IMF WORKING PAPER

WP/94/1

INTERNATIONAL MONETARY FUND

European I Department

ERM Money Supplies and the Transition to EMU 1/

Prepared by Marcel Cassard, Timothy Lane, and Paul R. Masson

January 1994

Abstract

Stage 2 of monetary union in the Europe is to involve greater monetary cooperation; the paper examines the case for using the M3 money supply aggregated across "core ERM" countries--those with low inflation and absence of realignments--as a vehicle for that cooperation. First, the existence of a satisfactory long-run money demand relationship and short-run dynamic equation is verified. The resulting demand equations have at least as satisfactory econometric properties as those for France and Germany separately. Second, the predictive power of the core-ERM aggregate relative to French and German inflation is examined; it is shown that the aggregate helps to predict German inflation, over and above the predictive power of German M3. Thus, core-ERM M3 has value as an indicator for the anchor country in hitting its own domestic objective, quite separate from any concern about economic developments in neighboring countries.

JEL Classification Numbers:

E41, E50

1/ The authors wish to thank Michael Artis, Carlo Monticelli, and Marc-Olivier Strauss-Kahn.

Table of Contents

Appendix Tables

Charts

Summary

Interest in monetary aggregates extending beyond national borders has been stimulated by the agreement reached by European Communities (EC) countries at Maastricht in December 1991 to proceed to monetary union (EMU). The eventual achievement of EMU would naturally lead to the use of monetary indicators for the monetary union as a whole; the properties of an aggregate of national money demands is therefore of interest. A European central bank would need credible targets, and it is possible that cross-country monetary aggregates could provide the basis for monetary targeting. Moreover, the presumption that money demand in EC countries will be increasingly affected by currency substitution as financial integration proceeds, and the likelihood that economic activity and inflation are influenced by monetary conditions in other countries, also make it natural to consider cross-country monetary aggregates.

The paper considers two empirical questions for a core group of countries that have maintained their parities against the deutsche mark for an extended period of time: 1) whether demand for core-ERM M3 is more stable and predictable than national demands for money, and 2) whether monetary aggregates in other countries are useful indicators of future trends in inflation. The paper focuses on aggregating German data with those of France, Belgium, Luxembourg, the Netherlands, and Denmark, which have low inflation, and which have not realigned relative to the deutsche mark since at least January 1987--in the case of the Netherlands, since March 1983. The Belgium-Luxembourg monetary union and the Netherlands have also limited fluctuations of their currencies relative to the deutsche mark to a greater extent than required by the narrow ERM band.

The conclusion of the preliminary work reported in the paper is that there appears to be some evidence of a long-run money demand relationship for a core group of ERM countries between M3, economic activity, the price level, and either domestic or German interest rates. Such a long-run relationship, together with an estimated dynamic adjustment equation, might be a useful indicator when formulating German, and ERM, monetary policy in the transition to monetary union. Though currency substitution is not tested directly, the stability of the core-ERM aggregate may reflect this phenomenon to some extent; currency substitution may also have caused the apparent lack of robustness of national money demands.

The results also show that core-ERM money has predictive power for German inflation. This is important, because it suggests that other countries' money supplies may also be useful indicators in achieving German domestic targets. One aspect of the results that is particularly suggestive is that estimates of core-group money demand and tests of linear feedback are stronger for the period from 1983 onward, when exchange-rate fluctuations within the core group were limited. This implies that as a zone of exchange rate stability is maintained, at least among a small group of countries, and as European integration proceeds, the relevance of core-group ERM money may increase.

I. Introduction

Interest in monetary aggregates extending beyond national borders has been stimulated by the agreement reached by EC countries at Maastricht in December 1991 to proceed to monetary union, and by recent tensions within the EMS, caused in part by the fact that short-term interest rates have remained high in Germany in order to curb excessive German money growth and combat German inflation, while inflation has been more moderate in neighboring countries such as France, Belgium, and the Netherlands. The eventual achievement of EMU would naturally lead to the use of monetary indicators for the monetary union as a whole; the properties of EC money demand are therefore of interest. A European central bank (ECB) would need credible targets, and it is possible that cross-country monetary aggregates could provide the basis for monetary targeting. Moreover, even at the present time, the presumption that money demand in EC countries may be affected by currency substitution as financial integration with other EC countries proceeds, and the likelihood that economic activity and inflation are affected by monetary conditions in other countries, also make it natural to consider cross-country monetary aggregates.

Cross-country monetary aggregates may receive increasing attention in stage 2 of the transition to EMU--which is to begin on January 1, 1994 and to end with the beginning of stage 3 in 1997 or 1999. For instance, the transition could be smoothed by devoting increasing attention to foreign monetary indicators. At one end of the spectrum is an asymmetric system in which developments in the anchor country--Germany--largely determine monetary policy for the ERM based on domestic economic conditions; at the other end is the symmetric system that is planned for EMU, in which the policy of the ECB will be guided by Europe-wide monetary developments. Giving gradually increasing importance to other ERM countries' monetary variables in the formulation of monetary policy might permit a smoother transition to an eventual target for the joint money supply of all participating EMU countries.

It is of course an empirical question whether ERM monetary variables are more stable and predictable than national ones, and whether monetary aggregates in other countries are useful indicators of future trends in inflation. With increasing integration in goods markets and possibly heightened currency substitution--both furthered by the creation of the "single market" as of January 1, 1993--and in the absence of currency realignments, developments that affect aggregate demand in one country will increasingly spill over onto other countries. For instance, to the extent that French M3 is an indicator of French aggregate demand conditions, it may also be a useful indicator for Germany. If so, it might be appropriate to give some importance to French M3 as an indicator in formulating German monetary policy. There is also the possibility that, during the transition to EMU, cross-country monetary aggregates could provide a focal point for monetary cooperation among national central banks.

In assessing monetary indicators, it is important to consider the role of the exchange rate. For countries whose exchange rates are free to fluctuate substantially against the deutsche mark--either within wide bands, as a result of realignments, or because they have freely floating exchange rates--there is much less of a presumption that their money supplies should be relevant for Germany. If such countries run divergent monetary policies relative to the anchor country's, the inflationary effects on Germany will be at least partly neutralized by exchange rate movements. 1/

In this study we therefore focus on a core group of countries which have maintained their parities against the deutsche mark in the recent period of turbulence--in particular France, Belgium, Luxembourg, the Netherlands, and Denmark. These countries have not realigned relative to the deutsche mark since at least January 1987; in the case of the Netherlands, since March 1983. The Belgium-Luxembourg monetary union and the Netherlands have also limited fluctuations of their currencies relative to the deutsche mark to a greater extent than required by the narrow ERM band, hence until the suspension of the narrow band on August 2, 1993, and its replacement by intervention thresholds of plus or minus 15 percent of central parities, they approximated a situation of fixed exchange rates relative to Germany. 2/

Even for an ERM core group, exchange rate parities are not necessarily fixed irrevocably, and imperfect credibility affects the interpretation of monetary indicators such as interest rates, and, to a lesser extent, cross-border aggregate money supplies. Indeed, the major difficulty in assuring a smooth transition to EMU is that stage 2 has elements both of an adjustable peg system and a monetary union. However, until stage 3 of EMU is attained, it is premature to imagine that monetary developments in other core-ERM countries would be given commensurate weight with those in Germany. Hence the exploration of intermediate arrangements in this study.

The plan of the study is as follows. First, an analytical section discusses the relevant issues and surveys the existing literature. A second section presents empirical results concerning the long-run properties and stability of French and German broad money demands (demands for M3) and compares them to the properties of an M3 variable for a core group of ERM members. A third section examines evidence of the predictive ability of other countries' aggregates in explaining output and inflation (in particular, of French M3 for German inflation, and vice-versa). A fourth

---

1/ Indeed, if there is overshooting of the exchange rate--as implied by the model of Dornbusch (1976)--Germany would initially not import inflation but rather deflation, as the deutsche mark would appreciate in real terms vis-à-vis the country undertaking monetary expansion.

2/ The Netherlands and Germany continue to respect the ± 2.25 percent bands for the guilder/deutsche mark rate, on the basis of a bilateral agreement.

section considers how a core-ERM M3 aggregate could be used in stage 2. A final section attempts to draw tentative conclusions.

II. An Analytical Framework

There are three issues concerning monetary policy within the EMS that deserve attention. First, the value of an intermediate indicator like the money supply rests on the stability and predictability of the relationship linking it to economic activity and the price level. Therefore, it is important to examine the relative stability of national money supplies versus monetary variables aggregated across countries. 1/ A second relevant question relates to the nature of the transmission of shocks from other countries when the exchange rate is fixed, or is limited in its fluctuation. These linkages may make it more useful to use an intermediate target that accounts for developments in other countries rather than a purely domestic target such as the domestic money supply. Finally, there is the issue of the transition to EMU, which may be facilitated by giving increasing attention to other countries' monetary developments; this would permit a gradual transition from an asymmetric system in which only the money supply in the anchor country was targeted to one where all countries' money supplies were given weights proportional to their size, as in EMU.

1. Stability and predictability of money demand

There has been considerable interest in the past few years in examining whether the demands for national aggregates have desirable properties, and conversely, whether an aggregation of money supplies across EMS countries is associated with a stable and predictable money demand. An article by Bekx and Tullio (1989) presented econometric evidence that the exchange rate of the deutsche mark against the dollar was better predicted by an EMS monetary aggregate than by German money. Kremers and Lane (1990) found evidence of a stable demand for M1 aggregated across ERM countries, 2/ while more recent work by Monticelli and Strauss-Kahn (1992b) and Artis, Bladen-Hovell, and Zhang (1993) suggests that a stable demand for broad money also exists for a subset of EC countries. Monticelli and Strauss-Kahn (1992a) survey national demand for money studies, and find that though a majority of the EC countries exhibit stability of money demand over the 1980s, there are some curious features for those demand functions for some countries.

