of readily encashable instruments which enable reserves to be held in large quantities. Thirdly, the assumption that a given central bank's transactions in the exchange markets will have no price effects holds good only if the volume converted from investment instruments to transaction instruments is relatively small. Finally, although borrowing can in part substitute for the actual holding of reserves, the cost of short-term financing at a precise moment of need is sometimes not inconsiderable.

Given the constraints on rapid, large-scale conversion, the choice of reserve currencies by individual central banks is partly a function of the levels of reserves. The larger the proportion of reserves held by a country for transaction needs, the greater the amount of currencies suitable for such purposes that will be held in its reserve portfolio. In other words, countries with large idle balances have more scope for diverting currency holdings away from transaction needs.

In this respect, reserves in countries which opt to have a deficit on their underlying balance of payments and to finance it by official external borrowing tend to be kept to the level of minimum working

balances. Holding reserves incurs a cost, explicitly or implicitly, which is almost equal to the spread between interest rates on borrowing and short-term investment.[32] For heavily indebted countries this cost tends to curb borrowing for purposes of augmenting reserves beyond the level of working balances. Edwards' (1985) finding that the net cost of borrowing has a statistically significant negative effect on the amounts of reserves held by developing countries is also consistent with the hypothesis that their reserves have been confined to the level of working balances. In several industrial countries, too, e.g. Sweden, Canada and, recently, Belgium, reserves have often been augmented by international borrowing, with some countries' borrowings in part comprising standby credit facilities as a means of readily obtaining foreign currencies.[33] In other words, these countries do not usually hold large "excess balances", and it is when large working balances are necessary for intervention that they borrow on international financial markets.

As long as foreign exchange reserves are held as transactions balances it is convenient for a central bank to hold them in dollars, the currency which can be used most promptly for interventions. In most exchange markets the dollar functions as the vehicle currency. This is reflected in the fact that most countries use the dollar for intervention irrespective of their exchange rate arrangements and of the pattern of their international trade, a notable exception being all the interventions at the margin or in some cases within the margins under the EMS exchange rate mechanism. In such circumstances, a requirement for holding other currencies as reserves together with dollars is high liquidity and low transaction costs whenever these currencies have to be converted into the vehicle currency. However, to the extent that the US dollar's function as the vehicle currency in

[32] It is assumed that the marginal return on borrowed capital is equal to the cost of borrowing and that the borrowing cost is independent of the borrower's reserve amount. It is possible, however, that the borrowing cost, e.g. a premium over LIBOR, will rise significantly in the event of reserves drying up.

[33] See Bank of Canada (1986).

Table 7
Functions of an international currency*

	Private operators	Official operators
Functions:		
unit of account	invoicing, denomination	exchange rate reference
medium of exchange	transactions	intervention
store of value	investment	reserves

Note: This table is taken from Leutwiler and Kaestli (1982) und Fratianni (1982) with slight changes by the author.

financial and exchange markets is attributable to high liquidity and low transaction costs in dollar markets, the potential advantage of other currencies is by definition limited.

