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ABSTRACT

This paper analyzes official reserve-holding behavior in the EU countries in an attempt to assess the effect EMU might have on official holdings of dollar reserves. A wide range of projections are presented for the effect of EMU on the overall demand for reserves, some based on earlier research results and some on new estimates. In the estimation and simulation of the behavior of EU countries in the last half of the 1980s, the contributions of country-specific factors appear to swamp the systematic components that had been isolated in earlier research. Earlier research results are also used to assess the effect of EMU on the currency composition of reserves. It is argued that official dollar holdings could decline on the order of 35 percent or more from current dollar holdings, although the range of uncertainty is quite large.

The Dollar as an Official Reserve Currency under EMU

Michael P. Leahy[1]

I. Introduction

Up until the summer of 1992, the European Community, now the European Union (EU), had made great strides toward its goal of economic and monetary union. The clarity of the agenda for European Monetary Union (EMU), set forth originally in the Delors Committee Report and subsequently given legal stature in the Maastricht Treaty, focused the attention of analysts and policy makers on the possible effects of EMU on economic and financial activity in Europe and in the rest of the world. While recent setbacks appear to have slowed the drive toward monetary union, questions remain about the impact of EMU. One broad area of questions raised by the prospect for EMU concerns its possible impact on the international monetary system.

In moving from a Europe of individual central banks linked by the European Monetary System to one European Central Bank, the political and economic weight of Europe in international monetary negotiations would be

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increased and, presumably, facilitated, as Europe came to speak with one voice. Whether this change would have a significant effect on these negotiations is an open question. Additional questions concern the effect of a single European currency on the international monetary system. Some analysts predict that the development of a single European currency would accelerate the move away from the dollar as the center currency in the international monetary system and result in a more balanced, tri-polar system--with the dollar, the yen, and the ECU playing more equal roles.

An examination of the effects of EMU on the dollar in the international monetary system has at least two aspects. One involves the increased use private sector firms and individuals would make of the ECU in international transactions. Questions in this area include the extent to which the ECU would replace the dollar as a unit of account and means of payment, the extent to which exchange rate risk would be shifted to U.S. firms, and the extent to which European banks and financial centers would gain a competitive edge over their U.S. counterparts in a system in which the ECU has an expanded role.

A second aspect of an examination of the effects of EMU on the dollar involves the increased use the official sector would make of the ECU. Will the EU countries reduce their holdings of dollars as a result of pooling their reserves once they form a monetary union? The answer to this question has possible implications for the dollar's foreign exchange value and perhaps also for dollar interest rates, particularly on longer-term assets. In addition, as the prominence of the ECU in the international monetary system increases, non-EU countries may substitute ECU holdings for dollar holdings, especially if these countries unilaterally peg their currencies to the ECU.

This paper takes a closer look at the question of whether EMU would lead to a reduction in demand for the dollar as an official reserve currency within the EU. Consistent with previous research on the demand for reserves, the question is broken down into two parts. The first examines the effect EMU might have on the overall magnitude of foreign exchange reserves held by EU countries, irrespective of currency. The second looks at how EMU might affect the share of those reserves held in dollars.

The presumption in most discussions of the first question is that the demand for reserves by the EU would ultimately fall under EMU. The EU has estimated that such scale effects might result in the reduction of total official reserves by $200 billion equivalent or possibly more.[2] On the other hand, with the elimination of the mark as a major reserve currency under EMU, the dollar share of EU reserves would presumably rise. If the presumed signs of these two effects are correct, the net effect on the holdings of dollars by EU countries depends on the magnitudes of the component effects. Using the results in previous analyses as well as some original work estimating and simulating the demand for reserves, this paper considers several estimates of the change in the demand for and currency composition of reserves by EU countries in an attempt to estimate the change in holdings of dollars by EU countries under EMU. While the different simulations provide no clear-cut verdict on the effect of EMU on the demand for dollars, under reasonable assumptions about the character of the European Central Bank under EMU, it is argued that official dollar holdings

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2. "One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union," European Economy, Directorate-General for Economic and Financial Affairs, Commission of the European Communities, Number 44 (October 1990), p. 183.

could decline on the order of 35 percent or more from current dollar holdings. The range of uncertainty around that decline is quite large, with some estimates showing much larger declines and others showing increases in the demand for dollars.

The remainder of this paper is divided into several parts. Section II contains a review of recent trends in holdings of official reserves. Section III presents a selective review of the literature on theoretical and empirical models of the overall demand for reserves. Section IV discusses a variety of estimates of the effect of EMU on the overall demand for reserves, including some original work estimating the demand for reserves in the EU countries and simulating that demand under assumptions consistent with the existence of EMU. Section V offers a review of the literature on the currency composition of reserves and presents some simulations of other analysts' models in an attempt to capture the effect of EMU on the dollar share of reserves held by EU countries. Section VI contains a summary and concluding remarks.

II. Trends in the Behavior of Foreign Exchange Reserves

Official holdings of foreign currency reserve assets continued to increase during the period of managed floating that followed the breakup of the Bretton Woods regime. As shown in table 1, foreign currency reserves for all the countries reporting to the IMF grew at a compound annual rate of nearly 10-1/2 percent in the 17 years between 1975 and 1992. This nominal growth exceeded the growth of the IMF index of import unit values and of the U.S. CPI. Thus, in real terms as well as nominal terms, reserves continued to grow. The picture for industrial countries and the EU countries is

similar. For all three country groups, the rate of growth of foreign currency reserves in real terms averaged between 4-1/2 percent, using the U.S. CPI as the deflator, and 6 percent, using the import unit value. The rate of increase in nominal and real terms for industrial countries is somewhat surprising, given the presumption that external financing needs would be lower under a regime of managed floating than in a pegged exchange rate system and that industrial countries generally have access to private and official sources of funds if it became necessary to intervene. Even though some industrial countries (i.e., ERM countries) continue to pursue policies of pegged exchange rates, many others do not. One wonders why countries that intervene infrequently continue to hold stocks of reserves that are large and growing in real terms.

As shown in table 2, the dollar share of official holdings of reserves declined on balance in all countries and in the industrial countries between 1975 and 1992. As the share of dollars in official reserves diminished, the shares of other currencies, particularly the mark and the yen, rose. By implication, the level of dollar reserves held by all countries and industrial countries did not grow as fast as total foreign currency reserves. Nonetheless, growth was positive in nominal and real terms. As shown in table 3, the level of dollar reserves in industrial countries increased in nominal terms at a pace of about 8-1/2 percent per annum, still faster than the rate of increase in consumer prices in the United States or industrial countries.

Under the assumption that the mix of reserves held by EU countries is similar to that reported by the IMF for industrial countries, non-EU currencies made up between 70 and 80 percent of total foreign currency

reserves at the end of 1992.[3,4] If the European Central Bank were to passively accept the effects of the aggregation of reserves holdings of the member country central banks, its consolidated balance sheet would show in the asset column the sum of the individual country holdings of gold, reserve positions in the IMF, and SDRs. The entry for foreign exchange reserves, however, would not be a simple sum of the individual country holdings. Only the sum of the non-EU currency reserves of the individual countries--the bulk of which are held in dollars--would count as foreign exchange for the European Central Bank. Holdings of marks or other EU-country currencies would presumably be replaced by ECU-denominated claims, and holdings of ECUs would not be considered foreign-currency reserves for the European Central Bank. Thus, the elimination of certain currencies as legitimate reserve currencies for the new central bank would result in a reduction in the aggregate reserves held by the EU, although it would not imply a reduction in dollar reserves. From 20 to 30 percent of total foreign currency reserves in the EU would disappear under EMU.