As discussed, for instance, in Monticelli and Strauss-Kahn (1992a) and in Kremers and Lane (1992b), there are two main factors which can affect the relative stability of national and ERM money demands, possibly in

---

1/ There is also the issue of the proper definition of national money supplies, for instance whether they should include non-resident holdings and deposits in foreign currencies with domestic banks. See Angeloni, Cottarelli, and Levy (1991) and Monticelli (1993).

2/ See however the comments by Barr (1992) and rejoinder by Kremers and Lane (1992).

conflicting ways. First, currency substitution--that is, shifts in the currency composition of money balances--can be expected to increase within the ERM, especially as monetary union approaches. Money balances in two different currencies should effectively be perfect substitutes if their exchange rate is expected to remain unchanged, and other factors, such as transactions costs, are similar. Conversion to a common currency (i.e., the ecu) with achievement of EMU would itself produce perfect substitutability of these currency holdings, and their anticipated conversion would therefore enhance their substitutability. Second, specification bias will affect ERM money demands, unless the functional forms of countries' demand functions are similar, and, more constrainingly, if parameter values are roughly the same. In practice, it seems that national money demands often differ both in the choice of included variables and in estimated coefficients, for instance income and interest rate elasticities. 1/ Therefore, estimation of an aggregate equation introduces a degree of specification bias, which may impair its stability, since changes in the composition of the aggregate money variable will also change apparent income and interest rate elasticities.

Currency substitution can be expected to have two effects on national money demands. First, it would tend to make them sensitive to interest rates in other ERM countries. Second, currency substitution would tend to make errors in demand functions in pairs of ERM countries negatively correlated, as shifts out of one currency into another that were not captured in the explanatory variables would show up as inverse shocks to money demands. Both of these factors would tend to make national money demands unstable, though to an extent that depends on the definition of national aggregates. Most national definitions of broad money for EC countries include foreign currency deposits of residents with resident banks, so at least part of currency substitution is internalized. (Monticelli and Strauss-Kahn, 1992a). However, even such an aggregate would likely be sensitive to the relevant foreign interest rates. As for money holdings of foreign residents (or holdings of residents abroad, even in the home currency), these are not included in conventional aggregates, so that summing these aggregates across countries will not internalize cross-border holdings. There may still be negative covariance of residuals from national demand functions--possibly because relevant interest rates are not included--and hence an ERM demand function may nevertheless have a lower error variance than national equations.

The first factor may not be adequately captured in national money demand equations, because structural changes leading to increasing substitutability would not be adequately picked up through regressions with fixed coefficients, and also because the inclusion of several interest rates may give inconclusive results because of multicollinearity. One way to

---

1/ See Fase and Winder (1992) and Monticelli and Strauss-Kahn (1992a) for a survey of recent empirical work on national money demand functions for EC countries.

allow for the second factor would be to estimate national money demand equations as a system of equations and allowing for cross-correlation of errors; in practice, national demand equations are generally estimated separately. 1/ Both factors could in principle be taken into account by creating a money variable that aggregated across the relevant countries and deposits. By internalizing shifts between money holdings, aggregation across countries could be expected to reduce residual error variance and also make unnecessary the inclusion of a large set of interest rate variables.

Specification bias may be more severe in short-run, dynamic equations than in long-run money demand relations. As argued in Monticelli and Strauss-Kahn (1992a), the properties of long-run money demand may be more critical than the short-run dynamics, given the emphasis on a medium-term horizon for money targeting, and in particular, for controlling inflation. Cointegration tests, that is, tests of whether nonstationary variables tend to "move together," help to identify long-run relationships among variables and therefore deserve special attention in the context of money demand. Studies using cointegration analysis show a degree of similarity across EC countries in price and income elasticities; interest rate semi-elasticities differ much more, partly as the result of choice of different variables. 2/

The net effect of currency substitution and specification bias will influence the usefulness of an aggregated money variable. One approach for evaluating this question is to estimate the demand for an aggregate money as well as demands for its national components, and to compare the equations' properties. Kremers and Lane (1990) for instance highlight the low standard error, stability, and high speed of adjustment of EC demand for M1 compared to national demands for M1; they contend that national equations give unreasonably low speeds of adjustment, perhaps as a result of omission of relevant foreign variables which are internalized in the wider aggregate. Another approach is the joint estimation of the national equations in order to test restrictions across coefficients and to allow for the negative covariance implied by currency substitution. Such an approach does not directly estimate the demand for an EC monetary aggregate, but rather suggests whether its stability properties are the result of similarity of coefficients or of currency substitution. Lane and Poloz (1992) conclude from such a decomposition that it is the latter that seems to account for the good properties of a European monetary aggregate; however, the evidence of currency substitution in the form of a significant role for exchange rates in money demand and negative covariances among countries' money demand disturbances admits of other interpretations.

As mentioned above, the link between the good performance of an aggregation of national money supplies and the existence of currency

---

1/ See however Lane and Poloz (1992).

2/ See Monticelli and Strauss-Kahn (1992a), Table 5.

substitution is not straightforward. Cross-border holdings are usually not included in conventional aggregates, while domestic residents' holdings with domestic banks in both domestic and foreign currencies are typically included. Therefore, a simple European aggregate will not capture a potentially important part of currency substitution related to delocalization--though aggregates are currently being redefined to address this problem.

Angeloni, Cottarelli, and Levy (1991) recalculate national monetary aggregates in order to include in those aggregates various measures of cross-border holdings; they find that these aggregates perform consistently better than the standard aggregates for most countries. Monticelli (1993) investigates whether including cross-border holdings in EC-wide monetary aggregates improves the properties of money demand equations and the predictive power of money in explaining EC output. He concludes that extended measures of EC money which contain EC-residents' holdings outside the EC and in non-EC currencies are poor at explaining EC income, while less extended measures (including only cross-border holdings within the EC or in EC currencies) perform well. However, none of the extended measures outperforms an EC-wide measure obtained by summing traditional national definitions. No doubt further work is warranted in this area, which may become more relevant as integration proceeds; however, this is beyond the scope of the present paper. The regression results reported below use the existing national money supply data, and aggregate across countries merely by summing these national money supplies, after conversion to a common currency. 1/

2. Transmission of shocks to the anchor country

In a fixed exchange rate union, just as in the limiting case of a monetary union with a common currency, the money supply of the union as a whole is relevant for output and inflation in any single country that is a member of the union. With financial integration, a single interest rate would prevail on comparable financial instruments, and it would be fruitless to try to establish separate monetary policies in different countries or regions. Money supplies could grow at different rates, however, because of differing shocks affecting demands for money in different countries or regions--principally shocks to real activity and inflation. 2/

An intermediate target like the money supply should satisfy two criteria: (1) it should give advance indication of factors affecting ultimate targets which can only be observed with a lag, and (2) provide a variable that is under at least the indirect control of the monetary authorities, and against which their performance can be judged. From the perspective of a single country whose target is its national inflation rate,

---

1/ The issue of what exchange rate to use is discussed below.

2/ As well as different trends in output and the velocity of circulation of money.

monetary indicators in other countries in an exchange rate union may provide information additional to that provided by the domestic monetary aggregate. For instance, shocks to inflation in a neighboring ERM country will show up in higher German import prices, and shocks to activity, in higher German exports and hence in greater pressures on capacity utilization in Germany. Therefore, it is in the interest of the anchor country to account for these developments in setting its short-term interest rate. From the second perspective, controllability, it is the case that foreign money supplies will not be under the direct control of the monetary authorities of the anchor country, though the authorities may, through their ability to vary interest rates throughout the union, be able to influence them indirectly. This will depend on whether the demand for the aggregate is negatively related to market interest rates.

Although the ERM is not a system of irrevocably fixed exchange rates, a core group of countries--Germany, France, the Benelux countries, and Denmark--have maintained fixed central parities for at least the last six years. If exchange rates are allowed to vary as a result of occasional realignments, then the transmission effects of inflationary pressures may be offset through eventual devaluation. There is therefore less of a presumption that monetary developments among all ERM countries are relevant indicators of inflation in the anchor country. From January 1987 until the widening of the bands of fluctuation agreed on August 2, 1993, the operation of the ERM among the core group was a compromise between monetary union and a system of adjustable pegs. Though realignments were not absolutely ruled out, they were viewed as increasingly unlikely. There was reinforced monetary cooperation among the core group, for instance between France and Germany in the September 1992-March 1993 period to defend the franc against speculative pressures. In these circumstances, inflation pressures elsewhere in the core group could affect inflation in the anchor country, because Germany might not be able to sterilize effects on its money supply if speculative pressures developed. 1/ Hence, such inflationary symptoms would be of concern for the anchor country, and might justify its central bank's giving some weight to monetary developments in the other core-group countries. For instance, if the money supply were growing faster elsewhere in the core group than in Germany, the Bundesbank could run a tighter monetary policy than otherwise, and conversely if other countries' money supplies were growing more slowly than Germany's.

Not resisting those inflationary pressures through monetary policy gives rise to a perverse feedback that has been noted in the operation of the ERM, namely that high inflation countries have low real interest rates when fears of devaluation are absent. Adjusting interest rates in the anchor country to account for inflationary pressures in other countries would offset this bias to some extent. Notwithstanding, countries whose inflation rate is persistently high would eventually have to realign, and

---

1/ See Deutsche Bundesbank (1993) for a discussion of the impact on liquidity in Germany resulting from the ERM crisis in 1992.

markets would demand higher nominal interest rates as a result. These countries would likely have substantially higher nominal interest rates than in the anchor country if their inflation rates remained high.

