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International Reserve Currencies

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Abstract

We study the composition of central bank holdings of foreign reserves when the level of currency riskiness is endogenously determined by economic structure and policymaker preferences in reserve issuing countries. Examination of the behavior of official foreign reserves of the industrial and developing country groups in the period 1977-1984 offers support to the notion that central banks employ mean-variance criteria in selecting international reserves.

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Summary

Central banks hold foreign exchange reserves to facilitate trade (a consideration more relevant for developing than for industrial countries) and to influence exchange rates through intervention in the foreign exchange markets (a concern more pertinent to industrial countries). While these two objectives imply that the demand for foreign reserves depends on the level of real income, the pattern of trade, and the exchange rate regime, they do not preclude considerations of return, liquidity, and risk from influencing the allocation of international reserves among assets denominated in different currencies. On the contrary, the development of world financial markets and an increase in exchange rate volatility during the last few years have required a more efficient (that is, profitable) management of official foreign reserve holdings.

This paper has two objectives. First, it analyzes the supply side, an aspect of international vehicle currencies (that is, currencies widely used in international transactions) that other studies have overlooked, by relating the return and risk of reserve currencies to the structure of the economy and to the preferences of the policymakers in the countries that issue these reserve currencies. This approach allows for the endogenous determination of risks and returns and hence provides a direct way of evaluating the effects of actual and expected changes in economic structure and policy priorities on the composition of international reserve portfolios. The analysis shows that a currency will possess desirable characteristics if a country faces small output disturbances and a trade-off between inflation and output that limits the effectiveness of stabilization policy. A currency is undesirable if policymakers are less concerned about inflation than about short-run changes in economic activity.

Second, the paper evaluates the hypothesis that central banks use a criterion that relies on returns and the volatility of returns in forming portfolios of international assets. The examination of the behavior of the industrial and developing country groups during 1977-84 offers support to the suggested criterion.

I. Introduction

Why do countries (central banks) hold international reserves? What criteria do reserve users employ in selecting a reserve currency? How is the conduct of monetary policy in any country affected by the adoption of its currency as an international money? What determines which national currencies will be valued in the world economy? Existing work seems to have produced satisfactory answers to the first three questions. It is accepted that countries hold reserves to facilitate trade and intervention in the foreign exchange markets (Dooley, Lizondo, and Mathieson, 1988; Frenkel, 1983; Levy, 1983; Saidi, 1981) and also because of portfolio considerations (Ben-Basset, 1980; Brown, Papell, and Rush, 1986, Heller and Knight, 1978). These motives for holding reserves imply that the demand for foreign reserves will depend on factors such as real income, the pattern of trade, the timing of receipts and expenses, the exchange rate regime; and also that currencies with desirable risk-return characteristics will be favored in international portfolios. Finally, as the collapse of the Bretton Woods system demonstrated, a likely result of seigniorage revenue opportunities will be an inflationary bias in the conduct of monetary policy in the reserve issuing country (Buiter and Eaton, 1983; Calvo, 1978; Dellas, 1988a; Mundell, 1971).

With regard to the fourth question, the discussion above implies that high return-low risk currencies of countries that play a prominent role in international transactions will emerge as the major reserve currencies. This prediction, however, relies on the demand side of the reserves market, so it does not give any insights on which currencies will possess these desirable characteristics; this is particularly important because reserve issuance gives rise to seigniorage revenue opportunities which, in turn, affects the properties of the inflation rate on a reserve currency. Consequently, the supply side has to be brought into the picture, an aspect that has been almost completely ignored in the existing literature (with the exception of Buiter and Eaton, 1983; Dellas, 1987).

In analyzing the emergence of a reserve currency, one cannot take the inflation and its variance as exogenous (as the reserve users do) but try to relate their endogenous behavior to the fundamental policy and structural economic parameters of the reserve issuing country. The advantage of such an approach is that it provides a direct way of evaluating the effects of actual and expected changes in economic structure and/or policy priorities on the composition of international reserve portfolios. Taking into account the supply side of reserves will help explain how the German and Japanese currencies became important international "vehicles" in the last few years.