This reduction in reserves is not, however, what analysts have in mind when they argue that the introduction of EMU would lead to an economizing on reserves. Rather than allowing reserves to be reduced passively as a result of the consolidation of individual EU country assets, it is assumed that reserves would be managed actively and that official

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3. According to the 1993 Annual Report of the International Monetary Fund, industrial country shares of dollar, Swiss franc, and yen holdings were 67 percent and 70 percent for 1991 and 1992, respectively. Unspecified holdings in 1991 and 1992 comprised 6-1/2 percent and 9 percent, respectively, of total foreign currency reserves for industrial countries.

4. This would be an overestimate if EU countries held proportionally more marks than non-EU countries. Nonetheless, without data on the currency composition of reserves in EU countries, I will proceed under the assumption that the reserve mix is roughly similar.

holdings would be adjusted to reflect transactions and trade needs of the EMU. These issues are discussed more thoroughly below in the review of the literature.

III. A Selective Review of the Literature

In general, the theoretical literature on reserve holding behavior takes the view that the overall demand for reserve assets depends on the costs of holding reserves and the expected costs of adjustment to external imbalances. In this approach, holding reserves or acquiring them via foreign borrowing reduces current income but leads to lower expected costs of future adjustment to imbalances. Adjustment can be defined broadly to include alterations in exchange rates, capital controls, or fiscal or monetary policy. Much of this literature was written before 1973, when the fixed parities of the Bretton Woods system naturally led to changes in official reserves for some countries and the focus was on so-called expenditure changing policies like changes in the stance of monetary or fiscal policy rather than the expenditure switching policies of devaluation or revaluation.

Theoretical Studies

Four types of variables are typically introduced into theoretical models of the demand for reserves: measures of uncertainty or variability of external shocks, measures of the opportunity cost of holding reserves, measures of scale, and measures of the cost of adjusting to external shocks.

Some measure of the variability of shocks to the balance of payments or reserves and some measure of the opportunity cost of holding reserves are considered important by most analysts, at least in theory. There is general agreement that increased variability should lead to an increase in the demand for reserves and that an increase in opportunity cost should lead to a decrease in the demand for reserves. The opportunity cost is the rate of return on the best alternative investment less the rate of return earned on the reserves. As noted below, however, researchers have encountered considerable empirical difficulties obtaining measures of opportunity cost that successfully enter the estimated demand equations.

It is generally agreed in the literature that an increase in scale--variously measured by the volume of foreign currency transactions, imports, or GDP--increases the demand for reserves. A key question for this study is whether demand rises proportionally with scale.

Rules of thumb that gauge the adequacy of reserves by, for example, the number of weeks of imports the reserves can buy or by the volume of private foreign exchange transactions they could support are essentially simple bivariate relationships that presumably represent a long-run equilibrium in which reserves demanded move in proportion to some scale variable, like the value of imports or the volume of foreign currency transactions. With this type of rule guiding behavior, economies in reserve holdings can arise only because of the less-than-proportional increase in the scale variable, not from a less-than-proportional increase in reserves demanded as the scale variable increases.

Economizing in the latter sense occurs when the coefficient on the scale variable is less than unity. Such demand behavior can be found in inventory models of the demand for money (Baumol [1952]) or in models

concerned with controlling the risk of reserve depletion (Olivera [1969]). In Baumol's model, the demand for money is a function of the square root of the volume of transactions. Thus, a doubling of the scale variable leads to an increase in the demand for money that is less than proportional. In a different framework, Olivera examines the quantity of reserves that would be desired if a central bank wants to rule out all but a small chance that it would run out of reserves. He shows that setting a target probability for the exhaustion of reserves can yield a demand for reserves that rises with the square root of the number of independent shocks. Under the assumption that enlarging the currency area generates no more than a proportional increase in the number of independent shocks, the demand for reserves rises less than proportionately.

The relationship between reserves and scale is potentially testable, and the result is important in determining the effect of EMU on the demand for reserves.

A key element in studies of the demand for reserves is determining the costs of adjustment to external shocks. Heller [1966] argued that in part the cost depends inversely on the marginal propensity to import. A deficit in the balance of payments could be eliminated with contractionary policies to decrease imports. The cost of such a policy is measured by the size of the decline in income necessary to generate a sufficient decline in imports. The larger the marginal propensity to import, the smaller the adjustment to income that would be necessary, and the smaller the cost of adjustment. This adjustment cost could be saved if the monetary authorities had sufficient reserves to finance the imbalance. Thus, the optimal level of reserves in this model varies inversely with the marginal propensity to import. In a more general model, Clark [1970] allows the speed of

adjustment and the optimum level of reserves to be determined simultaneously. His model also generates the result that the optimum level of reserves is inversely related to the marginal propensity to import.

There is some controversy, however, about the expected sign of the relationship between the propensity to import and the demand for reserves. Cooper [1968] argues that the average propensity to import corresponds to a country's vulnerability to external disturbances and, thus, should be positively related to the optimal level of reserves. Frenkel [1974] presents a monetary model in which the average propensity to import, the variable used in empirical work to proxy for the marginal propensity to import, has an ambiguous relationship to the demand for money and hence reserves.[5]

The Applicability of the Theory to the EU Countries and to EMU

Perhaps the most troublesome variable to include in the estimates for the EU countries in 1980s and for the simulations under the assumption of EMU is the average propensity to import. It is not obvious what variable could proxy for the cost of adjusting to external shocks in the current

5. In a monetary model of the demand for reserves, Frenkel shows that dR/R = k dT/T, where is R is reserves, k is the average propensity to import, and T is the terms of trade. Frenkel argues that under the assumption that dT/T is positive, an increase in k will lead to a further increase in R. Of course, it is also true that if dT/T is negative, an increase in k prompts a further reduction in R. Frenkel emphasizes the former result as the outcome of a specific interpretation of the small country assumption. I believe that narrow finding is perhaps too specialized for our purposes and would stress the alternative interpretation that the effect on reserves of a change in the average propensity to import is not clear cut. Perhaps the most we can say in this framework is that an increase in the average propensity to import magnifies the effect of changes in the terms of trade on reserves.

circumstances. Presumably it would still be relevant to consider the reduction in income associated with the adjustment to external disequilibria, but it is not clear that under current circumstances such a reduction is captured by the propensity to import.

Even if the propensity to import provides a reasonable proxy for something more difficult to measure, would it be the relevant measure under EMU? Underlying the models of Heller and Clark is the presumption that adjustment to downward pressure on the domestic currency would take the form of a tightening of fiscal or monetary policies. These expenditure changing policies reduce income, imports, and the balance of payments, with little said about capital flows. Because the EU countries for the most part operated under a regime of mostly fixed exchange rates in the late 1980s, it may be appropriate to consider the cost of expenditure changing policies rather expenditure switching policies in determining their demand for reserves. However, under EMU such a preference for exchange rate fixity would presumably be reduced, making the estimates less relevant for the EMU simulations.

Adapting these measures of the costs of adjustment to a world of flexible exchange rates may not be straightforward. Instead of focusing on the relationships between incomes, the balance of payments, and reserves, the models would need to relate incomes, exchange rates, and reserves, presumably through equations describing exchange rate determination and official intervention operations. The difficulties of successfully modeling exchange rates (and, in particular, the influence of intervention on exchange rates) are well known, and modeling the determinants of official intervention might prove to be nearly as troublesome.