The recent widening of the fluctuation bands greatly reduces the potential need for intervention by the Bundesbank, making it less likely that monetary developments in other ERM countries would spillover onto Germany. However, the widening of the bands is intended to be temporary, and deviations from central parities have so far been limited. Moreover, the Netherlands and Germany have concluded an agreement to defend the earlier narrow margins, and Belgium and Luxembourg have also expressed a desire to do so.

3. The transition to EMU

The Maastricht Treaty provides for the creation of a European Monetary Institute, which would take over from the Committee of Governors of EC Central Banks at the start of stage 2 and which would have the role of promoting monetary cooperation and facilitating the transition to EMU. However, it is clear that actual responsibility for monetary policies will continue to reside with national central banks. Therefore, the period at the end of stage 2 and the beginning of stage 3 could involve a difficult transition from an asymmetric monetary policy which is focused on economic developments in the anchor country, to one decided by the European central bank which accounts for conditions in all countries in the monetary union in a symmetric fashion. A means of smoothing the transition would be for the anchor country to give a gradually increasing weight to monetary aggregates in other ERM countries in setting its policies.

It is important to recognize that there are at least three difficulties with such a strategy, however. First, the distinction between a core group, whose money supply would be taken into account by the anchor country, and non-core-group countries, whose money supply would not, raises fundamental issues concerning the list of countries that would be able to proceed to monetary union in 1997 or 1999. The Maastricht Treaty stipulates that criteria for proceeding to stage 3 are to be based on information available in 1996 or 1998. Monetary coordination that occurs before then should not prejudge the set of countries proceeding to stage 3. Second, the assumption that the core-group countries themselves would not change their deutsche mark parities in the transition to EMU is far from certain. As argued above, if the transmission effects of inflationary pressures that arise in one country are to be neutralized by devaluation, or, if they endanger the credibility of parities, by higher risk premiums built into interest rates, it would be inappropriate to allow those pressures to lead to a tighter ERM monetary policy. Third, since the Bundesbank's mandate is to maintain the stability and purchasing power of its own currency, not to stabilize the ERM price level, it would have to be demonstrated that ERM monetary indicators were relevant to German inflation. Empirical evidence on this last point is provided in section 3 below.

III. Empirical Estimates of the Demand for Broad Money

In this section, evidence on the stability and predictability of the demand for broad money in France, Germany, and the ERM is discussed. Broad money (M3) is used, since it is the most relevant from the point of view of monetary targeting in Europe (both France and Germany currently have M3 targets). Existing studies are first briefly surveyed, and then new estimates are given for the demand for M3 in France, Germany, and a core group of ERM countries. The new estimates are made using the methodology of cointegration, which tests whether non-stationary series move together in the long-run, that is, are cointegrated (see Granger, 1983). If they are, then it can be shown that an error correction model describes the set of variables (Engle and Granger, 1987); in particular, a dynamic equation would relate the change in money balances to deviations from the long-run money demand and possibly to changes in other variables such as income and interest rates.

1. Existing studies

a. France

Studies for France give mixed results concerning the properties of the demand for broad money, both its long-run relationship with real income, prices and interest rates, and the stability of its short-run dynamics. Fröchen and Voisin (1986) analyze the stability of several monetary aggregates for France from 1970-84, and find that M3 especially seems to be affected by financial innovation in the 1983-84 period, leading to a sharp reduction in the income elasticity of money demand. The demand for M1 in contrast does not seem to be affected. Bordes and Strauss-Kahn (1989), using cointegration techniques, also find that M1 has more desirable properties than broader aggregates: M1 was cointegrated with income, the interest rate, and inflation but M3 was not (despite an attempt to adjust the official M3 series for financial innovation). De Bandt (1991) also does not find that French M3 is cointegrated with real GDP, the price level, interest rates, and inflation over 1981-1990, though he leaves open the possibility of cointegration when the opportunity cost of holding M3 balances is measured more precisely. Angeloni, Cottarelli, and Levy (1991), report relatively poor estimates of the demand for French M3 over 1982-1990, in that the only interest rate that enters is the short rate (a market rate, rather than the own rate), which enters with a positive sign.

b. Germany

Available studies of money demand relate to the pre-unification period; post-unification data for both monetary variables and for GNP are subject to serious statistical problems when used in econometric relationships, as is discussed below. Studies using pre-1990 data indicate quite high income elasticities (significantly greater than unity, and sometimes over two) and a greater responsiveness to long-term interest rates than to short rates. A recent study by Schmid and Herrmann (1991), also using pre-unification west

German data, finds cointegration of nominal money with nominal GNP and a market interest rate; however, it is not reported whether the constraint of a unit real income (as well as price) elasticity is tested. Post-unification stability is not examined. Estimates of the demand for a traditionally-defined M3 in Angeloni, Cottarelli, and Levy (1991) indicate a long-run income elasticity just over unity, and semi-elasticities of the own rate on M3 and the long-term interest rates that are both equal to 0.6, but opposite in sign; the equation is estimated over 1982-1990 using quarterly data.

c. The EC

Studies of EC money demand have generally presented promising results.

Monticelli and Strauss-Kahn (1992b) present cointegration tests and error-correction models for broad money aggregated across the EC, using current exchange rates (Luxembourg was omitted for statistical reasons, and Greece and Portugal were excluded because they had not joined the ERM by 1991). They find evidence of cointegration of real broad money balances with EC real income and a market interest rate (no data for the own rate on M3 was available), over periods extending from, at the earliest, 1977 to 1990, third quarter. Including a simple time trend has virtually no effect; in particular, it does not lower the relatively high income elasticity, estimated to be 1.6, which the authors interpret as reflecting to some extent the omission of wealth from the equation. A segmented trend starting only in the second half of the 1980s does lower the income elasticity, to 1.3. The interest rate semi-elasticity in the cointegrating equation is -0.7, characterized by the authors as low relative to national studies. Error-correction models give satisfactory results which are similar across different specifications, with a significant and strong feedback of departures from equilibrium equal to 30 or 40 percent per quarter.

Artis, Bladen-Hovell, and Zhang (1993) present results for both M1 and M2 demand, aggregated across 7 EC countries (Germany, France, Italy, the Netherlands, Denmark, Belgium, and Ireland), using quarterly data from 1979 to 1990, and using base-period exchange rates in aggregation. Both aggregates expressed in real terms (divided by consumer prices) are cointegrated with the log of EC real income and short-term market interest rates, with coefficients of 1.2 and -0.7, respectively. In addition, error-correction models with desirable statistical properties--stability, absence of serial correlation or heteroscedasticity, etc.--are identified for both aggregates. However, the speed of adjustment to long-term disequilibrium is significantly faster for M1 (73 percent) than for M2 (37 percent).

2. New estimates

The estimates reported below use quarterly M3 data for France, Germany, and an aggregation of core-ERM countries over a period extending from about the beginning of the EMS to 1990Q2 (see Appendix I for data sources). Later periods are mainly used for stability tests. There is an important break

point in 1990 because of problems with post-unification data for Germany. Hence only the earlier data, for west Germany alone, are initially used in estimation. However, an adjustment was also made to pre-unification data for both GNP and M3 to scale it up to the size of united Germany, in order to test whether an equation estimated over the earlier period could still be relevant after 1990.

Quarterly data for the following variables were used: seasonally adjusted broad money supply M3 (m_t), real GDP or GNP (y_t), a long-term interest rate (i_t), a money-market rate (im_t), a constructed own rate on M3 (r_{0t}), the consumer price index (p_t), and the inflation rate (Π_t). All variables, except interest rates and inflation, are expressed in logarithms.

Chart 1 plots series for the income velocity of M3 for France and Germany, the latter using the adjusted data. It can be seen that both series exhibit a downward trend, though the French data are considerably smoother. Chart 2 plots data for interest rates, including a constructed series for the interest paid on M3 money balances.

The estimation of a long-run money demand function for France, Germany and core ERM countries is conducted using both the Engle-Granger two-step error correction procedure and the Johansen procedure (See Appendix II for a description). The advantage of the Engle-Granger approach is its greater transparency, but its drawback is that the cointegrating vector estimated is not necessarily unique. On the other hand, the Johansen procedure provides a test of the number of cointegrating vectors among a set of variables.

The money demand functions were estimated using both short- and long-term interest rates, which provide alternative indicators of the opportunity cost of holding money. Money balances are deflated by either the GDP deflator or the CPI (either could be appropriate, depending on whether firms' or households' holdings of money are preponderant). Although all the results are listed in Tables 1-3 of Appendix II, only the most conclusive ones are discussed in the text.

a. France

Using the two-step procedure, the best long-run money demand function (deflated by the GDP deflator) was found to depend on real income and the difference between the long-term interest rate and the own rate on M3 (see Table 1, Appendix II). The long-run money demand function is given by:

$$m_t - p_t = -4.91 + 1.21y_t - 0.011(i_t - r_{0t}) + \epsilon_t \qquad (1)$$

A unit root test on the residuals allows the rejection of the null hypothesis of no cointegration and thereby suggests the existence of a long-run French money demand relationship. The alternative Johansen approach also suggests the existence of at least one long-run relationship which can be identified with long-run money demand (see Appendix II). In addition, contrary to the two-step approach, the Johansen procedure reveals that a long-run money demand relationship exists even when nominal money balances are deflated by the CPI. When a dummy was included to account for the deregulation and financial innovations that occurred during the mid-eighties, a long-run money demand relationship was found in almost all instances.