In Section II we argue that, in selecting a reserve currency, users use an expected return-risk criterion, 1/ weighted by a pattern of international trade factor. Potential reserve issuers, on the other hand, would like to use inflation to extract revenue from money holders; however, their monetary policy is also influenced by output stabilization considerations and the negative domestic welfare consequences of inflation. We employ a social welfare function similar to Barro and Gordon's (1983) to demonstrate that the optimal inflation rate and its variance (and hence the desirability of a currency) depend on the policymakers' preferences over the benefits and costs from inflation and the size of output disturbances that occur in the reserve issuing country. 2/ We assume that people have rational expectations and they know all the parameters of the model. This implies that cheating cannot take place, and a low inflation-variance currency maintains these properties even after its selection. In equilibrium, the optimal inflation rate is finite. 3/ Expected inflation in positive, but actual inflation can have either sign. If unexpected inflation is negative, then reserve users receive an indirect subsidy for holding assets denominated in a foreign currency.

In Section III we investigate the portfolio behavior of central banks in the industrial and developing countries groups for the 1977-84 period. We find that the actual composition of international reserves is consistent with a mean-variance optimization strategy. While other considerations (such as intervention in foreign exchange markets) may be present, our results indicate dominant portfolio motives. Finally, portfolio motives seem to be stronger in industrial countries than in developing countries.

1/ Brown, Papell, and Rush (1986) find that considerations of risk and return can account for a substantial fraction of central banks' reserve holdings under generalized floating.

2/ In this paper we abstract from the game theoretic considerations that would arise from letting the reserve user affect the behavior of the reserve issuer by designing a payoff-threat schedule. For a discussion of the game aspects in choosing a reserve currency, see Dellas (1987).

3/ It can be infinite if no explicit social cost is attached to inflation (Calvo, 1978; Dellas, 1988b).

II. The Model

Let potential reserve issuer 1/ i choose the inflation rate to minimize the following social cost function 2/

$$W_i = \frac{a_i}{2}(Y_{it}-\bar{Y})^2 - b_i(\pi_{it} - \pi^e_{it})B_{it} + \frac{c_i}{2}\pi^2_{it} \qquad (1)$$

where Y_{it} = current output in country i

$\bar{Y} = \bar{Y}_i$ = natural level of output in i

π_{it} = the actual inflation rate

π^e_{it} = the expectation of the inflation rate for period t formed in period t-1

B_{it} = currency i denominated assets that are held by the reserve users (in real terms)

and a_i, b_i, c_i are the weights attached to output stability, inflation tax revenue, and inflation costs, respectively. Actual output, Y_{it}, is assumed to deviate from its natural level, Y^*, by an amount that depends on an expectational error, $\pi_{it} - \pi^e_{it}$, plus some random productivity shock u_{it}

$$Y_{it} - Y^* = \theta_i(\pi_{it}-\pi^e_{it}) + u_{it} \qquad (2)$$

where u_{it} is white noise with variance σ^2_i.

1/ It seems realistic to assume that there exist two types of countries. One type consists of countries that play an important role in international transactions and also have advanced financial markets. We call this type "a potential reserve issuer." The other type, the "reserve riser" consists of small countries. Both potential reserve issuers and users choose international reserves from the first type.

2/ For a justification of this approach see Barro and Gordon (B-G). B-G rely on a labor market distortion to generate an inflationary bias in their model. While this can be very easily done in our model too, for our purposes it is more suitable to ignore such distortions and rely on the presence of the assets term in (1) to generate inflationary tendencies.

There are two ways of justifying government intervention in this model. One is to assume the existence of labor contracts. Productivity shocks that occur after the signing of the contracts are perceived by the public, but unless there is wage adjustment, they result in variations in employment and output. Since the social objective function we have adopted implies that such fluctuations are undesirable, active stabilization policy is welfare improving. An equivalent formulation would result if we dropped the assumption of labor contracts, but postulated that the government had an informational advantage over the private sector in recognizing output disturbances.