There may also be some problem with the scale variable chosen. In principle, one might think the scale variable determining the demand for reserves should be related to the size of intervention transactions necessary to achieve one's goal. While reserves are by definition gross assets in foreign currencies and as such take no account of foreign currency liabilities, the two main models of the interaction between intervention and exchange rates are based on net positions in currencies, which do take into account foreign currency liabilities. In the portfolio balance model of exchange rate determination, the size of an exchange market intervention must be large enough to significantly alter the currency composition of private sector net worth. Thus, one might think that some measure of private sector net worth is the appropriate scale variable. However, these wealth measures are notoriously difficult to come by. Alternatively, one might be tempted to use a measure of the volume of foreign exchange transactions as a proxy for net worth under the assumption that the ratio of transactions to wealth is roughly constant. However, technological advances that have dramatically improved information flows and reduced the cost of executing foreign exchange transactions have also presumably increased the ratio of transactions to net worth in recent years. In the other major model of the interacton between intervention and exchange rates--the signaling model--the size of an exchange market intervention must be large enough to create a significant cost for the central bank under the possibility that it is sending a false signal. Gains or losses on intervention activity are also related to net positions rather than gross. In either case, even if it is assumed that gross reserves are roughly equivalent to net reserves, determining the appropriate proxy for the desired underlying scale variable is difficult.

Empirical Studies

Empirical studies of the demand for reserves have produced specifications that are remarkably similar, despite differences in interpretations and some coefficient estimates.

Heller and Khan [HKh, 1978] estimate a model in which the demand for reserves is a function of the average propensity to import, a measure of the variability of reserves, and the level of imports as a scaling variable. They omit any variable that might capture the opportunity cost of holding reserves, citing other researchers' lack of success with it. HKh fit their specification to various groupings of countries for the period from 1964Q4 to 1976Q4. The equation for industrial countries excluding the United States is shown below, with t-values in parentheses below the coefficients:

$$\ln(R_t) = \underset{}{0.428} - \underset{(0.51)}{0.635}\ \ln(M_t/Y_t) + \underset{(-3.67)}{0.757}\ \ln(M_t) + \underset{(5.74)}{0.686}\ \sigma_t^2 + \underset{(2.35)}{u_t},$$

where R_t is total reserves (including not only foreign exchange but also gold, the reserve position in the IMF, and SDRs), M_t is nominal imports, Y_t is nominal GDP, σ_t^2 is a measure of shocks to reserves, and u_t is a first-order autoregressive error term. The estimated coefficient on the average propensity to import is negative and significant, consistent with Heller's explanation that it captures the income cost of adjustment. The estimated coefficient on the scale variable is positive, significant, and less than unity. Thus, the scale variable coefficient supports the interpretation that desired reserves move less than proportionally with imports. The coefficient on the measure of variability is also positive and significant.

Finally, the autoregressive coefficient estimate of 0.918 is near unity and strongly significant, indicating that reserves adjust slowly to new equilibrium levels after a shock.

Using a slightly different specification, Frenkel [1983] estimates demands for real rather than nominal reserves and uses real GNP or GDP rather than nominal imports as his scale variable. Frenkel's model is estimated with cross-section data from 22 developed countries for each year from 1963 to 1979.[6] In contrast to HKh, Frenkel finds the estimated coefficient on the average propensity to import has a positive and significant sign in each year, consistent with the vulnerability interpretation of the variable.[7] He also finds positive and significant coefficients for the measure of variability of reserves and the scale variable. Furthermore, Frenkel's coefficient estimates on the scale variable are roughly equal to unity, providing no direct support for the economizing hypothesis. Frenkel also divides the sample at 1973 and estimates his specification on the pooled data in the two subperiods. His equation for developed countries in the period between 1973 and 1979 is shown below:

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6. Frenkel also estimates demands for 32 developing countries using data from 1963 to 1977.

7. The sign of the coefficient on the average propensity to import is not sufficient to reject either theory. To see this, suppose that reserves are positively related to the level of both GDP and imports, i.e., the coefficients c_1 and c_2 in the underlying relationship $\ln(R) = c_1 \ln(GDP) + c_2 \ln(M) + \ldots$ are positive. In the HKh specification, the coefficient on $\ln(M/Y)$ would be equal to $-c_1<0$ and the coefficient on $\ln(M)$ would be equal to $c_1+c_2>0$. In the Frenkel specification, the coefficient on $\ln(M/Y)$ would be equal to $c_2>0$ and the coefficient on $\ln(Y)$ would be equal to $c_1+c_2>0$. Thus, the data could in principle support both interpretations. In this case, however, Frenkel's results are inconsistent with the results of HKh, because the relative magnitudes of Frenkel's coefficients imply that the underlying coefficient $c_1<0$, while H-K's results imply that $c_1>0$.

$$\ln(r_t) = \underset{(12.47)}{3.615} + \underset{(9.50)}{1.520}\ln(M_t/Y_t) + \underset{(29.1)}{1.105}\ln(y_t) + \underset{(6.06)}{0.636}\ln(\sigma_t) + u_t,$$

where r_t is total reserves in real terms, y_t is real GNP or GDP, σ_t is a measure of the variability of reserves, and u_t is an error term.

The models proposed by Heller and Khan and by Frenkel were primarily intended to determine how the demand for reserves changed when the world moved from the Bretton Woods system of pegged exchange rates to a system of managed floating. In general, the authors find that countries' holdings of reserves can be represented as a stable function of a limited number of (not necessarily the same) variables and that the move to more flexible exchange rate arrangements did not fundamentally alter that function. Lizondo and Mathieson [1987] reproduce the original results and extend them to an enlarged sample that includes data from the early 1980s. While they find that the disturbances in financial markets in 1981-82 were accompanied by changes in the structure of the demand for reserves that were comparable to those that occurred during the collapse of the Bretton Woods system, the effects appear to be more pronounced for developing countries than for developed countries, particularly when dynamic specifications are used that allow actual and desired levels of reserves to differ. There seems to be general agreement in the empirical literature that, while the demand for reserves by industrial countries may have shifted somewhat between the fixed exchange rate period prior to 1973 and the period of

managed floating, the shift has been smaller than most researchers had expected.[8]

IV. Estimates of the Effect of EMU on the Demand for Reserves

This section looks at different estimates of the effect of EMU on the overall demand for reserves by EU countries. The estimate of the EU Commission is discussed first, followed by some back-of-the-envelope calculations of the effect of EMU on the demand for reserves based on the results of the models estimated by Heller and Khan and by Frenkel. In the next section is the presentation of the estimation and simulation of "typical" reserve demand by EU countries. In the last section are some concluding remarks on the estimation of the overall demand for reserves.

Rules of Thumb, Backs of Envelopes, and some EU Arithmetic

The EU Commission estimates the reduction in reserves demanded using two methods. Both assume a proportional relationship between scale and demand. One takes the reduction in total reserves to be proportional to the share of intra-Union transactions in total foreign transactions. By this method, the Commission estimates $230 billion equivalent of reserves would be freed. With the other method, the reduction in reserves is based on a simple but widely used indicator of reserve adequacy--the ratio of total reserves to imports. Measured imports for the EU countries will

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8. Furthermore, its timing raises the possibility that it is associated with factors other than the shift in exchange rate regime. The 1973 oil shock is one alternative candidate.

necessarily decline under EMU after the exclusion of trade between EU countries, and it is assumed that total reserves will be reduced accordingly to bring the ratio for the EMU into line with the ratio for other industrial countries. This second method produces an estimated reduction of about $200 billion equivalent in total reserves, where total reserves includes not only foreign exchange reserves but also gold, SDRs, and reserve positions in the International Monetary Fund. A decline of this magnitude is roughly 50 percent of the aggregate holdings of total reserves by EU countries.