An error-correction model was then estimated to capture the short-run dynamics, in which the disequilibrium in the previous period, represented by the lagged residuals of the long-run equation, ϵ_{t-1}, was an explanatory variable. The specification of the dynamic equation was chosen on the basis of the significance of a set of variables that included current and lagged real income growth and changes in long-term interest rates. The most satisfactory dynamic money demand function for France is given by:

$$\Delta(m_t - p_t) = \underset{(0.002)}{0.004} + \underset{(0.15)}{0.44}\Delta(m_{t-1} - p_{t-1}) + \underset{(0.008)}{0.015}\Delta r_{0t-3} - \underset{(0.0025)}{0.004}\Delta im_{t-3} - \underset{(0.089)}{0.267}\epsilon_{t-1} \quad (2)$$

$R^2 = 0.30$, SER = 0.0083

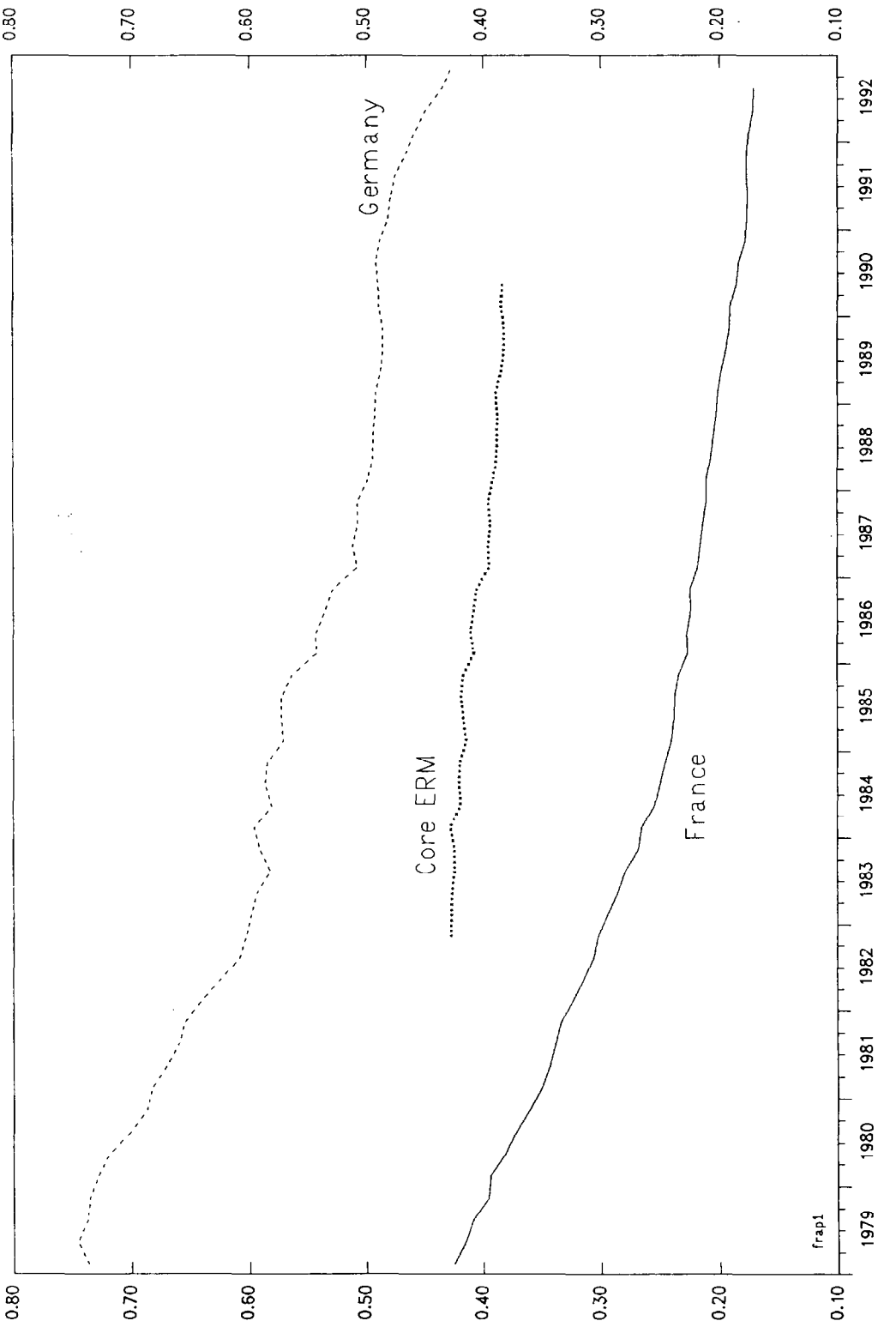
Estimated coefficient standard errors are included in parentheses. The equation standard error (SER) is less than 1 percent. Diagnostic tests for serial correlation, heteroscedasticity, linearity and normality are reported in Table 2 of Appendix II; the dynamic equation passes all diagnostic tests except the linearity test. The error-correction feedback term, ϵ_{t-1}, is significant at the 1 percent level with a coefficient of 0.27 indicating a moderate adjustment of real money balances. When the equation is used to forecast money demand for 1990Q3-1992Q3, a chi-square test suggests that the stability of the equation cannot be rejected at the 1 percent level but can be rejected at the 5 percent level. 1/

Satisfactory short and long-run money demand relationships thus seem to exist, which is encouraging given the problems with French money demand discussed in section 1.a above. From the perspective of monetary control, the above dynamic equation presents interesting features, namely the presence of the money market interest rate and the own rate on M3, which are both largely controllable by the authorities. Interestingly enough, a variant of the equation in which the French-

---

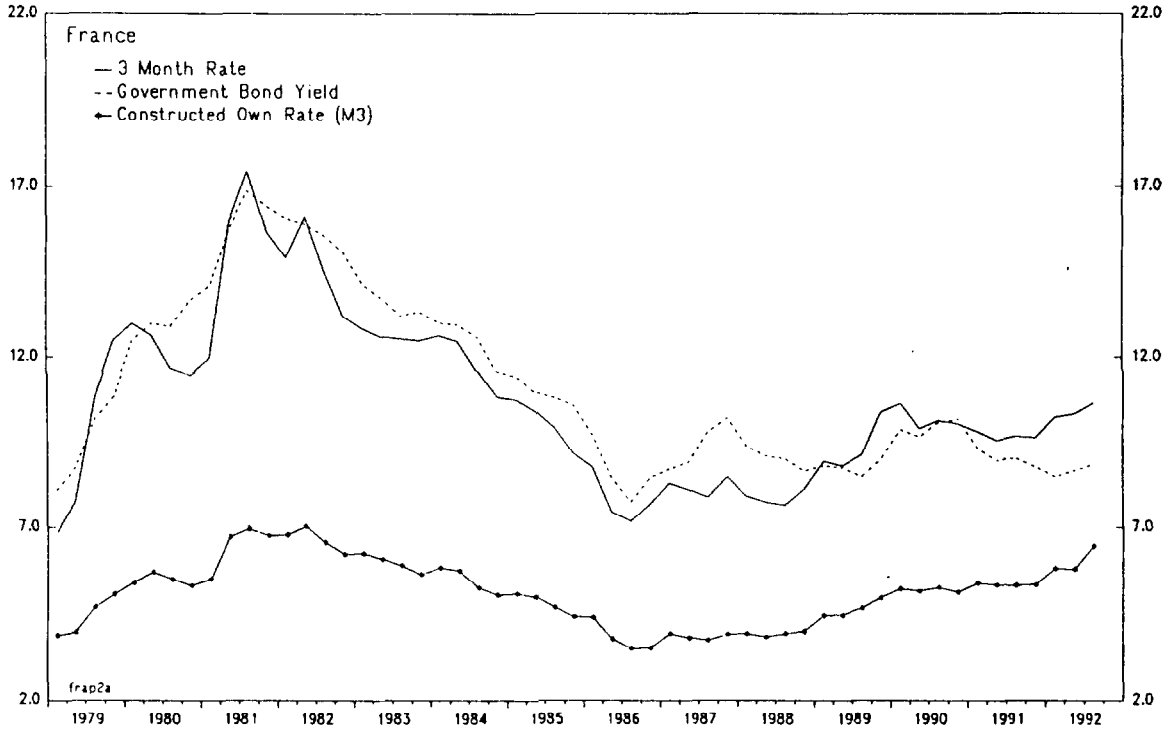
1/ Estimating through 1991Q3 and forecasting the next 4 quarters indicates stability at the 5 percent level.

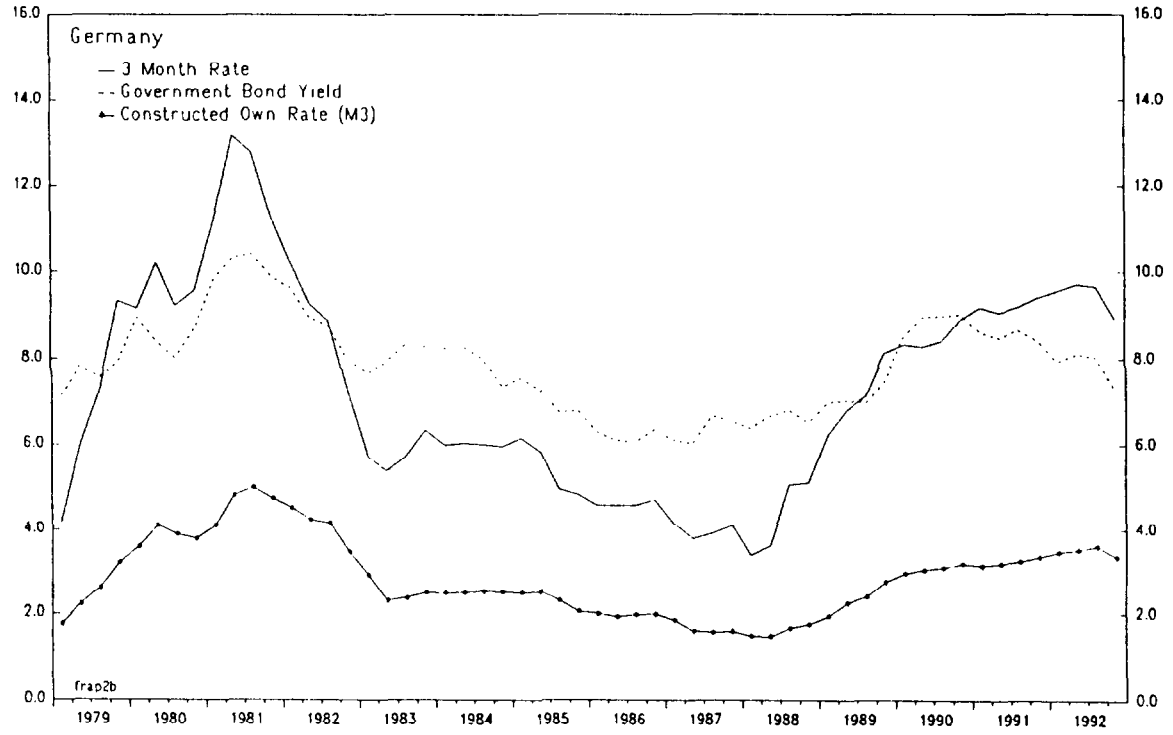
CHART 1
France, Germany, and Core ERM
Income Velocity Of Money (M3)



Sources: National Sources and Staff Estimates.