Minimization of W with respect to π_t gives (suppressing the i subscript)

$$\pi_t = \frac{b}{c} B_t - \frac{a\theta}{a\theta^2 + c} u_t \qquad (3)$$

Under the assumption of rational expectations, expected inflation is

$$\pi_t^e = \frac{b}{c} B_t .$$

The presence of inflation tax revenue opportunities for the reserve issuer introduces an inflationary bias into the conduct of monetary policy ($\pi_t^e > 0$). However, as the government attempts to stabilize output, the actual inflation rate will overshoot or undershoot its expected value depending on the sign and size of productivity shock. Deflationary monetary policy is still a possibility for a reserve issuer.

We now turn to the decision problem of the reserve user. We mentioned in the introduction that countries hold international reserves to facilitate trade and also because of portfolio considerations. 1/ To capture the first motive we will assume that countries face a flexible cash in advance constraint when they purchase imported goods. To finance consumption of foreign goods they can either acquire the currency of the desired consumption good in advance, or they can engage in currency exchange immediately before purchasing goods by paying an extra fee. The latter option captures the portfolio aspect of reserve holdings by enabling countries to hold currencies (assets) with good return-risk characteristics even if these currencies are not used to finance particular imports. However, the presence of the transactions cost will tend to favor the holding of currencies of major trading partners. For the second motive, we assume the standard mean-variance portfolio model.

1/ A recent (1984, p. 63) IMF annual report reads "... Expected rates of return together with considerations of liquidity and risks, exert an important influence on the allocation of international reserves among assets denominated in different currencies ...".

The representative user chooses a portfolio that maximizes $\nu = \nu(ER, V)$ subject to

$$ER = \sum_{i=1}^{n} S_i K_i R_i, \quad V = \sum_{i}^{n} \sum_{j}^{n} S_i S_j V_{ij}, \quad \sum S_i = 1, \quad S_i \geq 0 \tag{4}$$

where $K_i \in (0,1)$ is a measure of the importance of the trade links between the reserve user and country i, R_i is the expected real return on asset i, and V_{ij} is the variance of the inflation rate for currency i. 1/ Reserve users who are concerned about the level and stability of their consumption dislike changes in the inflation rate, and they also like the convenience of holding currencies that will be used in subsequent trade of goods.

From the solution of the optimization problem of the reserve issuing country we know that

$$\pi^{e}_{ti} = \frac{b_i}{c_i} B_{it}, \quad V_i^2 = \frac{(a_i\theta_i)^2}{(a_i\theta_i^2+c_i)^2}\sigma_1^2 \equiv A_i^2\sigma_i^2, \quad V_{ij}^2 = A_iA_j\sigma_{ij}^2$$

Consequently, the equilibrium asset shares can be written as $S = f(A,\Sigma.K,g)$ where Σ is the variance-covariance matrix of output shocks, $A = (A_1, \ldots, A_n)$, $K = (K_1, \ldots, K_n)$ and g is the relative risk aversion parameter.

The derivatives of f with regard to its arguments are as follows (assuming $\sigma_{ij}=0$): The higher the volatility (σ_i) of productivity shocks in country i, the higher the volatility of inflation in this country, hence the less desirable the currency. The more averse to inflation policymakers are (high c), the lower the expected depreciation of the currency. Similarly, the more concerned policymakers are about maintaining a stable level output at the expense of price stability (high a) or the steeper the short-run Phillips curve (high θ), the more volatile the inflation rate and hence the less desirable a currency. And finally, the stronger the trade links between the reserve user and country i (the higher K) the more likely that this currency will be chosen as reserve. If $\sigma_{ij} \neq 0$, then the risk inherent in any currency will depend on the portfolio with respect to which the risk is evaluated, so the covariance terms become important in a way suggested by the standard beta formulas.

1/ That is we identify unexpected changes in the rate of return with unanticipated inflation. This implies a constant expected real return.