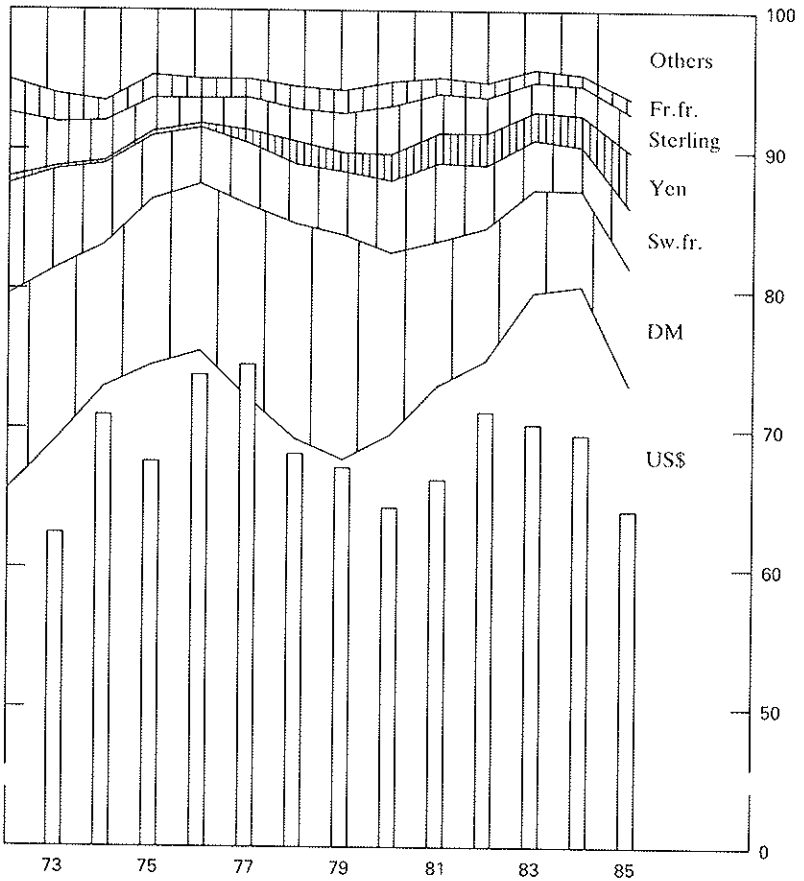
The predominant role of the dollar in international financial markets is illustrated in Graph 3. The lines in the graph show the percentage shares of major currencies in international banking liabilities, i.e. liabilities of the banks located in those countries which regularly report statistics to the BIS of their assets and liabilities vis-à-vis non-residents in domestic and foreign currencies and vis-à-vis residents in foreign currencies. The bars represent the US dollar share in these banks' liabilities vis-à-vis official monetary institutions. In broad terms, the former represent the relative importance of major currencies in all the deposits at international banks, and the latter that of the dollar in official monetary deposits at these banks. The main findings are summarised below; however, since the graph covers only banking liabilities on an aggregate basis, facts gleaned from the graph should be considered as having no more than an indicative value with regard to international capital transactions.

Firstly, the US dollar has continued to account for by far the largest proportion of total international banking liabilities (about 70 per cent.) of the BIS reporting banks. Although its share fluctuated somewhat during the period, a substantial part of these fluctuations appears to have reflected exchange rate changes. Secondly, the

Graph 3

Currency composition of international banking liabilities, end-1972 to end-1985

In percentages



Note: The shaded areas show the share of individual currencies in international liabilities of banks in the BIS reporting area (foreign and domestic currency liabilities vis-à-vis non-residents and foreign currency liabilities vis-à-vis residents). The bars represent the US dollar share in these banks' liabilities vis-à-vis official monetary institutions.

changes registered by the Deutsche Mark and, to a lesser extent, the Swiss franc shares were inversely proportional to the fluctuations in the dollar share. Thirdly, the yen's share showed a pronounced increase during the period, while the shares of sterling and the French franc decreased somewhat.

These developments in the currency composition of international banking liabilities are similar to those in reserve composition in several respects. One is the continued large share of US dollar balances of both official and private holders. With respect to other currencies, too, the difference between the currency composition of official reserves and that of international banking liabilities is much smaller than that between countries' reserve composition and the distribution of their international trade; it is likewise much smaller than that between the actual reserve composition and what is suggested by the aforementioned efficient portfolio exercise. Similarly, the direction of changes in reserve composition in the period under review roughly matches that of changes in total banking liabilities. This similarity partly reflects a causal link between reserve placement and international banking balances. Official reserve placement is an important source of international bank lending. To the extent that the proceeds of the lending are redeposited with the reporting banks in the same currency ex post, the initial official placement causes an expansion of banking liabilities in that currency. Even when some proceeds leak out of the banking system, the relative shares of each currency in total banking liabilities will not change as long as the ratio of leakage to total banking claims is the same across currencies. Official reserve placement is, however, only one of several sources of international banking funds. Deposits held by non-banks are another important source, but their share in total banking liabilities differs across currencies, as does that of interbank activities.[34] The similarity between the currency composition of international banking liabilities and that of official reserve balances cannot, therefore, be

[34] See BIS (1983).

attributed solely to this supply-side chain of causality from official holdings to banking activities. It also seems that the comparative advantage of certain major currencies for financial transactions has affected the choice of reserve currencies made by central banks.

In addition to this broad linkage on the basis of the usability of currencies for financial transactions, the relative importance of currencies in international financial markets affects countries' reserve management by more direct means. For example, at the end of 1984 non-OPEC developing countries owed $331 billion, 88 per cent. of which was accounted for by dollar-denominated debt, to banks within the BIS reporting area. In order to lessen their exposure to exchange rate and interest rate risks arising from foreign currency debts, these countries may wish to hold the currencies in which they are indebted, i.e. to hold a large proportion of dollars. This can be viewed as a specific instance of the importance of the role of transaction currency in determining the currency composition of reserve holdings.