CHART 2
FRANCE and GERMANY
Interest Rate Developments





Sources: IMF, International Financial Statistics and Staff Estimates.

German short-term interest rate differential is also included does attribute a significant coefficient for that variable, indicating some evidence of currency substitution.

b. Germany

Analysis of the stability and long-run properties of money demand function in Germany using data from the second quarter of 1978 to the second quarter of 1990 produces mixed results. 1/ Using either the two-step Engle-Granger or Johansen estimation procedures, the existence of a cointegrating vector is only apparent when money balances are deflated by the CPI and the long-term interest rate is used. The estimated long-run money demand equation, using the two-step approach, is given by:

$$m_t - p_t = -8.63 + 1.74y_t - 0.016(i_t - r_{0t}) + \epsilon_t \qquad (3)$$

Equation (3) implies a slightly higher elasticity for real income than that reported elsewhere, while the semi-elasticity with respect to the difference between bond yields and the own return on money (1.6) is within the range of estimates by other researchers.

The best dynamic money demand equation was the following:

$$\Delta(m_t - p_t) = \underset{(.0017)}{0.002} + \underset{(.13)}{0.42}\Delta(m_{t-1} - p_{t-1}) + \underset{(.12)}{0.32}\Delta(m_{t-3} - p_{t-3}) + \underset{(.01)}{0.027}\Delta r_{0t-2}$$

$$- \underset{(.003)}{0.008}\Delta im_{t-2} - \underset{(.0018)}{0.004}\Delta im_{t-3} - \underset{(.04)}{0.055}\epsilon_{t-1} \qquad (4)$$

$R^2 = 0.48$, SER = 0.0068

The coefficient values and the sign of the variables are sensible and the dynamic equation passes all the diagnostic tests. The coefficient of the error-correction feedback term is however small and not significant at even the 10 percent level. Other specifications, in which the change of nominal money balances rather than real balances was the dependent variable, also produced this result. Therefore, there is some doubt about the robustness of the cointegration result reported above, even over the period before unification. As for the stability of

---

1/ Using rescaled data for west Germany to make it comparable to latter data for the whole of Germany. Since GDP and M3 are in logarithms, only the constant is affected by the rescaling.

the dynamic equation, the results reject with 95 percent confidence the stability of the equation estimated through 1990 when it is used to forecast the 1990-92 period, even when a scale adjustment is made (Table 2, Appendix II).

c. Core-ERM money demand

The next stage in the investigation is to explore aggregate money demand for the ERM core group--that is, the group of countries whose currencies have remained in the ERM narrow band for several years, and have not realigned relative to the deutsche mark since at least January 1987. These countries include Belgium, Denmark, France, Germany, Luxembourg, and the Netherlands. Data were aggregated across countries using two methods: current purchasing-power parities (PPPs), 1/ and the ERM central parities against the deutsche mark that have prevailed since January 1987. Both methods have drawbacks: PPP weights are to some extent endogenous, as monetary policy will influence the path for prices, while central parities after 1987 are not obviously relevant for the earlier period. It turned out that estimates using PPP weights yielded more sensible results; these are reported in the text, while those using central parities in aggregation are relegated to Appendix III. Quarterly data are available for 1982Q4 through 1990Q2.

The data were first analyzed using the Engle-Granger two-step error correction procedure. 2/ Using PPP weights and data from 1982Q4-1990Q2, a simple relationship was found between real core group broad money (M3), real income (GDP), and the core group three-month interbank interest rate minus the own rate on money: 3/

$$m_t - p_t = -9.46 + 1.62y_t - 0.008(im_t - r_{0t}) + \epsilon_t \qquad (5)$$

Several features of this equation are noteworthy (see Table 3, Appendix II). First, test statistics suggest the existence of a significant long-run money demand relationship for an ERM core group. Second, the short-term interest rate (money market rate minus own rate) rather than the long-term interest rate appears as one of the variables

---

1/ Current PPP rates are derived from the rates published in the OECD's survey for 1985, by multiplying these rates by the ratio of the GDP deflators of each country to that of Germany. This is equivalent to aggregating real variables using base period weights. This method yields nominal aggregates expressed in deutsche mark, which are divided by a German price index to yield real aggregates expressed in 1985 deutsche mark.

2/ Preliminary testing revealed that first differences of all variables were stationary, as assumed by this procedure.

3/ Due to the difficulty of estimating an own rate for all the core countries, a GDP-weighted average of the French and German own rate was calculated. This is a close approximation since the two countries represent more than 80 percent of the GDP of the core group.

in the cointegrating equation for core-group money, thereby enhancing the controllability properties of the monetary aggregate. Third, the results obtained from the Johansen procedure also confirm the existence of at least one long-run money demand relationship among ERM countries. The ERM results appear more robust to the different combinations of interest rates and price deflators than those of either Germany and France.

Turning to the error-correction equation, the best dynamic specification was found to relate to the adjustment of nominal core-group money (aggregated and expressed in current deutsche mark), rather than for real balances as specified in the static equation. The error-correction equation estimated over the sample period 1983Q4 to 1990Q2 is as follows:

$$\Delta m_t = \underset{(.002)}{0.02} + \underset{(.1)}{0.37}\Delta m_{t-1} - \underset{(.19)}{0.41}\Delta p_{t-1} - \underset{(.22)}{0.55}\Delta p_{t-2} + \underset{(.005)}{0.015}\Delta r_{0t-3} - \underset{(.002)}{0.005}\Delta im_{t-3} - \underset{(.11)}{0.32}\epsilon_{t-1} \qquad (6)$$

$R^2 = 0.53$, SER = 0.0039

A noteworthy feature of the estimated dynamic equation is the error-correction coefficient, -0.32, which is statistically significant at the 1 percent level; it is larger in magnitude than those reported above for France and Germany, implying a faster adjustment of money balances to disequilibrium. This is encouraging, to the extent that specification errors are often reflected in low estimated error-correction coefficients (Kremers and Lane, 1992b). The estimated dynamic equation passes a range of specification tests, as reported in Table 4 of Appendix II. Short-term interest rates were found to be statistically significant in this dynamic adjustment equation, but as in the case of France and Germany, neither the long-term interest rate nor the growth of real GDP enter the dynamic equation. Finally, the standard error of the regression is significantly lower than those reported for France and Germany, implying a better fit for the ERM equation.

d. Simultaneous estimation: France, Germany, and other core group countries

Another approach to examining money demand within the core group is to estimate money demand equations for the component countries simultaneously, in order to determine whether aggregation is justified by the data. The appropriate way to do this is to estimate money

demands jointly, using the seemingly unrelated regressions (SUR) approach, and test the restrictions implied by aggregation. 1/

The form of equation that best lends itself to this kind of joint estimation is the one-step dynamic error-correction equation. The dependent variable was specified as the change in real money balances while the explanatory variables were current and lagged changes in income, prices and interest rates, as well as the lagged deviation of real money balances from their long-run relationship with real income and interest rates; the long-run income elasticity and interest semi-elasticity were estimated together with the other coefficients of the dynamic equation.

To reduce the dimension of the problem, the core group was divided into three components: France, Germany, and the remaining countries--Belgium, Denmark, Luxembourg, and the Netherlands--as a group. 2/ Both nominal and real variables for the remaining countries were aggregated into deutsche mark at post-1987 central parities. Money-market interest rates for the respective countries were used as the opportunity cost variable in money demand, and the own rate (which was not available for all countries) was omitted.

Money demand equations were estimated for each of these components, allowing different constant terms while constraining the slope parameters in the three equations to be equal (the j superscript ranges over F=France, G=Germany, and O=other core-ERM). The best joint specification for the three components was

$$\Delta m_t^j = a^j - \underset{(.08)}{.15}\,\Delta y_{t-1}^j + \underset{(.08)}{.31}\,\Delta m_{t-2}^j + \underset{(.11)}{.33}\,\Delta p_{t-3}^j \qquad (9)$$

$$- \underset{(.014)}{.021}\,(m_{t-1}^j - p_{t-1}^j - \underset{(.47)}{1.97}\,y_{t-1}^j + \underset{(.02)}{.03}\,im_{t-1}^j)$$

where $a^F = \underset{(.11)}{-.19}$; $a^G = \underset{(.12)}{-.20}$; and $a^O = \underset{(.10)}{-.17}$.

France:	$R^2 = .30$	SER = .0075	DW = 2.04
Germany:	$R^2 = .16$	SER = .0052	DW = 1.73
Others:	$R^2 = .02$	SER = .0075	DW = 1.91

1/ As mentioned above, the restriction of equal coefficients across equations is only approximate since the dependent variable is in logs.

2/ The shares of these components in aggregate 1987 GDP were 36.1 percent for France, 45.2 percent for Germany, and 18.7 percent for the other countries.