III. The Empirical Analysis

The theory developed above can be related to the empirical evidence in two days. One is to explicitly express optimal portfolio shares as a function of the fundamental parameters of the model (the f functions and their K, A, and Σ elements) and then proceed to formally estimate and test the model. The test then would constitute a joint test of equations (1) and (4). However, the practical difficulties associated with this approach seem quite insurmountable, as it requires knowledge of (a) the parameters of the social welfare function, (b) the size of productivity disturbances, Σ, and (c) the risk attitudes of central banks, g.

The second strategy sidesteps these difficulties by assuming that the actual changes in the risk return characteristics of vehicle currencies must reflect changes in the underlying structure/preferences of the reserve issuing economies according to equation (1). 1/ Our task then simply becomes to test a version of equation (4), that is, whether central bank portfolio of foreign assets are consistent with the implications of the mean-variance model.

Unfortunately, data availability on the currency composition of official reserves is a major problem. No such data are publicly available for individual countries. The only information on official holdings of foreign exchange pertains to country groups (industrial, developing, world) and is contained in the IMF Annual Report, 1985. Table 1 below reports the shares of the four 2/ national currencies considered in the empirical analysis (U.S. dollar, U.K. pound, the DM, and the Yen).
It can be seen that U.S. dollar holdings have been decreasing at the expense of the DM and the Yen. While the growing importance of the German and Japanese economies must have played a role in this, we believe that with the existing low transaction costs, it has to be the case that portfolio considerations dominate trade transaction considerations.

1/ There exists substantial evidence that there has been a change in relative inflation uncertainty across countries that favors the DM at the expense of the U.S. dollar (see, for example, Froyen and Waud, 1987). The relative decrease in the predictability of inflation in the United States makes dollar assets riskier and leads to a decrease in the share of U.S. dollar denominated assets in international portfolios (so the return on dollar assets increases). Our theory suggests that the increase in relative inflation volatility is caused by an increase in the variance of productivity shocks and/or a change in the preferences of the policymakers. The latter factor seems consistent with the actual behavior of monetary authorities in the United States and Germany.

2/ Relative importance in portfolios motivated this choice.

Table 1. Official Holdings of Foreign Exchange (Shares)

	1977	1978	1979	1980	1981	1982	1983	1984	1977-84
All countries									
U.S. dollar	85.4	82.6	80.1	74.9	78.5	78.2	78.7	76.4	79.4
Pound sterling	2.0	1.9	2.2	3.4	2.4	2.7	3.0	3.4	2.6
Deutsche mark	10.0	11.9	13.7	16.8	14.5	14.0	12.9	14.1	13.5
Japanese yen	2.6	3.6	4.0	4.9	4.6	5.1	5.4	6.1	4.5
Industrial countries									
U.S. dollar	91.7	88.8	86.4	80.6	81.9	81.2	80.2	76.1	83.4
Pound sterling	0.9	0.7	0.8	0.8	0.7	0.8	0.9	1.7	0.9
Deutsche mark	5.6	8.1	10.0	15.0	13.5	13.2	13.5	15.7	11.8
Japanese yen	1.9	2.4	2.7	3.6	3.9	4.7	5.4	6.5	3.9
Developing countries									
U.S. dollar	78.6	73.4	73.1	68.5	74.6	74.5	76.8	77.0	74.6
Pound sterling	3.2	3.6	3.8	6.1	4.3	4.9	5.5	5.5	4.6
Japanese yen	3.5	5.5	5.3	6.3	5.5	5.7	5.5	5.5	5.4

Source: IMF, Annual Report 1985, p. 54.

Table 2a reports that real return and standard deviation 1/ on individual reserve currencies as well as the standard deviation of the inflation rate in the reserve issuing countries. Table 2b reports the variance-covariance matrix of the returns. The construction of the real rate of return of reserve holdings of currency j is based on equation (5) and follows closely Frankel and Engle (1984).

$$1 + R_{ti} = \frac{1 + Q_{ti}}{(P_{t+1}/P_t) \cdot (E_{ti}/E_{t+1,i})} \qquad i = 1, 2, 3, 4$$

$$P_t = \prod_{i=1}^{4} (P_{ti}E_{ti})^{a_{ti}} \tag{5}$$

where Q_{ti} is the nominal interest rate on one-month eurodeposits in currency i, E_{ti} is the nominal exchange rate index between country i and the U.S. dollar ($ per currency i), and P_{ti} is the consumer price index in country i.

