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Economic and Monetary Integration and the Aggregate Demand for Money in the EMS

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Abstract

This study shows that the aggregate demand for M1 in the group of countries participating in the Exchange Rate Mechanism (ERM) of the European Monetary System can be expressed as a stable function of ERM-wide income, inflation, interest rates, and the exchange rate of the European Currency Unit (ECU) vis-à-vis the U.S. dollar. A notable feature of the model is the rapid elimination of monetary disequilibria, in contrast with most single-country estimates which tend to find implausibly slow adjustment. These results are suggestive: if robust, they would indicate that, even at the present stage of economic and monetary integration, a European central bank could, in principle, implement monetary control more effectively than the individual national central banks.

JEL classification
311, 423

*/ Both authors were with the International Monetary Fund when this paper was started; the first author has since joined the Ministry of Finance in the Netherlands. Views expressed are personal and do not reflect official positions of either institution. We would like to thank Leslie Lipschitz, Thomas Mayer, Donogh McDonald, Donald Mathieson, and Massimo Russo for comments and suggestions, and Behrouz Guerami for efficient research assistance.

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Summary

This paper presents estimates of aggregate demand for narrow money (M1) for the group of countries participating in the exchange rate mechanism (ERM) of the European Monetary System (EMS). It is shown that aggregate demand for M1 in the ERM can be represented as a stable function of ERM-wide income, interest rates and inflation, and the exchange rate of the European Currency Unit (ECU) vis-a-vis the U.S. dollar. The model is formulated using a two-step error correction procedure. The equations estimated perform well, on the basis of both specification tests and tests for parameter instability, over the period between the inception of the EMS, in 1979, and 1987.

The results pertaining to short-run dynamics are of particular interest. The dynamic money demand equation estimated for the ERM implies quite rapid adjustment of real money balances toward their long-run equilibrium level, implying, for instance, that the mean lag in the response of real money balances to a change in real income is only one month. This seems more plausible than the slower adjustment implied by many money-demand estimates for single countries.

Since the money-demand estimates for the ERM appear to be not only acceptable but also in some respects actually more satisfactory than many estimates for individual countries--a finding that is perhaps counter-intuitive--the possible reasons are explored. The implications of aggregating across countries involve two types of bias: aggregation bias can arise to the extent that different countries have different money-demand relationships, while specification bias arises to the extent that there are omitted variables, measurement errors, or other errors in the equation's specification. Aggregation may actually improve the overall performance of an equation if it reduces specification bias to a greater extent than it increases aggregation bias. Currency substitution, as well as international portfolio diversification more generally, would imply that the demand for money in the form of one country's currency depends on other countries' incomes and interest rates, and thus may be potential sources of specification bias in estimating the demand for money in European countries. Under some circumstances, these biases may be alleviated by aggregating across countries, and this may, in particular, be reflected in a more rapid estimated adjustment toward the long-run demand for money.

The results suggest that monetary policy based on money-supply targets could, at least in principle, be feasible for the EMS as a whole. In fact, if the apparent superiority of the ERM-wide money-demand equation over single-country estimates turned out to be robust, this would suggest that a European central bank might even, in principle, be able to implement monetary control more effectively than the individual central banks.

I. Introduction and Synopsis

This paper examines the determinants of the aggregate demand for narrow money (M1) in the countries participating in the exchange rate mechanism (ERM) of the European Monetary System (EMS).

Its motivation is twofold. First, the increasing degree of stability in exchange rates and the process of liberalizing capital movements within the ERM area are likely to have raised the substitability of money and other assets denominated in the various participating currencies. As a result of this development and of the increased degree of integration of the ERM economies, the demand for money in individual currencies may have become more volatile, while at the same time the demand for money in the ERM area as a whole may have become more stable. Russo and Tullio (1988) and others have argued that this may have rendered the ERM-wide money stock a more important determinant of inflation in the ERM than the domestic money stocks, which in turn might justify lifting monetary policymaking to a European level.