Given that dollar holdings by central banks are due, to such a significant extent, to the dollar's preferred profile as a transaction currency, the potential for reserve currency diversification within portfolios held as transactions balances depends on the extent to which other currencies attain this status. In other words, for there to be a large diversification into another reserve currency, a synergic process will have to evolve: the development of liquid instruments and lower transaction costs, which are usually brought about by deep financial markets, will stimulate the wider use of such a currency for financial and exchange transactions, and thus official transactions, which in turn will encourage a broadening of the financial markets in that currency.

On the other hand, central banks which, for whatever reasons, have large idle balances in their reserve portfolios have broader scope for currency diversification. However, some countries in this group regard only part of their official external assets as foreign exchange reserves. For example, the Saudi Arabian Monetary Agency is reported to have been holding $92 billion of interest-

earning foreign currency funds (excluding SDRs) in August 1984,[35] whereas Saudi Arabia's foreign exchange reserves, as reported to the IMF, amounted to $14 billion. The distinction between the two types of assets is believed to reflect the difference in the motives and purposes of asset holding and therefore the forms of investment in terms of the liquidity and risk of each asset type.

The distinction between transactions balances and idle balances is made more explicitly in some central banks. For example, the Bank of Norway holds four months' worth of imports of goods and services plus the deficit on interest and unilateral transfers in very liquid form under its internal definition of foreign exchange reserves, while the remainder is classified as other foreign assets,[36] although the combined amount is reported to the IMF as constituting Norway's foreign exchange reserves. For such a country, therefore, there are two potential levels of reserve currency diversification, the one — diversification on transactions balances — being more subject to liquidity constraint than the other. In fact, the Bank of Norway, which increased the proportions of Deutsche Mark and yen in its reserves between December 1983 and November 1985, suggests that a broader range of options meeting the central bank's requirement for liquidity in these currencies is part of the reason for this change in currency composition.[37] At the same time it says that "other foreign assets", for their part, consist of placements where the emphasis is more on yield than on the degree of liquidity.[38]

Although countries which hold more reserves than required for immediate transaction purposes have a broader scope for reserve diversification, there are constraints on rapid alteration of the currency composition of reserves. As far as EMS countries are concerned, there is a provision stipulating that the limits set for working balances held by central banks in Community currencies

[35] See Muehring (1984).
[36] See Norges Bank (1986).
[37] See Norges Bank (1986).
[38] In this regard it is also interesting to note that this bank's sterling holdings increased during this period, which is consistent with one of the results of the efficient portfolio exercise outlined in this paper.

may be exceeded only with the consent of the central banks concerned.[39] Some other large reserve holders have also entered into agreements with reserve centre countries whereby they undertake to make no sudden changes to reserve investments in the reserve countries' currencies. In addition to constraints, there is a certain inertia governing reserve currency composition. For example, given their "responsibility for orderly conditions in the international exchange markets" (Norges Bank (1986)), central banks may not wish to alter the currency composition of reserves rapidly.

In sum, for countries which have small reserves in relation to their transaction needs, the scope for reserve diversification is limited. While the US dollar has a predominant role as a transaction currency and therefore a large role in working balances, the extent to which reserves of these countries can be placed in currencies other than the dollar is dependent on the liquidity of instruments and markets in the non-dollar currencies. On the other hand, central banks which hold ample reserves, for whatever reasons, have greater scope for currency diversification, although reserve management in such countries may be subject to a degree of inertia on account of legal or moral constraints even if the central banks do wish to diversify.

4. Concluding remarks

At an empirical level there are two major findings in this paper: on a global basis, diversification of exchange reserves out of dollars into other currencies was quite modest in the 1970s, although there was pronounced diversification out of sterling into the Deutsche Mark and the Japanese yen; during the early 1980s diversification out of the dollar, mainly by industrial countries (excluding the three

[39] See Article 15 of the Agreement of 13th March 1979 between the Central Banks of the Member States of the European Economic Community.

largest reserve centre countries), has accelerated somewhat. The descriptive examination of reserve management in this paper suggests that these developments have not closely reflected changes in the distribution of international trade. Neither have they fully accorded with changes in countries' exchange rate arrangements or with "efficient" portfolio practices as represented by this paper's model of the minimum-variance portfolio. On the other hand, the direction of changes in the currency composition of countries' exchange reserves was in some instances consistent with what "efficient" practices would suggest, while in some other instances there were changes which seem to have been incidental to exchange rate management, e.g. related to intervention within the EMS exchange rate mechanism. These mixed findings could be interpreted as indicating that factors other than those often cited as the incentives towards reserve currency diversification have significantly influenced countries' management of reserve currency composition. To the extent that reserves are held as transactions balances, central banks' currency preferences are likely to have been influenced, inter alia, by financial transaction needs in individual currencies. They may also have depended on the range of liquid instruments available in each currency in which reserves can be held and which can swiftly be converted into the transaction currency when the need arises. In addition, switching of reserve currencies seems in some instances to have been checked by formal agreement or informal understandings between central banks.