While clearly the models of HKh and Frenkel were not estimated with this exercise in mind, one can employ their coefficient estimates to compute a "back-of-the-envelope" estimate of the effect of EMU on the demand for reserves. Assume that the aggregate demand for reserves of the 11 member countries of the EMU is roughly equal to 11 times the demand of a country that has average GDP and average imports. In addition, assume that any differences in the variability of reserves before and after the establishment of EMU are negligible. Then, it can be shown that with the coefficent estimates in HKh, reserves demanded after EMU would be 50 percent of the aggregate of reserves demanded before EMU. Similarly, on the basis of Frenkel's estimates, reserves demanded would decline to 36 percent of pre-EMU reserves.[9] Thus, based on these crude calculations, the models in HKh and Frenkel would show significant reductions in the demand for reserves

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9. These estimates are derived using the formula $\exp((c_1+c_2-1)\ln(11) + c_2\ln(0.43))$, where c_1 is the coefficient on GDP in the underlying model and c_2 is the coefficient on imports. The first term in the exponential function captures the scale effects of going from one "average" country to an aggregate of eleven "average" countries. The second term incorporates the effect of excluding from imports the trade within the EMU. Imports from countries other than EU countries was about 43 percent of total imports for the eleven EU countries between 1985 and 1990.

under EMU, roughly in line with the scale of reductions suggested by the EU Commission. While the magnitudes of the reductions in the analyses are roughly comparable, the explanations for them differ. In HKh, the reduction must be attributed solely to scale effects, since the decline in the average propensity to import under EMU acts to increase the demand for reserves when the coefficient on the propensity to import is negative. In contrast, in Frenkel's specification, the reduction in the demand for reserves must be attributed to the decline in imports, since the coefficient on the scale variable is slightly greater than unity. Similarly, the reduction estimated by the EU Commission must be attributed to the decline in imports or external transactions.

Estimation and Simulation of Demand for Reserves

In this section I estimate the demand for foreign currency reserves in the EU countries in an attempt to calibrate behavior that might be typical of central banks in the EU countries in the second half of the 1980s. Under the assumption that the behavior of a European Central Bank would be similar to the behavior identified as typical of EU countries during a period when macroeconomic policies in the various countries appeared to be converging, I simulate what the demand for reserves would have been during the period had EMU been in existence. The objective is to compare the simulated demand with the actual holdings of EU countries during the period to determine, to the extent possible, the sign and magnitude of the change in the demand for foreign currency reserves that might come about under EMU.

Two caveats should be mentioned at the outset. The theoretical underpinnings of this exercise are clearly weak. Lacking a theory of the demand for reserves appropriate for modern industrial countries with well-developed private capital markets, I rely heavily on the previous empirical literature for guidance in the formulation of the basic structure of the empirical model and, in particular, in the selection of variables. Furthermore, without an understanding of the micro-foundations underlying these empirical models of the demand for reserves, the exercise I conduct is clearly subject to Lucas's critique of economic policy evaluation. With respect to the Lucas critique, however, one may be able to take some solace in the findings of previous empirical work that significant changes to the international monetary system did not fundamentally change the general structure of the estimated demand for reserves.

The specification used here employs key variables from previous theoretical and empirical work, with some adaptations to make the simulation exercise possible. It takes as the dependent variable the value of foreign currency reserves rather than total reserves, which include gold, SDRs, and the reserve position in the IMF. I assume that holdings of gold and particularly SDRs and reserve positions in the IMF are not managed actively by EU central banks. This assumption is useful in the subsequent exercise determining the currency composition of reserves. Some preliminary checking shows that the estimation results for the overall levels of reserves demanded would not be changed much by using total reserves as the dependent variable. As in other studies, the specification includes GDP, imports, and a measure of the variability of external shocks as explanatory variables and excludes a measure of the opportunity cost of holding reserves. However, the GDP and import variables enter the specification separately rather than

as the average propensity to import and a scale variable. This feature is largely cosmetic, since with the functional form I use the different specifications are equivalent. Lacking data on the past variability of reserves under EMU, I do not to use that variable in the joint estimation of the EU country demand for reserves. Instead, I use the lagged value of the variance of daily percent changes in a country's exchange rate against the dollar during each quarter. With this measure of the volatility of external shocks, it is relatively straightforward to substitute the variance of daily changes in the ECU against the dollar when producing the EMU simulation.

I also add a trend to the list of explanatory variables to help alleviate the problem of spurious correlation that is common with trending variables. As in some but not all of the previous literature, the formulation is conducted in terms of real variables and is explicitly dynamic in that it includes a lagged dependent variable. The dynamic specification allows for the possibility that there are adjustment lags in moving from actual reserves to the desired level of reserves.

For a given country, let R_t be the dollar value of foreign currency reserves at the end of quarter t, E_t^e be the exchange rate (local currency per dollar) at the end of quarter t, E_t^a be the average exchange rate during the quarter, P_t be the country's GDP or GNP deflator during quarter t, Y_t be the dollar value of nominal GDP, M_t be the dollar value of nominal imports, and σ_t^2 be the variance of the daily change in the exchange rate during quarter t. Real values for reserves, GDP, and imports are given respectively by r_t, y_t, and m_t, where $r_t = E_t^e R_t/P_t$, $y_t = E_t^a Y_t/P_t$, $m_t = E_t^a M_t/P_t$. The basic equation used to derive the estimated specification is given below:

$$\ln(r_t) = a_0 + a_1 t + a_2 \ln(r_{t-1}) + a_3 \ln(y_t) + a_4 \ln(m_t) + a_5 \sigma^2_{t-1} + u_t.$$

Rewriting the specification above in terms of nominal magnitudes yields the equation used to estimate the demand for reserves in the eleven EU countries:

$$\ln(R_t) = a_0 + a_1 t + a_2 \ln(R_{t-1}) + a_3 \ln(Y_t) + a_4 \ln(M_t) + a_5 \sigma^2_{t-1} +$$

$$b_6 \ln(P_t) + b_7 \ln(P_{t-1}) + b_8 \ln(E^e_t) + b_9 \ln(E^e_{t-1}) + b_{10} \ln(E^a_t) + u_t,$$

where $b_6=(1-a_3-a_4)$, $b_7=-a_2$, $b_8=-1$, $b_9=a_2$, and $b_{10}=a_3+a_4$.

A set of coefficients for each EU country is estimated with quarterly data from 1985Q1 to 1990Q4 using a seemingly unrelated regression technique. This technique allows a random shock to the reserves of one country to affect the reserves of another in the same quarter. Allowing for this possibility can improve the efficiency of the estimates. In the unconstrained version of the model, the restrictions on coefficients b_6 through b_{10} are not imposed, and no coefficients are constrained to be equal across countries. With only 13 degrees of freedom in each country equation, the estimation is not precise. However, it provides a benchmark in terms of generality against which further restrictions can be assessed. In particular, a test of the resrictions associated with pooling the time series and cross section data is described below. Pooling data to estimate coefficients that might reflect the behavior of a typical EU central bank is useful in the subsequent simulation exercise. With the coefficients from the pooled estimation and data for the EU countries appropriately aggregated so as to be representative of what aggregate EMU data would have been, one

can simulate what demand for reserves would have been had EMU been in place during those years. The final step is to compare the demand for reserves of the hypothetical European Central Bank and the actual sum of foreign currency reserves demanded by the EU countries during those years to get a sense of how EMU might affect the demand for reserves.