Second, irrespective of whether the aggregate demand for money in the ERM is more stable than its counterparts in the individual countries, the present discussion about a single monetary policy for the EMS, to be conducted by a single European monetary authority or otherwise, poses the question of whether an aggregate demand for money function can be identified which may serve as a guide for such a policy.

The estimation of a money demand function for a group of countries with different currencies adds several aspects, both of a conceptual and of a practical nature, to the aggregation issues normally encountered in modelling macroeconomic money demand. Conditions that may justify and make worthwhile the analysis of money demand at the level of ERM-wide aggregates are discussed in Section 2 of the paper.

If it can be assumed that such conditions are satisfied, then a more practical problem remains: which exchange rates to use in aggregating to the ERM level the national variables appearing in the money demand function. Three alternative conversion rates are juxtaposed in Section 3, namely, current exchange rates, fixed base-period exchange rates, and purchasing power parity rates. The first approach, using current nominal exchange rates, would be appropriate if exchange rates vere irrevocably fixed, but its merit is less obvious in the case of the ERM given that exchange rates have remained adjustable. This approach has been applied by Gray, Yard and Zis (1976) in a study of world money demand during the Bretton-Woods era. The second method, using fixed base-period exchange rates, has been used by McKinnon (1982, 1984) and Spinelli (1983) to study the determination of money and prices at the world level under flexible exchange rates, and by Bekx and Tullio (1987) in an analysis of the demand for money in the ERM. It renders the measurement of aggregate variables impervious to nominal exchange rate changes. The third approach, using purchasing power parity (PPP) rates, shares this feature with respect to real variables. The first and third approaches would of course be equivalent if exchange rates were maintained consistent with PPP on a continuous basis, the second and third if all ERM countries had identical inflation rates, and the first and second if exchange rates were fixed.

The econometric specification of money demand presented in this paper is the result of an examination of the data generated by all three alternative methods of aggregation, as well as of econometric experimentation with the second and third (base-period and PPP) approaches. The third approach, based on PPP, has some particularly attractive properties: for one thing, since money stocks and incomes are converted to a single currency in proportion to the purchasing powers of the currencies in which they are originally measured, the weight of each country in the ERM aggregate reflects the size of its real economy. Another desirable feature of the PPP approach in studying the demand for narrow money, held largely for transactions purposes, is that it reflects the money's purchasing power in the country in which it is spent--which, in the ERM countries, is still primarily the country in which the money is issued. Supporting this approach, exploratory work suggests that a money demand equation using base-period exchange rates, namely that of Bekx and Tullio (1987), is not well-specified: results presented in Appendix A show that their money demand function suffers from parameter instability. 1/

Estimating a money demand function using data based on aggregation at PPP yields more satisfactory results. Section 4 applies the error correction model developed by Hendry (1986), Engle and Granger (1987) and others, drawing a careful distinction between long-run developments and short-run fluctuations in the ERM-wide demand for real M1. It is found that the demand for real narrow money in the ERM can be expressed as a stable function of ERM-wide real income, inflation, interest rates, and the exchange rate of the ERM vis-à-vis the U.S. dollar. The long-run relationship between these variables is stable and well determined: a unit income elasticity, negative elasticities with respect to inflation and the level of interest rates, and a positive elasticity with respect to the strength of the ECU exchange rate vis-à-vis the U.S. dollar. Short-run fluctuations in the demand for real M1 can be expressed as a stable function of changes in real income, changes in interest rates, and disequilibrium feedback from deviations of the real ERM money stock from its long-run desired position. An interesting feature, discussed theoretically in Section 2, is the relatively rapid elimination of such disequilibria; this contrasts with most earlier econometric work on individual countries which finds slower adjustment. The model satisfies a broad set of diagnostic tests for possible misspecification, and fits the data at least as well as the money demand functions customarily estimated for individual ERM countries (e.g., Atkinson et al. (1985), von Hagen and Neumann (1988)).

1/ This probably reflects other features of their model as well, notably the absence of dynamics.

II. Theoretical Aspects of Aggregation

In this paper not only is it found that a stable and well-behaved money demand function can be specified for the ERM as a whole, but it also appears that this function has properties that are more satisfactory than those of similar estimates for single countries. Because this is perhaps counter-intuitive, the gains and losses from aggregating across the ERM countries must be explored.