The diversification out of dollar assets by certain industrial countries in the first half of the 1980s moderated the appreciation of the dollar on the exchange markets, if it can be assumed that official reserve shifts had some influence.[40] The dollar started to depreciate against most other reserve currencies in early 1985, and by September 1986 its cumulative depreciation against the Deutsche Mark, the yen and the Swiss franc amounted to over 40 per cent. If the dollar continued to decline on the exchange markets, concerns about reserve currency diversification similar to those in the late 1970s might revive. According to the analysis in this paper, however,

the future course of reserve diversification will depend not only on the relative performance of reserve currencies on the exchange markets but also on the liquidity features of these currencies and the level of international reserves in relation to reserve needs. With regard to liquidity features, both the domestic and the international markets for liquid instruments in several reserve currencies have deepened and widened since the late 1970s as a result of financial deregulation and innovations. In this respect, therefore, the scope for holding currencies other than the US dollar as official monetary transactions balances and hence also the scope for active portfolio management may have broadened and still be broadening. As far as the degree of reserve ease is concerned, on the other hand, it is perhaps fair to say that in a number of countries reserve conditions have since tightened. Consequently, the size of "excess" exchange reserves, which can more easily be diversified than those held as transactions balances, may have decreased. However, while the developments regarding the liquidity of reserve instruments have been brought about by structural changes in markets and do not seem likely to be reversed in a cyclical context, the overall degree of

[40] Scepticism about the validity of this assumption is partly based on the view that private asset holdings dwarf official reserves. As far as gross volumes of financial assets are concerned, there is no doubt that private holdings far exceed official reserves. For example, at the end of 1984 deposits held by official monetary institutions at banks in the BIS reporting area amounted to only 6 per cent. of these banks' total deposits. On a net basis, however, official reserves are not insignificant. The official monetary institutions thus had a $17 billion asset position in Deutsche Mark vis-à-vis banks within the BIS reporting area (including external assets and liabilities vis-à-vis banks in Germany) at the end of 1984, while private banks and non-banks had a $6 billion asset position and a $40 billion liability position respectively. The corresponding figures in terms of Japanese yen were, respectively, a $9 billion asset position and liability positions of $8 billion and $17 billion. In order to evaluate private and official mobile assets comprehensively, a portion of the private assets held in domestic currencies at domestic banks and both official and private assets held in financial markets — whether international or domestic — other than banking systems have to be added to these figures. Even if all the private assets are regarded as a potential instrument of portfolio management, however, it is known that, as long as private holders are reasonably averse to risk, they tend to hold an overwhelmingly large proportion of their portfolio in domestic currencies (see Levy and Sarnat (1975, 1983), von Furstenberg (1981) and, for institutional barriers to cross-border security investments in particular, Cooper and Kaplanis (1986)).

reserve ease/tightness can change, as happened in the late 1970s and, in the opposite direction, in the early 1980s. Such changes depend on balance-of-payments and credit-market developments both in reserve currency countries and in reserve holding countries.[41] In other words, economic developments in reserve currency countries may influence the process of currency diversification not only through exchange rate movements but also through their impact on reserve ease.

[41] See Group of Ten (1985).

Appendix 1

The method of breaking down changes in currency composition

The estimate of factors contributing to the changes in currency composition is derived from the following stock data for each currency:

ALL72, ALL84	Vectors representing currency shares in global foreign exchange reserves at end-1972 and at end-1984 respectively.
XUS72, XUS84	Vectors representing, as at end-1972 and at end-1984 respectively, currency shares in reserves of all countries excluding the United States and countries whose reserve composition is unknown.
XUDJ72, XUDJ84	Vectors representing, as at end-1972 and at end-1984 respectively, currency shares in reserves of all countries excluding the United States, Germany, Japan and countries whose currency composition is unknown.
H84	A vector of hypothetical currency shares in all countries excluding the above four at end-1984 constructed on the assumption that each group of countries was holding foreign exchange reserves in the same way as at end-1972.