The weights a_{ti} used in the construction of P_t reflect the importance of currency i in trade transactions for the country group under consideration in period t. More specifically,

$$a_{ti} = \frac{I_{ti} + C_{ti}}{\sum_{i=1}^{4} I_{ti} + C_t} \quad \text{with } C_{ti} = \begin{cases} C_t \text{ if } i = \text{U.S.A.} \\ 0 \text{ otherwise} \end{cases}$$

where I_{ti} are the imports of the country group under consideration from country i and C_t is oil imports of the country group (oil imports are paid in U.S. dollars).

1/ Caution has to be exercised in interpreting the return-standard deviation of return figures because of the choice of the U.S. dollar as the numeraire in equation (5) below. This choice implies that the investors' initial wealth is in U.S. dollars. Consequently, the variance on the dollar appears lower. However, the choice of a numeraire currency does not affect the comparison of actual and optimal portfolios in table 3. Note also that it is the last row in Table 2 that relates to Section I. The unconditional variance of inflation figures are consistent with the story told in footnote 1 page 6 for the conditional inflation variance.

Table 2a. Return and its Standard Deviation (s.d.) on Reserve Currencies; Standard Deviation of Inflation, 1977-84

	U.S. dollar	U.K. pound	DM	Yen
World				
Return	5.7	2.4	-1.8	3.1
s.d	16.1	22.2	23.5	27.7
Industrial				
Return	6.1	2.8	-1.4	3.6
s.d	16.4	21.5	23.1	28.5
Developing				
Return	4.9	1.6	-2.6	2.3
s.d	16.7	24.1	25.0	26.7
Inflation (CPI) s.d.	0.18	0.23	0.10	0.09

Table 2b. Variance-Covariance Matrix of Returns (World)

	Dollar	Pound	DM	Yen
Dollar	0.026	-0.008	-0.012	-0.018
Pound		0.049	0.013	-0.002
DM			0.55	0.013
Yen				0.076

The idea here is that the relevant price deflator for nominal returns on international reserves is a consumption price index that reflects the trade expenditure pattern of the importing country group, that is the K_i's in (4) in Section I (somewhat similar deflators have been used by Ben-Bassat, 1980; and Brown, Papell, and Rush, 1986). Frankel and Engle's (1984) use of GNP shares as a_{it}'s is essentially a proxy variable for our a_{it}'s.

Monthly data were used in the construction of all the variables (see the Appendix for more details). The first two rows in Table 3 report the return and standard deviation of the actual portfolios held by the central bank in the period 1977-84 (that is, with the shares from Table 1).

The construction of the optimal portfolios is more problematic. The solution to the maximization problem given by equation (4) does not give a unique vector of portfolio shares because the choice of the optimal composition depends on the preferences of central banks (the risk aversion coefficient). We have decided against experimenting with "plausible" values for the coefficients of relative risk aversion both because of the lack of consensus on individuals risk aversion parameters and because there is no compelling reason to believe that central banks have the same risk attitudes as private investors.