In determining how aggregation affects estimates of the demand for money, two kinds of bias can be distinguished (see Pesaran, Pierse and Kumar (1989)). First, aggregation bias can arise to the extent that different countries in the group have different money demand relationships; due to this bias, aggregate estimates may not converge to a "true" money demand relationship in any one country, or even to an appropriately weighted average. Second, specification bias can occur to the extent that there are omitted variables, errors in the measurement of the explanatory variables, or other errors in the equation's specification. The specification bias could be reduced through aggregation, for example, if the bias reflected the omission of aggregate variables from the individual country equations. Thus, taking both aggregation and specification bias into account, it is possible that aggregate estimates would actually perform better than single-country ones. 1/

In examining the demand for money in a relatively integrated financial area such as that corresponding to the ERM, there are two obvious potential sources of specification error in single-country equations. First, there may be currency substitution, with individuals or firms resident in any country holding transactions balances located in more than one country and denominated in more than one currency. 2/ This would imply that money holdings in a given country's currency would depend not only on income and interest rates in that country, but also on incomes and interest rates in other countries. Moreover, with currency substitution, a shock to money demand in one country may be correlated either positively or negatively with shocks to money demand in other countries. To the extent that these shocks are associated with irregularities in payments and receipts in trade, the correlation may be negative: for example, someone's delayed receipt is someone else's delayed payment, so that one person's money holdings may temporarily be

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1/ This possibility, which applies to the aggregation of economic relationships in general, was first examined by Grunfeld and Griliches (1960). Zellner (1962) addressed the aggregation issue in his development of the seemingly unrelated regression equations (SURE) approach. Pesaran, Pierse and Kumar (1989) provide a useful recent treatment.

2/ Currency substitution often refers to a more specific concept, namely that expected exchange rate movements affect the demand for money in opposite directions in different countries. Here, we use the term in the broader sense that individuals can satisfy their demand for money by holding balances in more than one currency.

less that planned and the other's temporarily greater. The same holds for unexpected changes in spending plans: for example, if rainy Mediterranean weather keeps German tourists at home, this could lead to a temporary positive shock to Germans' money balances accompanied by a temporary negative shock to Italians' balances. Such would also be the case if there are unobserved changes in the anticipated relative returns on money balances held in different currencies, as, for example, if the public bases its expectations of exchange rates on data, such as political developments, that are not taken into account by the econometrician-observer. On the other hand, money demand shocks that correspond to common changes in transactions technology or preferences tend to be correlated positively across countries.

In addition to currency substitution, international portfolio diversification more generally (of which currency substitution is a special case) implies that individuals may hold domestic as well as foreign assets, and thus may take the rates of return on foreign assets into account as part of the opportunity cost of holding money. In this case, and especially given the existence of capital controls, which create imperfect asset substitutability and thus imply that interest rate differentials do not merely correspond to anticipated exchange rate movements, interest rates in other countries, and especially in other ERM countries, would affect the demand for money in individual ERM countries (see, for example, Brillembourg and Schadler (1979)).

In empirical estimates of the demand for money, dynamic specification is particularly important both from an econometric and from a theoretical and policy perspective. Empirical money demand equations typically either include a conventional lagged dependent variable or use an error correction specification; either of these formulations implies that money balances adjust gradually toward their equilibrium relationship with explanatory variables such as income and interest rates. Empirical studies of the demand for money in many countries have estimated partial adjustment or error correction coefficients that imply a speed of adjustment that is implausibly slow--especially to the extent that, in an economy as a whole, income, interest rates and prices, rather than individual money holdings, adjust to equate actual and desired money balances (e.g., Laidler (1982), Lane (1990)). Goodfriend (1985) showed that specification error may account for the implausibly slow adjustment speeds that emerge from many empirical studies. 1/ If this explanation were valid, then reducing specification error would be expected to give rise to higher--and therefore arguably more plausible--implied adjustment speeds.