Using these notations, the effects classified in Table 3 are defined as follows:

US and statistical effects (U) = (ALL84 − XUS84) − (ALL72 − XUS72)

German and Japanese effects (G) = (XUS84 − XUDJ84) − (XUS72 − XUDJ72)

Distributional effects (D) = H84 − XUDJ72

Net diversification (N) = XUDJ84 − H84

Total changes = ALL84 − ALL72 (= U + G + D + N)

The changes in reserve composition due to valuation effects caused by exchange rate changes are not explicitly taken into consideration in this calculation. Even where the changes in a central bank's reserve currency composition are directly caused by valuation effects, they reflect the central bank's stance in favour of accepting such changes when it could have stopped them. Of course, in the very short run a central bank may not be holding its preferred portfolio because of delayed adjustment to changing circumstances. After allowance is made for an adjustment period, however, the difference between changes in composition due to new acquisitions and those due to valuation effects is the difference between active and passive reserve management.

Appendix 2

The procedure for the estimation of minimum-variance portfolios

Procedure

The selection of the optimum portfolio in this paper is based on the standard international portfolio selection model.[42] The following explanation of its calculation method is based on the algorithm developed by Roll (1977).

Using i(j) to denote the unannualised nominal interest rate of reserve currency j in a three-month period, e(j) the percentage change in exchange rate j against the holder's currency in the domestic currency term and p the inflation rate during the three-month period, the real return on investment in currency j is approximately expressed as follows: (This is for explanation purposes only. In the experiment conducted in the paper, cross-terms are properly taken into consideration.)

$$r(j)=i(j)+e(j)-p$$

Define x(j) as the proportion of currency j in the portfolio and X as a vector of x(j). Obviously,

$$X'e=1 \qquad (1)$$

where e is the unit vector.

Also, define R for the mean return vector and V for the covariance matrix of individual assets r(j) respectively. Then we obtain the mean m and variance s^2 of a portfolio as follows:

$$m=X'R \qquad (2)$$
$$s^2=X'VX$$

The efficient portfolio frontier is composed of portfolios with minimum variance at each possible level of mean returns, which is found by minimising s^2 subject to (1) and (2). Setting the Lagrangian form,

$$L=X'VX-\lambda_1(X'R-m)-\lambda_2(X'e-1)$$

the result obtained is that the investment proportion of any portfolio

[42] See de Macedo (1982) and Adler and Dumas (1983).

which lies on the efficient frontier satisfies the following relations at any given mean of the portfolio return r(p):

$$X=V^{-1}(R,e)A^{-1}(r(p),1)' \quad (3)$$

The variance $s^2(p)$ on the efficient frontier is obtained by

$$s^2(p)=(r(p),1)A^{-1}(r(p),1)' \quad (4)$$

where A is a symmetrical matrix whose (1,1) element is $R'V^{-1}R$, (1,2) and (2,1) elements are $R'V^{-1}e$, and (2,2) element is $e'V^{-1}e$.

The return on the minimum variance portfolio is obtained by minimising (4) with respect to r(p).

$$r(p)^*=R'V^{-1}e/e'V^{-1}e$$

By substituting $r(p)^*$ in (3), we obtain the optimum composition X^*, which is

$$X^*=V^{-1}e/e'V^{-1}e$$

On the other hand, the maximum return portfolio adjusted for portfolio risk and the degree of relative risk aversion b can be obtained as follows:

$$\text{Max } z=r(p)-(b/2)s^2(p) \quad (5)$$

By maximising (5) with respect to r(p), we get the return on the optimum portfolio:

$$r(p)^{**}=r(p)^* +(1/b)(R'V^{-1}Re'V^{-1}e-R'V^{-1}e^2)/e'V^{-1}e$$

By substituting $r(p)^{**}$ in (5) we obtain the optimum composition X^{**}, which is

$$X^{**}=X^*+(1/b)V^{-1}(R-(R'V^{-1}e/e'V^{-1}e)e)$$

The first term of this optimum portfolio is the same as in the minimum-variance model. The second term is what de Macedo (1983) calls the speculative portfolio.

In accordance with this explanation, a computer program has been developed, for which I am greatly indebted to Dr. J.S. Alworth and Dr. W. Fritz.

Data

Interest rates of five reserve currencies: three-month Euro-currency deposit rates. (For the period prior to the third quarter of 1977, for which Euro-yen and Euro-French franc rates are unavailable, domestic three-month interbank rates are used.)