This equation has a number of interesting features. First, it confirms that a common specification of money demand fits France, Germany, and the Benelux-Denmark grouping, as indicated by the low standard errors of the equations for the individual countries and because it satisfies a test that the same slope coefficients fit all three cases. Second, this is an error-correction formulation, with negative feedback of the deviation of real money from its long-run money demand relationship, as given by the last term. Within the implied long-run relationship, income and interest elasticities are within the range that is typically found in the literature: the income elasticity of almost 2, while high, is not beyond the bounds of plausibility. The money-market interest rate also enters this relationship, with a semi-elasticity of 3.0.

Perhaps the most unsatisfactory aspect of the equation is the estimated error correction coefficient of only .021 (which does not even quite reach statistical significance at the 10 percent level). This implies a very slow dynamic adjustment of real money balances to variables affecting long-run money demand, and in particular to changes in interest rates--which were not found to have any statistically significant influence on monetary adjustment except through the error correction term.

In conclusion, the simultaneous estimation provides some, but limited, support for the aggregation needed to estimate a core-ERM equation that is not mis-specified. The characteristics of the individual country equations using the joint specification--low standard errors, little evidence of serial correlation, and satisfying tests of common coefficients--are, on the whole, favorable. They suggest that a common money demand framework does not lead to serious misrepresentation of the behavior of the individual national components. However, the common equation estimated for the three components is not identical to the one estimated for the core group as a whole, and it has some undesirable properties. To be sure, this is not surprising since some of the changes in the individual components may be submerged in the aggregate for the group as a whole, and the money demand estimation for the core group gives more weight to the larger countries, whereas the simultaneous equations approach treats each of the components symmetrically, without regard to size. Several questions were not resolved, and remain for further work, including the appropriate method of aggregation and the best choice of interest rate variables.

IV. Evidence on the Transmission of Monetary Impulses

As discussed in section 1 above, goods market integration will tend to imply that shocks to monetary variables in foreign countries will have effects on domestic economic activity and inflation. This effect is likely to be especially important when the countries are linked by fixed exchange rates. In this section some evidence of effects of

French, German, and core-ERM money on inflation in France and Germany is presented. 1/

There is an extensive literature that tests for the effects of the domestic money supply on economic activity and inflation. This is usually done in the context of "causality tests," in which the additional explanatory power of a variable is tested in the context of a regression equation that already includes lags of the dependent variable, and perhaps other variables as well. Tests of cross-border effects in the European context are however recent and limited in number. Bayoumi and Kenen (1992) use causality tests to see whether the aggregate ERM money supply is a useful predictor of short-run changes in inflation and growth, over and above the domestic money supply. They find that money seems not to be systematically related to real activity, but that ERM money is at least as good a predictor of inflation as the domestic money supply in a subset of nine EC countries.

In this study, a variant of causality tests, namely the conditional linear feedback test (see Appendix II), is used because results are generally more conclusive, as argued by Artis (1992). The purpose of the tests is to see whether French M3 or core-ERM M3 has predictive power for German inflation (and similarly for France).

The tests were done for two sample periods, 1979 to 1990 and 1983 to 1990 (see Table 5, Appendix II). The first sample corresponds to the span of the EMS until German unification. The second, shorter sample excludes the first four years of the EMS, during which there were a number of realignments and large divergences in inflation rates. The effects of French money on German inflation, and of German money on French inflation, are insignificant for the longer period, while German and French money supplies, respectively, do have significant effects. Interestingly enough, however, in the more recent sample period both monetary aggregates have a significant influence (at the 10 percent level) on each other's inflation rate. Table 5, Appendix II also shows that the ERM money supply has a significant effect (at the 10 percent level) on both French and German inflation. Therefore, it seems that the later period with more infrequent realignments produces effects that one would expect in a currency union, namely that additional predictive power exists in other countries' monetary aggregates.

V. Using Core-ERM Money in Stage 2

The statistical results presented above are only preliminary, and more work has to be done to test their robustness. Clearly they could not form the basis for monetary policy implementation without thorough

---

1/ Lack of quarterly national accounts data for other core-ERM countries limited our experiments to these two countries.

evaluation. It is nevertheless useful to consider how in principle core-ERM money might be used in the transition to stage 3. 1/ On the one hand, core-ERM money could serve as an additional indicator that might at times influence German monetary policy, or, on the other hand, there could be a formal target for core-ERM money.

As an additional indicator, core-ERM money could supplement the existing target for German M3. For instance, if German M3 were growing quickly but other ERM countries' money supplies were growing much more slowly, so that core-ERM M3 was growing at a satisfactory pace, then this might temper the concern for excessive German M3 growth. Conversely, too rapid growth in other ERM countries might induce caution in reducing German interest rates. In this perspective, the role of core-ERM money would be to aid in the interpretation of German developments, for example because at times the demand for German M3 might be distorted by exchange rate tensions or currency substitution.

As a formal target, core-ERM M3 could anticipate the mode of operation that would prevail under EMU, when monetary conditions of all countries in EMU would be given equal weight. 2/ This would represent a polar case, however; other arrangements might give more weight to meeting targets for German M3, and less to other core-ERM countries' M3. Allowing for a degree of symmetry in the monetary targets themselves need not involve symmetry in the implementation of monetary policy, since the anchor country could retain responsibility for determining monetary growth, while other core-ERM countries could devote their monetary instruments to maintaining their exchange rates relative to the deutsche mark.

VI. Conclusions

The tentative conclusion of the preliminary work reported above is that there appears to be some evidence of a long-run money demand relationship for a core group of ERM countries, between M3, economic activity, the price level, and either domestic or German interest rates. Such a long-run relationship, together with an estimated dynamic adjustment equation, might be a useful indicator when formulating German, and ERM, monetary policy in the transition to monetary union. Though currency substitution is not tested directly, the stability of the core-ERM aggregate may reflect this phenomenon to some extent; currency substitution may also have caused the apparent lack of

---

1/ Use of EC-wide aggregates in the transition to EMU has been discussed by, among others, Angeloni, Cottarelli and Levy (1991), van Riet (1992), Monticelli and Viñals (1992), and Commissariat Général du Plan (1993).

2/ How an EC monetary aggregate could be targeted is discussed by Russo and Tullio (1988).

robustness of national money demands. Some ways in which a core-ERM monetary indicator could be used are discussed above.

Nevertheless, although the statistical results seem very promising, there are some properties of the estimated money demand equations for core-ERM countries that are not satisfactory. First, income elasticities tend to be high--though this is also a problem for some single country estimates. More work is necessary to construct other relevant variables, in particular wealth. Second, interest elasticities tend not to be precisely estimated, and contemporaneous interest rates do not enter the dynamic core-ERM equation at all. This would be a serious drawback if the equation were to be used for monetary control. However, this is again also a problem for national estimates of a broad aggregate like M3; moreover, core-ERM money demand seems to be more sensitive to money market rates than to long-term market rates, which is a plus for controllability. Finally, though tests of aggregation restrictions across the countries of the core group give support for the validity of aggregation, results of pooled estimation differ in important respects from the estimated core-ERM money demand equation.

A major difficulty in the investigation of money demand at either the national or the multi-country level is the treatment of cross-border money holdings (Angeloni et al., 1991). In principle, national monetary aggregates include only residents' deposits in resident financial institutions. For currency holdings, it is difficult to determine the holder's residency, so a demand equation for a multi-country narrow monetary aggregate may internalize some cross-border currency holdings. However, cross-border deposits will typically be excluded from traditional national and multi-country aggregates, and this may introduce measurement error in estimating the demand for a broader definition of money. If the core-ERM aggregate were adjusted for cross-border holdings, the demand for this aggregate might perform better than is indicated by the results reported here, though the results of Monticelli (1993) are not too promising on that score.

It is clear that use of a core-group monetary indicator may encounter institutional hurdles in the anchor country. In particular, the mandate of the Bundesbank is to ensure the purchasing power of the deutsche mark, not some external target. Therefore, the statistical test that core-ERM money has predictive power for German inflation is important, because it suggests that other countries' money supplies may also be useful indicators in achieving a domestic, German target. One aspect of the results that is particularly suggestive is that estimates of core-group money demand and tests of linear feedback are stronger for the period from 1983 onward, when exchange-rate fluctuations within the core group were limited. This suggests that as a zone of exchange rate stability is maintained, at least among a small group of countries, and as European integration proceeds, the relevance of core-group ERM money may increase.

Data Sources and Definitions

1. Germany

Broad Money (m): Average of end-month seasonally adjusted M3 stock. West Germany up to and including 1990Q4; united Germany thereafter. Adjusted M3 data was also calculated to make a consistent pre- and post-unification series: west German money was scaled up by 14.3 percent over 1970Q1-1990Q3 and by 12.9 percent in 1990Q4. Source: Bundesbank tape.

Income (y): Real income based on GNP at 1991 prices. Seasonal adjustment of east German data based on west German seasonal factors. Sources: west German data from Bundesbank tape; east German data from *DIW, Economic Bulletin, Vol. 30, No.2 (April 1993). To make pre-*unification data consistent with post-unification data, an adjusted series was also created, in which real GDP was scaled up by 9.2 percent over 1970Q1-1990Q3, and by 8.2 percent in 1990Q4.

Long-term Interest rate (i): 10-year government bond yields.

Money market rate (im): 3-month interbank rate.

Source: Bundesbank tape.

Own rate (r0): The own rate on M3 is constructed as the sum of time and statutory deposit rates weighted, respectively, by the period-by-period shares of time deposits and statutory savings in broad money. Sources: Bundesbank tape and Monthly Report.

Prices (p): Consumer Price Index or GDP deflator.

Source: Bundesbank tape.