1/ Using the partial adjustment framework, Goodfriend (1985) showed that measurement errors may bias the coefficient on the lagged dependent variable toward unity; similarly, Kremers and Lane (1989) showed that, in the error correction framework, such specification errors may bias the error correction coefficient toward zero.

In this paper, the demand for money is examined within a two-step error correction framework, 1/ which entails first estimating a static equation often interpreted as the long-run or equilibrium relationship among the variables. Subsequently a dynamic equation is estimated in which the lagged residual from the static equation is included as an explanatory variable representing disequilibrium feedback. The coefficient on the residual, the error correction coefficient, is interpreted as a measure of adjustment in response to deviations from the equilibrium relationship (see Salmon (1982)). Because of the two-stage nature of this error correction framework, measurement or other specification errors affecting the static equation are reflected in the first-stage residual, which may in turn bias the error-correction coefficient (as well as other coefficients) in the dynamic equation. Kremers and Lane (1989) showed that if the measurement error results primarily from the exclusion of foreign income from each country's money demand equation when there is currency substitution, as discussed above, the error correction coefficient will be biased toward zero, wrongly implying a slow adjustment toward equilibrium in money balances.

Aggregation across ERM countries replaces one set of restrictions with another: it replaces the exclusion of foreign income from each country's demand for money with the restriction that all countries' money demand has roughly the same structure, and that the weight of any country's income in influencing another's demand for money is roughly proportional to the weight of that country's money in aggregate money. Whether misspecification is reduced under this alternative set of restrictions is an empirical question. One way of tackling this question is by considering whether one can identify, for the ERM as a whole, an error correction money demand model that passes a range of specification tests. Based on the foregoing discussion, an additional point of attention is whether the ERM-wide money demand estimation yields an error correction coefficient that is larger than has typically emerged from single-country studies. To anticipate the results, the answer to both of these questions is "yes".

III. Derivation of the Aggregate Data

In this section the aggregate data are presented and their salient features discussed. 2/ Seven countries are included in the analysis:

1/ The use of this framework is appropriate if both real money balances and the explanatory variables are I(1), but a cointegrating relationship between these variables can be found such that the residuals from this relationship are I(0). Under these circumstances, consistent estimates of the cointegrating relationship can be obtained using Ordinary Least Squares, without requiring the usual assumptions about the orthogonality of the explanatory variables to the disturbance term. See Granger (1986), Engle and Granger (1987).

2/ Exact source references for all the data are relegated to Appendix B.

Belgium, Denmark, France, Germany, Ireland, Italy, and the Netherlands. This compromises the entire ERM except Luxembourg, for which not all of the required data are available.

For this study of the demand for narrow money (M1), it is preferable to use data encompassing the total monetary asset holdings of domestic residents, held domestically as well as abroad, in both domestic and foreign currency. In light of the requirement that the data should be comparable across countries, the study is based on narrow money as defined in the International Monetary Fund's International Financial Statistics (IFS). This measure of money includes, for each country, currency outside banks as well as demand deposits in domestic currency of the domestic private nonbank sector with domestic banks. The measure unfortunately does not include the nonbank private sector's demand deposits in foreign currency held either in domestic or in foreign banks. Deposits held by ERM residents in offshore markets are therefore not included in the analysis, but, given that these are largely held in time deposits rather than demand deposits or currency, this is probably not a serious omission. On the other hand, domestic notes and coins in the hands of foreigners are included; this is likely to be an advantage, since a large part of each of the ERM countries' currency held by foreigners is probably held elsewhere within the ERM area.

The income variable is, depending on availability, either real GNP or real GDP (in 1985 prices). For Germany, France, and Italy the income variable is available at a quarterly frequency, while for the other countries annual data are interpolated according to the quarterly pattern of industrial production. The income variables, as well as the money stocks, are seasonally adjusted at the national level.

Both the short-term interest rate and the long-term interest rate play a role in the empirical analysis. The former is represented by the short-term interbank money market rate, and the latter by the government bond yield. 1/ The consumer price index (CPI) is used to deflate nominal money and to measure the rate of inflation.