Table 3. Actual and Optimal (Efficient) Portfolios, 1977-84

	Actual		"Optimal" (efficient)
	Return	s.d.	Return
World	4.47	11.62	5.10
Industrial	5.08	12.66	5.60
Developing	3.48	11.97	4.40

Table 4. Minimum Variance Portfolios, 1977-84

	Return	s.d
World	3.56	7.99
Industrial	3.82	8.14
Developing	3.11	9.23

There is an alternative way of deriving the optimal portfolio of risky assets which does not require the specification of preferences, namely, by connecting the risk-free return to a point of tangency with the efficient frontier. This alternative, however, requires either the assumption of a risk-free asset (what would that be?) or a zero beta asset. Due to the assumption we have made in (3) that central banks cannot take short positions we cannot know whether a zero beta asset exists. Consequently, we have chosen to resort to more informal and less stringent test of the optimality of central bank portfolios. Row three in Table 3 reports the "optimal" (efficient frontier) portfolio returns that correspond to the actual standard deviations appearing in line two of Table 3. 1/ By comparing efficient to actual returns we can get some idea of how close the actual portfolios are to the efficient frontier. Clearly, the standard deviations are too large relative to the returns, so the power of any formal statistical test of equality between actual and efficient portfolios is low. 2/ Nevertheless, Table 3 offers strong support to the notion that portfolio considerations are of great importance in the

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1/ The efficient portfolio shares the solution to the following maximization problem:

$$\min \sum_{i=j}^{4} \sum_{i=j}^{4} S_i D_j \sigma_{ij}^2 \quad \text{subject to } R = \sum_{i-j}^{4} S_i = 1, \; S_i \geq 0.$$

The return in column three in table III were obtained using the actual σ_{ij} in the solution to this problem. Hence they represent points on the efficient frontier.

2/ A more formal test can be conducted as in Frankel and Engle (1984). However, we do not think that such a strategy is appropriate here because central banks, unlike private investors, have also other objectives besides satisfying optimal portfolio criteria (such as intervention in foreign exchange markets) and one cannot decompose official holdings into these separate categories. Moreover, the problem with choosing a value for relative risk aversion remains.

Finally, note that our approach would be in a disadvantage vis-á-vis either the Frankel-Engle or the traditional approach only if the return on the actual portfolio was above the corresponding return on the efficient frontier. In such a case one would have to consider the possibility that investors are combining the portfolio of risky assets with some risk-free asset. From Table 3 we see that we do not have to worry about such a composition.

selection of international reserves. 1/ Notice that the correspondence between the actual and the efficient portfolio is closer for the industrial countries than for the developing. This disagrees with earlier findings by Ben-Bassat who only looked at the 1976 actual portfolio using returns from the 1972-76 period. A possible explanation may be that portfolio considerations became stronger (and intervention motives weaker) as we moved further away from the time of the abandonment of the Bretton Woods agreement and the flexible exchange regime became established.

Finally, Table 4 reports the minimum variance portfolio return and standard deviation. 2/

IV. Conclusion

A country whose currency is used as an international reserve will exhibit an inflationary bias. If, however, monetary policy aims at satisfying other objectives besides raising inflation revenue from foreign holders of the reserve currency (such as output stabilization), the risk characteristics of the reserve currency will be affected. At the same time no systematic redistribution of wealth towards the reserve issuer is possible.

We undertook an empirical investigation of the hypothesis that central banks use the mean variance optimization criterion in forming portfolios of international assets. The examination of the behavior of the industrial and developing country groups offered support to this hypothesis.

1/ The corresponding optimal asset shares are:

	Dollar	Pound	DM	Yen
World	77.9	3.7	0.0	18.4
Industrial	81.1	3.5	0.0	15.4
Developing	79.4	0.0	0.0	20.6

2/ The corresponding optimal asset shares are:

	Dollar	Pound	DM	Yen
World	49.6	18.3	14.1	18.0
Industrial	48.4	20.7	16.1	14.8
Developing	51.8	14.1	9.6	24.5

APPENDIX

Q_{ti} = the return on one-month eurocurrency deposits (Source: Morgan Guaranty Trust Company, World Financial Markets)

E_{ti} = the exchange rate between the U.S. dollar and currency i, dollar per currency i (Source: IMF, International Financial Statistics (IFS))

P_{ti} = consumer price index in country i (Source: IFS)

I_{ti} = total imports of the country group under consideration from country i (source: IMF, Direction of Trade Statistics (DOT))

C_t = total oil imports of the country group under consideration (Source: DOT)

All raw data used are monthly.

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