Data adjustments for the cointegration tests raise west German money by 12.9 percent in 1990Q4 and by 14.3 percent in the period 1970Q1-1990Q3; raise west German nominal GNP by 7.2 percent in 1990Q4 and by 8.3 percent in the period 1970Q1-1990Q3; and raise real GNP by 8.2 percent in 1990Q4 and by 9.2 percent in the period 1970Q1-1990Q3.

2. France

Broad Money (m): Average of end-month seasonally adjusted M3 stock.

Source: International Financial Statistics (IFS).

Income (y): Real GDP at 1980 prices. Seasonally adjusted.

Source: INSEE national accounts.

Long-term Interest rate (i): 10-year government yields.

Money market rate (im): 3-month interbank rate.

Source: IFS.

Own rate (r0): The own rate on M3 is a weighted average (with weights based on average shares in M3) of the returns on: M1 (assumed zero); M2-M1 (proxied with the interest rate on "comptes sur livrets A ou bleus"; M3-M2 (proxied with the call money rate or "taux au jour le jour").

Source: IFS.

Prices (p): Consumer Price Index or GDP deflator.

Source: IFS.

3. Other ERM countries

Broad money (m): M3 data, harmonized in accordance with instructions from the Committee of EC Central Bank Governors, were obtained from national sources for Belgium, Denmark, and the Netherlands. Before December 1982, a series for money plus quasi-money (IFS), seasonally adjusted, was used in place of M3 for the Netherlands. For Luxembourg, time and savings deposits (IFS) were used. The series for the four countries plus Germany and France were aggregated using the central deutsche mark parities which have prevailed since January 1987.

Income (y): Annual GDP for Belgium/Luxembourg, Denmark, and the Netherlands, was interpolated to quarterly using as a guide series French real GDP. Series were aggregated as for M3.

Source: World Economic Outlook.

Prices (p): Consumer price index or GDP deflator for Belgium, Denmark, Luxembourg, and the Netherlands were aggregated using shares of GDP in 1987.

Source: IFS.

Money market rates (im): Short-term rates.

Source: IFS.

Technical Details Concerning Estimation Results

1. Cointegration analysis

Two techniques are used to test for cointegration: the two-step procedure of Engle and Granger (1987), in which ordinary least squares are used in the first step to estimate the long-run equation, and the residuals are tested for stationarity; and the maximum-likelihood Johansen procedure (Johansen, 1988; Johansen and Juselius, 1990) in which a vector autoregression is estimated with the cross-equation restrictions implied by one or more cointegrating vectors; the existence of such vectors is examined using tests on the eigenvalues of the VAR adjustment matrix (see Table 1, Appendix II).

In the two-step procedure, stationarity of residuals is tested using either the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) or Phillips-Perron (PP) test (Phillips, 1987; Phillips and Perron, 1988). The PP test differs from the ADF test in the treatment of serial correlation in the noise process. Specifically, the PP test corrects for serial correlation by adding to the original unit root test statistic a correction factor that eliminates the dependency of the asymptotic distribution on the serial correlation of the noise function. The PP approach is nonparametric with respect to noise parameters and has more power than the ADF test for models with moving average errors and positive serial correlation. However, when a parametric correction is needed, the PP test may be less reliable than the ADF test.

In the Johansen tests reported in the paper, a constant and three lags of each variable are included in estimation of the VAR.

2. Diagnostic tests

The dynamic equations were subjected to a number of tests to see whether they had satisfactory properties (see Table 4, Appendix II). The tests are described in Spanos (1986).

- Lagrange multiplier tests for first-order or first to fourth-order serial correlation. The test statistic is distributed as $F(1,n-2)$ or $F(4,n-8)$ where n = the number of time periods minus explanatory variables.

- Autoregressive conditional heteroscedasticity (ARCH) test for errors whose variance obeys first-order serial correlation. Distributed as $F(1,n)$.

- Normality test for excess skewness and kurtosis relative to a normal distribution. Distributed as $\chi^2(2)$.

- RESET test for linearity (includes powers of explanatory variables). Distributed as F(4,n-4).

  Hendry test for forecast stability. Distributed as $\chi^2(p)$, where
  p = number of forecast periods.

3. Aggregation tests

In connection with SUR estimation of a common money demand equation for France, Germany, and the Benelux-Denmark group the restrictions of common parameters were tested. The null hypothesis is that all coefficients (except the constant term) are the same across all three equations. The test statistic is a standard F test of linear restrictions using the residual sum of squares added across the three equations. The numerator degrees of freedom are the number of restrictions implied by equal coefficients; the denominator degrees of freedom are the number of observations minus parameters in the unrestricted version. The value of test statistics for equation (9) in the text was 1.80, compared to a critical value of 1.83.

4. Conditional linear feedback tests

The conditional feedback test differs from the Granger test in that it includes leads and lags augmented with lagged dependent variables, in order to correct for the residual serial correlation that is likely to occur with one-sided tests (Geweke, 1982). A two-sided distributed lag of money growth on inflation is estimated for both France and Germany, and the exclusion of leads of money growth is tested. This provides a test of whether the particular monetary aggregate has predictive power or not (see Table 5, Appendix II).

Table 1. France: Estimates of Long-Run Money Demand Relationship
(1978Q2-1990Q2)
(t - ratios in parentheses)

	CPI Deflator	CPI Deflator	GDP Deflator	GDP Deflator
		(Two-Step Procedure)		
Constant	-2.1	-1.3	-5.3	-4.9
y_t	0.85	0.74	1.26	1.21
	(11.2)	(14.8)	(38.8)	(56.2)
$im_t - r_{0t}$	-0.016	--	-0.008	--
	(-5.9)		(-4.9)	
$i_t - r_{0t}$	--	-0.023	--	-0.011
		(-10.7)		(-7.7)
R^2	0.84	0.90	0.97	0.98
SER	0.028	0.028	0.018	0.015
ADF	-1.65	-1.50	-2.50	-3.02
PP	-1.34	-1.34	-2.52	-2.87
		(Johansen Procedure)		
Constant	-5.8	-3.6	-7.1	-5.5
y_t	1.46	1.09	1.56	1.31
$im_t - r_{0t}$	-0.039	--	-0.026	--
$i_t - r_{0t}$	--	-0.023	--	-0.014
Null Hypothesis				
$r = 0$ (34.9) 1/	37.2**	40.3**	29.8	36.3**
$r \leq 1$ (20.0) 1/	20.2**	22.4**	14.6	20.1**
$r \leq 2$ (9.2) 1/	7.4*	7.0	4.3	6.4
No. of cointegrating vectors	2	2	--	2

1/ Critical values at the 5 percent level are in parentheses.
* Null hypothesis rejected at 10 percent significance level.
** Null hypothesis rejected at 5 percent significance level.

Table 2. Germany: Estimates of Long-Run Money Demand Relationship
(1978Q2-1990Q2)
(t - ratios in parentheses)

	CPI Deflator	CPI Deflator	GDP Deflator	GDP Deflator
		(Two-Step Procedure)		
Constant	-8.5	-8.6	-7.2	-7.3
y_t	1.71 (31.3)	1.74 (27.3)	1.52 (31.8)	1.54 (27.4)
$im_t - r_{0t}$	-0.011 (-4.7)	--	-0.009 (-4.4)	--
$i_t - r_{0t}$	--	-0.016 (-4.7)	--	-0.0068 (-0.9)
R^2	0.96	0.94	0.96	0.94
SER	0.026	0.300	0.022	0.027
ADF	-2.66	-3.50**	-2.27	-2.50
PP	-2.56	-2.50	-2.67	-2.23
		(Johansen Procedure)		
Constant	-16.6	-3.2	-1.1	-8.6
y_t	3.12	0.92	1.17	1.66
$im_t - r_{0t}$	-0.136	--	-0.547	--
$i_t - r_{0t}$	--	-0.090	--	0.080
Null Hypothesis				
$r = 0$ (34.9) 1/	50.0**	40.0**	54.0**	53.0**
$r \leq 1$ (20.0) 1/	8.0	18.7*	11.3	18.1 *
$r \leq 2$ (9.2) 1/	2.4	3.9	2.6	2.7
No. of cointegrating vectors	1	1	1	1

1/ Critical values at the 5 percent level are in parentheses.
* Null hypothesis rejected at 10 percent significance level.
** Null hypothesis rejected at 5 percent significance level.

Table 3. Core-ERM Countries: Estimates of Long-Run Money Demand Relationship (1982Q2-1990Q2)
(t - ratios in parentheses)

	CPI Deflator	CPI Deflator	GDP Deflator	GDP Deflator
		(Two-Step Procedure)		
Constant	-12.1	-11.6	-9.5	-9.1
y_t	1.94 (34.5)	1.88 (20.0)	1.62 (48.3)	1.58 (30.6)
$im_t - r_{0t}$	-0.017	--	-0.008 (-4.0)	--
$i_t - r_{0t}$	--	-0.012 (-2.5)	--	-0.007 (-2.6)
R^2	0.98	0.97	0.99	0.99
SER	0.017	0.020	0.001	0.011
ADF	-2.70	-2.18	-3.20	-2.30
PP	-3.07	-2.16	-3.77*	-3.00
		(Johansen Procedure)		
Constant	-12.9	-7.7	-7.9	-5.4
y_t	2.06	1.38	1.42	1.08
$im_t - r_{0t}$	-0.046	--	-0.011	--
$i_t - r_{0t}$	--	-0.005	--	-0.0002
Null Hypothesis				
$r = 0$ (34.9) 1/	46.1**	42.7**	36.2**	45.4**
$r \leq 1$ (20.0) 1/	14.4	19.9*	20.9**	14.1
$r \leq 2$ (9.2) 1/	4.1	5.6	7.2	2.5
No. of cointegrating vectors	1	1	2	1

1/ Critical values at the 5 percent level are in parentheses.
* Null hypothesis rejected at 10 percent significance level.
** Null hypothesis rejected at 5 percent significance level.