In the pooled time-series, cross-section estimation, an equation is specified for each country, as before. However, all the coefficients except a_0 and a_1 are constrained to be equal across countries. Thus, it is assumed that a given increase in, for example, GDP has the same effect on Italian reserves as it does on German reserves. The constant term a_0 and the coefficient on the trend a_1 are allowed to be different across countries to capture country-specific effects that may be relevant for reserve-holding behavior but not controlled for by the other variables in the specification. In particular, some EMS countries may have systematically different behavior because of their participation or nonparticipation in the exchange rate mechanism or because of the stage of development of their local financial markets. In other cases, certain countries may have idiosynchratic components in their desires for reserves. The separate terms for the constant and trend in these equations can capture fixed and time-varying country-specific effects like these, while all the other variables serve as observations on typical EU relationships. As before, the estimation allows for contemporaneous correlation between error terms u_t across countries, and the restrictions on coefficients b_6 through b_{10} are not imposed. An F-test

of the 90 cross-equation restrictions described above fails to reject the hypothesis that the restrictions are valid.[10]

The results of this constrained estimation are shown in table 4. The estimates for the coefficients on the lagged dependent variable and the country-specific constants and trends are all positive, and all but one are clearly significantly different from zero. The coefficient on the lagged dependent variable is estimated to be about 0.6, indicating that in two quarters reserves will adjust about 65 percent of the way toward their long-run equilibrium levels. The estimated coefficient on GDP is positive but not significant, and the estimated coefficient on imports is negative and insignificant. The combination of signs and magnitudes on these two variables would yield a negative coefficient on the average propensity to import and a coefficient on the scale variable that is positive but less than one. The estimated coefficient on the measure of exchange rate variability is positive and significant at the 95 percent confidence level. The table also shows, in the bottom-left corner, estimates of the long-run coefficients for the key independent variables and their associated t-values. The long-run coefficient estimates on GDP and imports are not significant at conventional levels, while the long-run coefficient estimate on exchange rate variability is positive and nearly significant at the 95 percent confidence level. Tests of the additional restrictions on the coefficients of this specification--restrictions on coefficients b_6 through b_{10} or restrictions that the constant and trend coefficients are also equal across equations--are rejected at confidence levels of 95 percent or higher.

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10. The test statistic 1.068 has a p-value of 0.359 under the null hypothesis that it is distributed F(90,143).

Next we determine what the long-run equilibrium level of reserves in the EU would have been under monetary union if a hypothetical European Central Bank were to follow the behavior embodied in the equation estimates. To conduct the simulation, hypothetical variables for the EMU are constructed. It is assumed that under EMU reserves and nominal GDP would be equal to the sums of the reserves and nominal GDPs of the eleven EU countries, that imports would be equal to the sum across countries of each country's imports less imports from other member countries, that the exchange rate and exchange rate variability are given by the level and variability of the ECU against the dollar, and that the GDP deflator is equal to the GDP-weighted average of GDP deflators of the member countries.

Chart 1 shows a range of projected reserve demands, corresponding to the range of country-specific coefficients. The estimated coefficients in the equation for Portugal generated the highest levels of reserves on average over the six year period; the estimated coefficients for the Netherlands generated the lowest levels of reserves on average. The chart also shows the median projected levels of reserves, generated from the estimated coefficients for Belgium. The country-specific factors have a dominant role in the equations specifying the demand for reserves, apparently overwhelming the systematic cross-country effects. On the basis of these results alone, it is difficult to arrive at a conclusion about the effect of EMU on the sign of the change in reserves holdings much less the magnitude, since it appears that reserves could be higher or lower depending on what one assumes about the idiosynchratic characteristics of the European Central Bank.

Table 5 provides a breakdown by country of the projected reserve demands. Evidently, after controlling for GDP, imports, and exchange rate

variability, the countries of Portugal, Greece, Spain, and Italy tend to hold relatively more reserves on average than the countries of Germany, the United Kingdom, France, and the Netherlands. This ordering of countries may be related in part to the stage of development of the countries' local financial markets.

If one is willing to assume that the idiosynchratic characteristics of the European Central Bank could be approximated by the median projection, then foreign currency reserves would be expected to decline to about 35 percent of the aggregate level of pre-EMU reserves. The drop could be even larger if one is willing to assume that the European Central Bank would behave more like the central banks in Germany, the United Kingdom, France, and the Netherlands than it would behave like those in the other EU countries. Under the exchange rate mechanism of the EMS, many countries held reserves because of their obligations to peg exchange rates. Because the European Central Bank would have no such obligation, one might believe that the coefficients estimated from data on the group that includes Germany would be more appropriate. On the other hand, previous empirical work seems to have found little change in the structure of the demand for reserves as exchange rate policies shifted from fixed to floating.

Another way to arrive at an average EU behavior is to suppress altogether any country-specific effects and estimate the model under the assumption that the coefficients on each variable are equal across countries. Table 6 shows the estimation results for this specification. An F-test that the additional restrictions are valid is clearly rejected,[11]

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11. The test statistic 3.31 has a p-value of 0.00 under the null hypothesis that it is distributed F(20,233).

indicating that the two specifications are statistically different. This can be verified by looking at the changes in the coefficient estimates. The estimated coefficients for the constant and trend are no longer positive and no longer significantly different from zero. The estimated coefficient on the lagged dependent variable increases to more than 0.9, indicating a much slower pace of adjustment of reserves to their desired levels. The statistical significance of the estimated coefficients on GDP and imports increases, while the significance of the estimated coefficient on the measure of exchange rate variability decreases.

Even though the behavioral characteristics are significantly different in the two specifications and the data seem to favor the specification with country-specific effects, it may not be unreasonable to compute the projected level of reserves for the specification with no country-specific effects. In this case, the constrained estimation can be viewed simply as a method of averaging the different behaviors rather than as an attempt to quantify stable, underlying behavioral parameters. The simulation results for this specification show that on average under EMU the long-run equilibrium demand for foreign-currency reserves would be about 97 percent of the average of the aggegate holdings of EU central banks during the second half of the 1980s, but because of the high coefficient on the lagged dependent variable, the long-run equilibrium is quite sensitive to small changes in the explanatory variables.

Summary of Findings

Changes in the aggregate level of reserves held by EU countries in the move to EMU can arise in at least four ways. One is not behavioral but

definitional. It derives from the process of aggregation of the assets of the EU central banks and the elimination of certain assets as foreign currencies. The remaining are behavioral. One arises from applying some simple linear rules of thumb about reserve holding behavior after allowing for a less-than-proportional increases in key EU scale variables. Another involves models of behavior where reserve holdings rise less-than-proportionally with the scale variables. And yet another is driven by a shift in the balance of country-specific factors that contribute to reserve-holding behavior.

A variety of projections are considered. While some projections show an increase in the demand for reserves, most call for declines, although the magnitudes of the declines are quite variable. Using linear rules of thumb, the EU Commission projects a decline of about 50 percent in the demand for reserves after monetary union. Back-of-the-envelope calculations with the empirical models of HKh and Frenkel show post-EMU demands at 50 percent and 36 percent, respectively, of their pre-EMU levels. The dominant behavioral factor underlying the results of the HKh model is the less-than-proportional increase in the demand for reserves when the scale variable increases. In contrast, the Frenkel model results are the outcome of linearly proportional behavioral characteristics but a less-than-proportional increase in imports.