Domestic inflation: three-month changes in seasonally adjusted consumer prices.

Estimation periods

Quarterly between the first quarter of 1974 and the fourth quarter of 1984, with two sub-periods: 1974 Q1 – 1979 Q4 and 1979 Q4 – 1984 Q4.

Reservations

Firstly, there is no consensus on the measurement of the real value which central banks intend to maintain. Some argue that since reserves are ultimately held — implicitly or explicitly — for intervention needs, the value of the reserves should be measured in terms of the currency (or, in the case of floating currencies, some effective exchange rate) to which the domestic currency is pegged (or tied). Others maintain that, because reserves are held to avoid payment shortfalls which would otherwise result in a shortage of imports, the real value of foreign exchange reserves should be measured in terms of the countries' import prices.[43] In the case of a private asset holder, choosing the appropriate numeraire for his international portfolio is relatively easy. Since it is reasonable to assume that his utility function depends on the current and future real consumption streams, the real value of the returns on his assets ought to be assessed in relation to the prices of his consumption bundle. The lack of consensus on real value measurement in the case

[43] Heller and Knight (1978) maintain that a country that pegs its own currency to a single foreign currency can eliminate exchange risk by holding its foreign exchange reserves in the currency to which it pegs and that this consideration is relevant to actual reserve holdings of central banks because they exhibit a strong aversion to exchange losses. For countries which peg their currencies to a composite basket and those which float their currencies, it is appropriate to hold reserves according to the weights in the basket and weights in some effective exchange rate index respectively. For a similar reason, Henk and de Jong (1984) use a country's domestic currency as the numeraire of the value of its foreign exchange reserves and assess returns on reserve investment in nominal terms. Ben-Bassat (1984), on the other hand, conducts his empirical analysis of optimum portfolio composition on the basis of import prices because he considers a central bank's utility to be dependent on import volumes.

of central banks stems from the lack of consensus on the form of their utility functions. In this paper, the consumer price index of the central bank's country is used as a deflator of nominal returns on portfolio on the assumption that inflation measured in terms of consumer prices is the most relevant variable affecting the utility of the central bank.

Secondly, the optimum portfolio is defined in this paper as a portfolio which minimises the portfolio risks arising from changes in interest rates, exchange rates and domestic inflation. Credit risk and the political considerations involved in currency preference are, therefore, ignored. This approach also implies that central banks do not assume risks in order to increase the expected return on investment. However, in reality these factors may play important roles at certain times or in certain countries.

Thirdly, it is a point of contention whether the "optimum" portfolio should be constructed on gross reserves or net reserves, the latter being reserves net of external liabilities. There are basically two lines of argument. One is that changes in the exchange rate and other disturbances affect the value of both financial assets and liabilities and that, therefore, the currency composition of assets and that of liabilities are inseparable.[44] Diametrically opposed to this is the argument that the two problems are separable because foreign debt is largely composed of relatively long-term obligations, while the investment horizon for reserves is typically short.[45] The extent to which each view reflects individual countries' reserve management depends crucially on the countries' decision-making procedure. For example, there are some countries where reserve management and debt management decisions are taken quite independently by different institutions. In other countries they are taken by a single body or by different bodies in close consultation. In addition, in

[44] See Dooley (1986). The finding in the Group of Thirty (1982) that the matching of foreign liabilities and assets is a factor affecting the currency selection of several central banks also lends support to this view.

[45] See Ben-Bassat (1984).

countries of the latter group, not all the debt is necessarily taken into account in the management of foreign exchange reserves.

Fourthly, it is assumed that the "desired" composition is independent of the level of exchange reserves. Indeed, it is widely held that the composition of reserves is affected by uncertainty as to the future value of foreign currencies, while the demand for total reserves is dependent on the variability of external payments.[46] However, it is possible that official external assets excluded from foreign exchange reserves are taken into consideration when the composition of foreign exchange reserves is determined. This problem has some overlap with the second and third points made above.

The final reservation concerns the data from which the optimum portfolio is estimated. The estimate is made using past data on exchange rates and inflation rates. More specifically, the actual variability of these variables and the correlation between them, but not their individual trends, are assumed to be fully reflected in central banks' expectations of their future developments. It is, however, likely that central banks base their strategy for efficient reserve management on their judgement of the future relationship between these variables, which might be quite different from its past movements. Nevertheless there is clearly no knowing their expectations of the variance and covariance of variables.

[46] See Ben-Bassat (1984).

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