Table 4. Diagnostic Statistics 1/ for Dynamic Money Demand Equations

	France 1979Q2-1990Q2	Germany 1979Q2-1990Q2	Core ERM 1983Q4-1990Q2
Serial correlation 2/			
First order	1.27	0.23	0.28
Lags 1-4	0.61	2.07	0.74
ARCH (1) test for heterosedasticity	0.30	3.0	0.59
Normality test 3/	3.06	0.26	1.02
RESET (4) test for linearity	3.14 *	0.26	0.59
Forecast stability 4/	20.20 *	17.80 *	--

1/ All statistics are in F form unless otherwise mentioned. Test statistics exceed 5 percent critical values only when starred.

2/ Lagrange multiplier test.

3/ Jacque-Bera test, distributed as chi-square with 2 degrees of freedom.

4/ Out of sample forecast for 1990Q3-1992Q3. Distributed as chi-square with 9 degrees of freedom.

APPENDIX II

Table 5. Conditional Feedback Tests of Effects of Money on Inflation

	Inflation in: France	Inflation in: Germany
	(1979Q1-1990Q2)	
French money growth	3.90 **	1.14
German money growth	2.26	3.22 *
	(1983Q1-1990Q2)	
French money growth	6.00 **	3.36 *
German money growth	4.80 **	2.72 *
Core-ERM money growth 1/	2.79 *	2.79 *

The table reports the F-statistics for excluding the variable. A single asterisk indicates that the variable is significant at the 10 percent level. A double asterisk indicates that the variable is significant at the 5 percent level.

1/ The core-ERM money supply growth excludes the growth of the domestic money supply.

Core-ERM Money Demand Aggregate Using Central Parities

A long-run money demand equation for the aggregate constructed using central parities prevailing since January 1987, was estimated for the period 1980Q4 through 1992Q3: 1/

$$(m_t - p_t) = -9.57 + 1.85\, y_t - .010\, (im_t - r_{Ot}) \qquad (A1)$$

This long-run equation is similar to the one obtained with PPP weights over the shorter sample: it has a fairly high long-run income elasticity (1.85) and a reasonable interest semi-elasticity (1.0). 2/ However, the evidence of cointegration is fairly weak, since the significance of the ADF test statistic (3.15) is borderline.

Therefore, instead of a two-step procedure, one-step estimation was performed in which lagged levels of the variables in the long-run equation were included directly in a short-run dynamic equation, along with differences of these variables, in order to see if there was significant error-correction feedback when the long-run money demand was estimated directly. The best specification of this dynamic equation was the following equation, in which the dependent variable is the change in nominal money:

$$\Delta m_t = \underset{(.14)}{-.35}\, \Delta m_{t-3} + \underset{(.093)}{.201}\, \Delta y_{t-2}$$

$$- \underset{(.006)}{.024}\, m_{t-1} + \underset{(.003)}{.015}\, y_{t-1} - \underset{(.00038)}{.00037}\, (im_{t-1} - r_{Ot-1}) \qquad (A2)$$

$R^2 = .96$ SER = .0042 DW = 2.26

This error-correction specification implies results that are broadly consistent with those of the long-run equation--with the major exception

---

1/ A larger series for M3 was created by extending the Netherlands data bank before 1982, and adjusting post 1990 German data for unification (see Annex I). The longer sample period was used in order to maximize the number of observations since the beginning of 1987--most relevant given the central parities used.

2/ If only the 1987Q1-1992Q3 period is used in estimation, the estimated coefficients on the real income and interest rate variables are 1.19 and 0.002, respectively.

that the coefficients on the levels of money and income imply an income elasticity of money demand (0.63) that is much lower than in equation (9). The German interest rate enters the dynamic equation only through the error-correction component; its coefficient is of the same order of magnitude as in equation (9), but is not statistically significant. The dynamic equation passes all of the specification tests including out-of-sample forecasts when the equation was re-estimated stopping at 1990Q2 and used to forecast 1990Q3-1992Q3, with the exception of the test for autoregressive conditional heteroscedasticity.

Bibliography

Angeloni, Ignazio, Carlo Cottarelli, an Aviram Levy, "Cross-Border Deposits and Monetary Aggregates in the Transition to EMU," IMF Working Paper WP/91/114, November 1991.

Artis, Michael J., "Monetary Policy in Stage Two of EMU: What Can We Learn from the 1980s?" (mimeo, revised draft, 1992).

Artis, Michael J., Robin C. Bladen-Hovell, and Wing Zhang, "A European Money Demand," in Paul R. Masson and Mark Taylor, eds., Policy Issues in the Operation of Currency Unions, (Cambridge: Cambridge University Press, forthcoming in 1993).

Barr, David, "The Demand for Money in Europe: Comment on Kremers and Lane," International Monetary Fund Staff Papers, Vol. 39 (September 1992), pp. 718-29.

Bayoumi, Tamim, and Peter B. Kenen, "Using An EC-Wide Monetary Aggregate in Stage Two of EMU," IMF Working Paper WP/92/56, July 1992.

Bordes, Ch., and Marc-Olivier Strauss-Kahn, "Cointegration et Demande de Monnaie en France," Banque de France, Cahiers Economiques et Monétaires No. 34 (1989), pp. 161-97.

Commissariat Général du Plan, A French Perspective on EMU (Paris: La Documentation Française, 1993).

De Bandt, O., "Politique Monétaire et Agrégats de Monnaie en France," Banque de France, Bulletin Trimestriel, No. 78 (juin 1991), pp. 79-93.

Deutsche Bundesbank, "The Impact of External Transactions on Bank Liquidity, The Money Stock and Bank Lending," Monthly Report (January 1993), pp. 19-34.

Dickey, D.A. and W.A. Fuller, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root, Econometrica, Vol. 49 (1981), pp. 1057-72.

Dornbusch, Rudiger, "Expectations and Exchange Rate Dynamics," Journal of Political Economy, Vol. 84 (December 1976), pp. 1161-76.

Engle, Robert, and Clive Granger, "Cointegration and Error Correction: Representation, Estimation, and Testing," Econometrica, Vol. 55 (1987), pp. 251-76.

Fase, M.M.G. and C.C.A. Winder, "The Demand for Money in the Netherlands and the Other EC Countries," CEPS Working Document No. 72 (Brussels: Centre for European Policy Studies, 1992).

Fröchen, Patrick, and P. Voisin, "La Stabilité des Equations de Demande de Monnaie: le Cas de la France de 1970 à 1984," Banque de France, Cahiers Economiques et Monétaires No. 21 (1986), pp. 5-47.

Geweke, John, "The Measurement of Linear Dependence and Feedback Between Multiple Time Series," Journal of the American Statistical Association, Vol. 77 (1982), pp. 304-13.

Granger, Clive, "Cointegrated Variables and Error-Correcting Models," University of California at San Diego Working Paper 83-13, 1983.

Johansen, Soren, "Statistical Analysis of Cointegration Vectors," Journal of Economic Dynamics and Control, Vol. 12 (1988), pp. 231-54.

_____, and Katarina Juselius, "Maximum Likelihood Estimation and Inference on Cointegration--with Applications to the Demand for Money," Oxford Bulletin of Economics and Statistics, Vol. 52 (1990), pp. 169-210.

Kremers, Jeroen, and Timothy Lane, "Economic and Monetary Integration and the Aggregate Demand for Money in the EMS," International Monetary Fund Staff Papers, Vol. 37 (December 1990), pp. 777-805.

_____, and _____ (1992a), "The Demand for Money in Europe: Reply to Barr," International Monetary Fund Staff Papers, Vol. 39 (September 1992), pp. 730-37.

_____, and _____(1992b), "The Implications of Cross-Border Monetary Aggregation," IMF Working Paper WP/92/71, September 1992.

Lane, Timothy, and Stephen Poloz, "Currency Substitution and Cross-Border Monetary Aggregation: Evidence from the G-7," IMF Working Paper WP/92/81, October 1992.

Monticelli, Carlo, "All the Money in Europe? An Investigation of the Economic Properties of EC-wide Extended Monetary Aggregates," mimeo, July 1993.

Monticelli, Carlo, and Marc-Olivier Strauss-Kahn (1992a), "Broad Money Aggregates and Money Demand in European Countries Economies et Sociétés, Série monétaire, No. 9 (September-October 1992), pp. 147-97.

_____, and _____ (1992b), "European Integration and the Demand for Broad Money," BIS Working Papers No. 18 (Basel: Bank for International Settlements, April 1992).

Monticelli, Carlo, and José Viñals, "European Monetary Policy in Stage Three: What Are the Issues?" Paper Presented at the CEPR Conference The Monetary Future of Europe, La Coruña, Spain, December 1992.

Phillips, Peter, "Time Series Regression with Unit Roots," Econometrica, Vol. 55 (1987), pp. 277-302.

Phillips, Peter, and Pierre Perron, "Testing for a Unit Root in Time Series Regression," Biometrika, Vol. 75 (1988), pp. 335-346.

Russo, Massimo, and Guiseppe Tullio, "Monetary Coordination within the European Monetary System: Is There a Rule?" Part II of Policy Coordination in the European Monetary System, IMF Occasional Paper No. 61 (Washington, D.C.: International Monetary Fund, 1988).

Schmid, P. and H. Herrmann, "Federal Republic of Germany: Old and New Problems Posed by a Target-Guided Monetary Policy," in The Orientation of Monetary Policy and the Monetary Policy Decision-Making Process (Basel: Bank for International Settlements, April 1991), pp. 68-86.

Spanos, Aris, Statistical Foundations of Econometric Modelling (Cambridge: Cambridge University Press, 1986).

van Riet, A.G., "European Integration and the Demand for Money in the EC," De Nederlandsche Bank Quarterly Bulletin 1992/3, December 1992, pp. 33-43.