The simulations that allow for country-specific characteristics to influence the demand for reserves show the widest range of projected outcomes. These idiosynchratic components tend to dominate the systematic components in both the estimation and simulation of the demand for reserves. The coefficient estimates for the Netherlands generate a demand for reserves under EMU that is 12 percent of pre-EMU levels, while the comparable

coefficient estimates for Portugal produce a demand that is 19 times higher than pre-EMU levels. The median projection, based on the coefficient estimates for Belgium, shows reserves at about 34 percent of their pre-EMU levels. Finally, estimation and simulation of the behavior of the EU countries with no country-specific factors leaves the demand for reserves little changed on average under EMU.

Under the assumption that the currency shares for the industrial countries listed in table 2 are representative of the currency shares held by EU countries, we can see that between 20 and 30 percent, depending on what assumptions one makes about the currency composition of the unspecified component, of EU foreign currency reserves would disappear with the extinction of the individual-country currencies. This decline occurs, of course, with no change in dollar holdings. If, however, overall foreign currency reserves are to decline 50 percent or more, the European Central Bank would necessarily reduce also its holdings of non-European currencies. How much of that further decline would come from EU holdings of dollars depends on the desired currency composition of reserves of the European Central Bank under EMU.

V. Estimates of the Effect of EMU on the Composition of Reserves

Because data on the currency composition of reserves in EU countries is not available, no original estimation of share equations is presented here. However, using empirical work done by researchers at the IMF, I simulate what the effect of EMU might be on the share of reserves held in dollars. These simulations, like the simulations of the overall demand for reserves, are vulnerable to Lucas's critique of econometric

policy evaluation, largely because the currency share equations I use were originally estimated under the assumption that reserves could be held in German marks, U.K. pounds, and French francs--currencies that would no longer be available under full monetary union. Nonetheless, the simulations provide some basis on which to assess the effect of EMU on the share of dollars held as reserves.

Two modeling strategies have been employed in previous studies of the composition of reserves. One strategy borrows from the portfolio balance literature, arguing that currency composition of reserves should be based on considerations of relative return and risk. The other, described as a transactions approach by Dooley, Lizondo, and Mathieson [DLM, 1989], posits that currency composition should be related to the exchange market activities of the monetary authorities and the costs of converting or borrowing currencies.

Dooley [1986] argues against the use of portfolio balance models to determine the optimal composition of reserves. First, he notes that because reserves are measured as gross asset positions in various currencies and gold, portfolio balance models, which typically determine net currency positions, are not applicable. Second, to be useful, the portfolio optimization must be done over all the assets and liabilities of the authorities and should include the variances and covariances of these positions with the more limited set of reserve assets.

According to Black [1985], empirical work using a portfolio balance approach during the 1960s, when reserves were composed largely of dollars and gold, generally found that rates of return did seem to matter to central banks. Following the demonetization of gold, however, the results are less clear. Ben-Bassat [1980] found that for industrial countries as a group the

gap between actual and optimal portfolios increased between 1976 and 1980. He infers that portfolio optimization is less important for the industrial countries, which are more concerned about international monetary stability, than it is for developing and semi-industrialized countries.

Asserting that central banks have broader objectives than portfolio optimization, Heller and Knight [HKn, 1978] argue that the currency composition of a country's reserves is in part the outcome of the choice of intervention currency. Furthermore, they claim that this choice may be constrained by transactions costs or by an official exchange rate arrangement. Using OLS, they estimate 5 cross-section equations on a sample of 55 countries for 1975 in which the endogenous variables are the shares of each major reserve currency (dollars, sterling, marks, French francs, and other--the yen is not explicitly included). These data are supplied on a confidential basis to the IMF. HKn find that countries generally hold a greater proportion of their exchange reserves in the currency to which they peg and in the currencies of those reserve centers that are their major trading partners.

DLM use a similar approach, formulating an empirical specification in which the proportion of a country's reserves held in assets denominated in a particular currency is influenced by the currency composition of trade flows (and debt servicing payments, for developing countries) and by its exchange rate arrangements. They estimate 5 cross-section, time-series equations, with the dependent variables the proportion of reserves held in five key currencies (the dollar, mark, yen, sterling, and French franc), using data on the currency composition of reserves (again, supplied on a confidential basis to the IMF) for 19 industrial and 39 developing countries. The data are annual from 1976 to 1985. Because the dependent

variable--the currency share--in these equations is constrained to be between zero and one, they investigate two alternative estimation techniques--Tobit estimation and symmetrically censored least squares (SCLS)--in addition to ordinary least squares (OLS). They find that in general a higher level of trade between an industrial country and a particular reserve-currency country leads the country to hold a larger proportion of its reserves in that currency. They also find that exchange rate arrangements most strongly affect the proportions of reserves held as dollars, francs, and marks.

Lacking data on the currency composition of reserves in EU countries, I cannot estimate comparable share equations for EU countries in the late 1980s. Instead, I use the estimates published in HKn and DLM. With their coefficient estimates and aggregations of EU trade data that exclude intra-EU trade, I simulate what the dollar share of the foreign currency reserves of the European Central Bank might have been had EMU been in place.

As shown at the top of table 7, the share of foreign currency reserves held in U.S. dollars is estimated to rise when the trade shares are adjusted to exclude intra-EU trade (see the middle section of the table), although the magnitudes of the projections are quite different. With the HKn specification, shown in the bottom part of the table, the dollar share is projected to rise from 46 percent of total foreign currency reserves to 77 percent; with the DLM specification, the rise is from 78 percent to 85 percent. A comparison of the pre-EMU estimates with IMF data on the dollar share held by industrial countries between 1985 and 1990 in table 2 shows that the HKn estimate is below the range of industrial country shares over that period and the DLM estimates are above. Under the assumption that the

currency shares of EU countries are similar to the currency shares of industrial countries, it seems reasonable to benchmark the currency share estimates to the IMF average. One way of doing this to average of the HKn and DLM estimates; the average of the two estimates, which is quite close to the average share in table 2 between 1985 and 1990, may be more accurate than either estimate alone. Carrying this averaging through to the post-EMU projections indicates that the desired dollar share would rise from 62 percent of foreign currency reserves to 81 percent under EMU--a 30 percent increase in holdings of dollars, all else equal. If, however, the decline in the overall demand for reserves is greater than 30 percent, as it was in many of the estimates discussed earlier, the net effect on the official EU demand for dollars is negative.

VI. Summary and Concluding Remarks

This paper analyzes official reserve holding behavior in the EU countries in an attempt to assess the effect EMU might have on the holdings of dollar reserves. The analysis is conducted in two parts. The first part considers the effect EMU might have on the overall demand for foreign currency reserves; the second considers the effect on the currency composition of reserves.

A variety of estimates of the effect of EMU on the overall demand for reserves is presented. These estimates generate projections of reserve demand under EMU that range from a decline to 12 percent of pre-EMU reserves, on the one hand, to a rise to 19 times the level of pre-EMU reserves, on the other. The median behavior among the country-specific estimates is represented by Belgium, and, if that behavior is descriptive of

the European Central Bank, then the overall demand for reserves declines to about 35 percent of its pre-EMU levels. A comparable simulation with no country-specific effects shows essentially no decline in the overall demand for reserves under EMU. Crude back-of-the-envelope calculations not incorporating country-specific effects project declines to between 35 and 50 percent of pre-EMU reserves. These are roughly consistent with the estimates of the EU Commission.

These estimates of the effect of EMU on the overall demand for foreign currency reserves can be combined with the estimated effect on the currency composition of reserves to determine the net effect on the official demand for dollars by the European Central Bank under EMU. Averaging the forecasts of two models shows the dollar share of reserves held by the EU rising to 81 percent from 62 percent in the absence of EMU. Thus, the contribution of this component of the demand for dollars rises about 30 percent.

The net effect of the change in the overall demand for reserves and the change in the desired composition of reserves obviously pivots on the assumption one makes about the change in the overall demand for reserves. Given that the unspecified country-specific factors appear to swamp the more systematic components of the demand for reserves in the estimation and simulation of EU-country reserve-holding behavior in the second half of the 1980s, it would seem reasonable to put more weight on the results of simulations that incorporate country-specific factors. Unfortunately, that paring of candidate models fails to reduce the range of projections. Further assumptions about the nature of the European Central Bank must be made. If one is willing to assume that the reserve-holding behavior of the European Central Bank under EMU is better-described by the country-specific

estimates of behavior for the central banks of Germany, the United Kingdom, France, and the Netherlands than it is by the country-specific estimates of Portugal, Greece, Spain, and Italy, then the overall demand for reserves declines. An alternative assumption that seems just as reasonable is that the European Central Bank would take on the characteristics underlying the median projection. In either case, reserves would decline to 35 percent of pre-EMU levels or lower. Declines of that magnitude would generate a net decline in the demand for dollars by the European Central Bank of 35 percent or more from the levels of dollars held by EU countries before the establishment of EMU. At levels of reserves held by EU countries at the end of 1992, this decline would amount to a cumulative decline in dollar holdings of roughly ~~$90~~ 55 billion or more.

It must be stressed, however, that this point estimate is essentially a judgment. While it is informed by data and analysis, the theory behind the analysis is clearly weak, and the simulations are vulnerable to Lucas's critique of econometric policy evaluation. The full distribution of outcomes, wide as it is, is probably a more accurate description of what we currently know about the demand for reserves. The dominance of the unspecified country-specific effects in the estimation and simulation of the overall demand for reserves reinforces the view that our understanding of the systematic behavior behind countries' holdings of foreign currency reserves is still very rudimentary.

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TABLE 1

OFFICIAL HOLDINGS OF FOREIGN EXCHANGE RESERVE ASSETS* END OF YEAR, MILLIONS OF US DOLLARS

Country Group	1975	1980	1985	1990	1992	Change (ppa) 1975-1992
All Countries	160,551	323,511	351,961	806,388	860,686	10.4
Industrial Countries	81,532	164,279	177,697	497,685	462,775	10.8
EU Countries	49,372	98,373	90,492	261,207	255,740	10.2

*ECU issued against dollars by the EMCF are included in foreign exchange assets but ECU issued against gold are not included.

IMPORT UNIT VALUES, PERCENT CHANGE, ANNUAL RATE

Country Group	1975-1980	1980-1985	1985-1990	1990-1992	1975-1992
All Countries	11.8	-3.13	5.46	-.23	3.97
Industrial Countries	12.0	-3.37	6.07	-.30	4.10
EU Countries	11.7	-4.93	8.06	-.22	4.11

CONSUMER PRICES, PERCENT CHANGE, ANNUAL RATE

Country Group	1975-1980	1980-1985	1985-1990	1990-1992	1975-1992
All Countries	11.6	12.6	13.5	12.5	12.6
Industrial Countries	8.88	6.22	3.57	3.61	5.89
EU Countries	7.84	8.34	3.92	4.40	7.17
United States	8.91	5.48	3.95	3.64	5.80

Sources: Annual Report of the International Monetary Fund; various years
International Financial Statistics

TABLE 2

SHARE OF NATIONAL CURRENCIES IN TOTAL IDENTIFIED OFFICIAL HOLDINGS OF FOREIGN EXCHANGE (END OF YEAR, PERCENT)

All Countries	1975	1980	1985	1986	1987	1988	1989	1990	1992
US Dollar	78.6	69.2	64.8	67.0	67.8	64.6	60.2	57.5	62.5
German Mark	8.5	15.0	15.1	14.6	14.3	15.5	18.8	18.6	13.7
Other European Currencies	7.18	9.16	7.12	6.46	6.33	6.71	6.67	8.20	7.28
Japanese Yen	1.80	4.38	8.01	7.84	7.52	7.69	7.72	8.34	8.38
Unspecified	3.88	2.33	4.92	4.09	4.03	5.50	6.62	6.93	8.06

Industrial Countries	1975	1980	1985	1986	1987	1988	1989	1990	1992
US Dollar	86.8	77.4	65.2	69.4	71.4	67.7	59.6	56.0	61.7
German Mark	7.32	14.3	19.5	16.7	15.9	17.3	22.5	21.9	15.8
Other European Currencies	2.90	3.83	5.01	4.03	4.35	5.02	4.98	6.69	5.73
Japanese Yen	1.90	3.30	8.94	8.31	7.07	7.03	8.10	9.56	7.86
Unspecified	1.05	1.18	1.40	1.37	1.26	2.99	4.83	5.89	8.93

Source: International Monetary Fund

TABLE 3

IMPLIED HOLDINGS OF DOLLAR-DENOMINATED RESERVES, END OF YEAR, BILLIONS OF US DOLLARS

	All Countries	Industrial Countries
1975	126,193	70,770
1980	223,870	127,152
1985	228,071	115,858
1986	275,532	156,616
1987	406,966	257,944
1988	403,904	260,868
1989	408,560	247,865
1990	463,673	278,704
1992	537,929	285,532
Average Change (ppa) 1975-1992	8.90	8.55

Table 4

Coefficient Estimates for Equation Describing the Overall Level of Foreign Exchange Reserves
with Country-Specific Effects
1985 Q1 to 1990 Q4

$$\ln(R_t) = a_0 + a_1 t + a_2 \ln(R_{t-1}) + a_3 \ln(Y_t) + a_4 \ln(M_t) + a_5 \sigma^2_{t-1} + b_6 \ln(P_t) + b_7 \ln(P_{t-1}) + b_8 \ln(E^e_t) + b_9 \ln(E^e_{t-1}) + b_{10} \ln(E^a_t) + u_t$$

Cross-Country Estimates

coefficient	estimate	t-value
a_2	0.592	16.2
a_3	0.415	1.40
a_4	-0.104	-1.33
a_5	0.0118	1.97
b_6	-1.82	-2.36
b_7	-0.843	-1.02
b_8	0.114	0.440
b_9	0.412	1.87
b_{10}	-0.654	-1.36
$a_3/(1-a_2)$	1.018	1.38
$a_4/(1-a_2)$	-0.254	-1.31
$a_5/(1-a_2)$	0.0290	1.94

Country-Specific Estimates

country	a_0	t-value	a_1	t-value	R^2	SEE
Belgium	15.8	5.89	0.0469	5.09	0.998	0.277
Denmark	16.0	6.29	0.0241	3.39	0.857	0.189
France	15.6	5.77	0.00943	1.43	0.620	0.162
Germany	15.7	5.98	0.0112	2.11	0.925	0.0893
Greece	16.7	6.00	0.111	5.57	0.797	0.322
Ireland	15.8	6.13	0.0143	2.04	0.733	0.156
Italy	16.6	4.71	0.0642	5.86	0.916	0.237
Netherlands	15.5	6.17	0.0116	2.56	0.940	0.114
Portugal	17.0	6.16	0.117	6.02	0.939	0.285
Spain	16.6	5.62	0.0588	5.33	0.976	0.111
United Kingdom	15.5	6.08	0.0521	5.31	0.960	0.177

ACTUAL EU FOREIGN CURRENCY RESERVES AND
VARIOUS PROJECTED RESERVE DEMANDS UNDER EMU

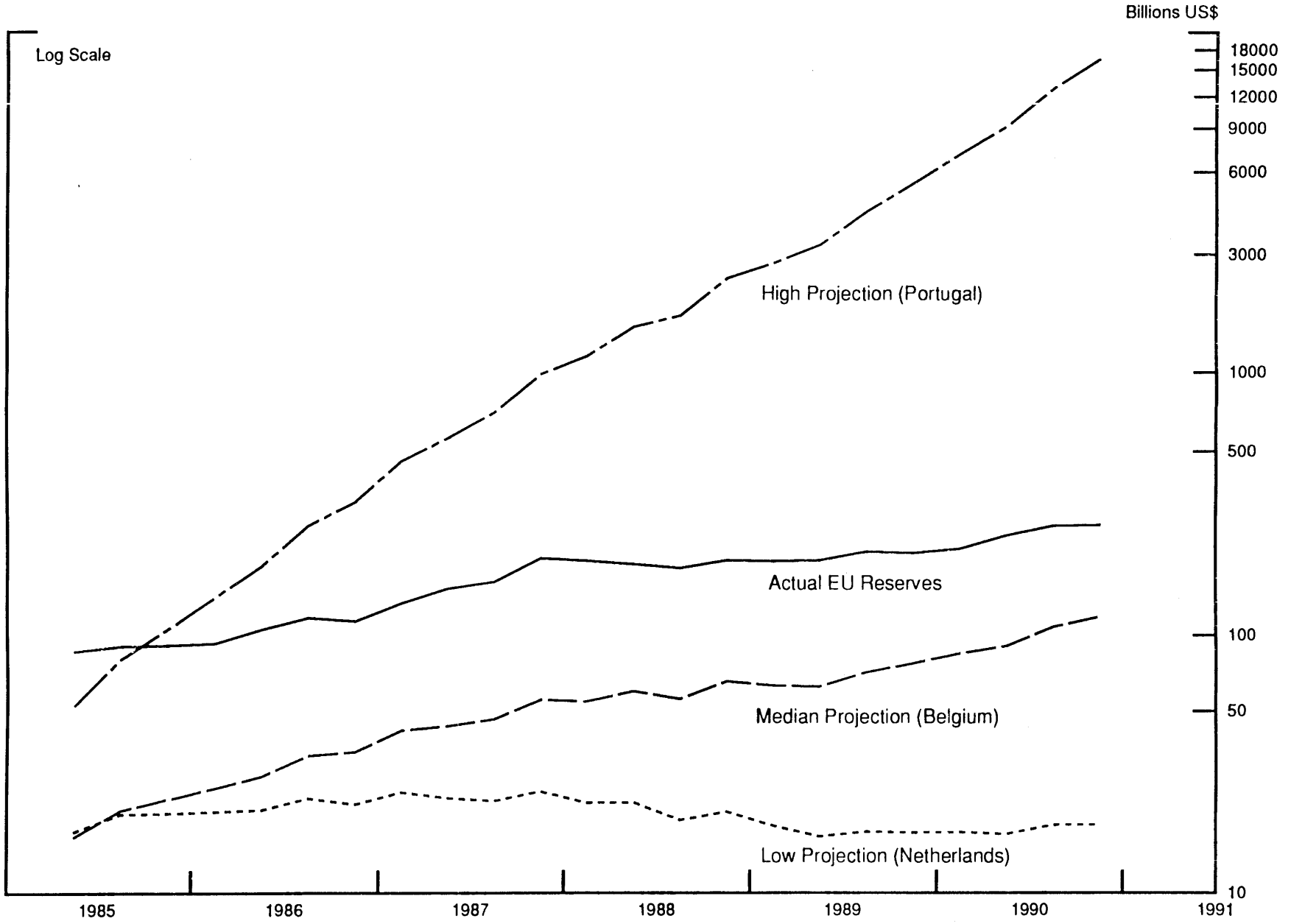

TABLE 5

MEAN PROJECTED RESERVE DEMANDS UNDER EMU 1985 - 1990

Simulation Coefficients from Equation for:	Mean Foreign Currency Reserve Demand (in millions of US$)
Portugal	3,131,596
Greece	1,195,076
Spain	496,995
Italy	442,597
Denmark	72,409
Belgium	55,567
Ireland	48,496
Germany	34,285
United Kingdom	30,078
France	27,952
Netherlands	20,113

MEMO: Mean value of aggregate foreign currency reserves for EU countries from 1985 to 1990 was $162,559 million.

Table 6

Coefficient Estimates for Equation Describing the Overall Level of Foreign Exchange Reserves
with no Country-Specific Effects
1985 Q1 to 1990 Q4

$$\ln(R_t) = a_0 + a_1 t + a_2 \ln(R_{t-1}) + a_3 \ln(Y_t) + a_4 \ln(M_t) + a_5 \sigma^2_{t-1} + b_6 \ln(P_t) + b_7 \ln(P_{t-1}) + b_8 \ln(E^e_t) + b_9 \ln(E^e_{t-1}) + b_{10} \ln(E^a_t) + u_t$$

Cross-Country Estimates

coefficient	estimate	t-value
a_0	-0.178	-0.341
a_1	-0.000220	-0.149
a_2	0.923	56.9
a_3	0.0869	3.03
a_4	-0.0485	-1.68
a_5	0.00543	0.724
b_6	0.0975	0.341
b_7	0.952	3.96
b_8	-0.492	-0.653
b_9	0.716	0.906
b_{10}	-1.05	-2.28
$a_3/(1-a_2)$	1.136	4.36
$a_4/(1-a_2)$	-0.633	-1.84
$a_5/(1-a_2)$	0.0709	0.722

Country-Specific Estimates

country	R^2	SEE
Belgium	0.912	0.313
Denmark	0.824	0.209
France	0.508	0.184
Germany	0.916	0.0941
Greece	0.721	0.378
Ireland	0.608	0.189
Italy	0.904	0.253
Netherlands	0.945	0.110
Portugal	0.910	0.346
Spain	0.971	0.122
United Kingdom	0.964	0.169

Table 7

Estimates of Share of Foreign Currency Reserves
Held in U.S. Dollars by EU Countries
1985 Q1 to 1990 Q4

Model	Pre-EMU	Post-EMU
Heller-Knight [1978]	0.46	0.77
Dooley-Lizondo-Mathieson [1989]	0.78	0.85
average	0.62	0.81

Memo: According to Annual Report of the IMF, the share of U.S. dollars in total official holdings of foreign exchange by industrial countries averaged 64.9 percent between 1985 and 1990.

Aggregate EU Trade Shares with Selected Countries
and Hypothetical EU Trade Shares under Assumption of EMU
1985-1990

Country	Actual	Hypothetical
United States	0.079	0.187
United Kingdom	0.078	---
France	0.094	---
Germany	0.141	---
Japan	0.030	0.071
total	0.422	0.258

Models and Variables

Heller-Knight [1978]

$share = 0.662 + 0.603*usts - 0.945*ukts - 1.195*frts - 0.464*gets

Dooley-Lizondo-Mathieson [1989]

$share = 0.9317 + 0.16*usts - 0.81*ukts + 0.41*frts - 0.64*gets - 1.62*jats

Variables

$share = proportion of foreign exchange reserves denominated in U.S. dollars
usts = proportion of EU trade with the United States relative to EU total trade
ukts = proportion of EU trade with the United Kingdom relative to EU total trade
frts = proportion of EU trade with France relative to EU total trade
gets = proportion of EU trade with Germany relative to EU total trade
jats = proportion of EU trade with Japan relative to EU total trade

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