The ERM-wide aggregate for the income variable is derived in three alternative fashions, namely using current nominal exchange rates, fixed base-period nominal exchange rates, and purchasing power parity rates. The average nominal exchange rates for 1979 (the first year of the EMS) underly the second method. The third method is based on the purchasing power parity rates published by the OECD (1989), which are designed to correspond to purchasing power parity for the entire Gross Domestic

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1/ The use of interest rates to measure the opportunity cost of holding money may, in principle, be confounded by the payment of interest on deposits. However, although demand deposits bear interest in some ERM countries during some or all of the sample period, rates were generally low and varied little, so this issue is likely to be of little concern in estimating the demand for M1.

Product. They rely on a large-scale international survey conducted in 1985; the parity rates for the years before and after 1985 (which is near the middle of the EMS sample) are computed by utilizing changes in the GDP deflators in the various countries. In order to maintain the national relativities between money and income in the ERM aggregate, the money stocks are added up at the same exchange rates as are the income variables.

The average ERM interest rates are computed as weighted averages of the national rates, using as weights the shares of the national currency in the ECU in 1989 (Ungerer et al. (1986), Table 4) redefined to exclude the United Kingdom and Luxembourg. These shares purport to reflect the relative importance of the various ERM economies and the role of their currencies in the international financial market place. The aggregate CPI is computed as a weighted average of the national indices, the weights being the shares of the real income variables in the ERM aggregate computed either at current nominal exchange rates or at purchasing power parity rates. 1/

The resulting data set is presented in Charts 1 through 6, and is now briefly reviewed. Chart 1 shows aggregate real GNP in the ERM, expressed in deutsche mark and derived on the basis of the three alternative methods discussed above. The pattern of nominal appreciation of the deutsche mark is clearly reflected in the downward movement of aggregate real GNP based on current nominal exchange rates. Given that in fact each of the ERM economies expanded during this period, the aggregation method is obviously unsatisfactory. It is also apparent from the chart that the aggregation at base-period exchange rates produces a pattern very similar to that resulting from aggregation at purchasing power parity rates. In the latter measure Germany has a slightly smaller weight than in the former, while particularly Italy is weighted more heavily. This is reflected in a slightly faster growth of the ERM aggregate on the latter measure. In Chart 1 these facts are illustrated in a comparison of German growth with that in the ERM derived at purchasing power parity rates.

Chart 2 depicts the corresponding series for the nominal money stock in the ERM and in Germany, and in Chart 3 these are shown deflated by the matching CPI indices. The behavior of the nominal series derived at base-period exchange rates is again quite similar to that based on purchasing power parity rates; Chart 2 shows that, from 1979 through 1987, nominal money growth in Germany was considerably more restrained than in the ERM as measured by the latter series. However, this is not true as far as the real money stocks are concerned: it appears from Chart 3 that real money growth (based on purchasing power parity rates) was faster in the ERM than in Germany in 1979-81, about equal in the ERM and in Germany in 1982-84, but considerably faster in Germany in

1/ Bekx and Tullio based their ERM-wide CPI on the 1979 ECU weights, and hence that procedure will be followed for the estimates replicating their model (see Appendix A).

1985-87. This pattern is also reflected in the liquidity ratio, defined as the ratio of real money over real GNP (Chart 4). This variable, which will play an important role in the empirical analysis in Section 4, fell more rapidly in Germany in the first half of the EMS period, but this was followed by a relatively steep rise in the second half.

The process of inflation reduction and convergence in the ERM is documented in Chart 5. Finally, Chart 6 displays short-term and long-term interest rates in the ERM and in Germany.

IV. Empirical Results

Given that the aggregate time series based on current nominal exchange rates have some undesirable properties, the demand for money in the ERM was analyzed employing aggregate data relying either on fixed base-period exchange rates or on purchasing power parity rates. As a benchmark for the investigation, the model proposed by Bekx and Tullio (which relies on base-period rates) was briefly scrutinized (see Appendix A) and found to be misspecified. Therefore an alternative model is presented that relies on purchasing power parity rates and has a richer dynamic structure; this model turns out to be satisfactory.

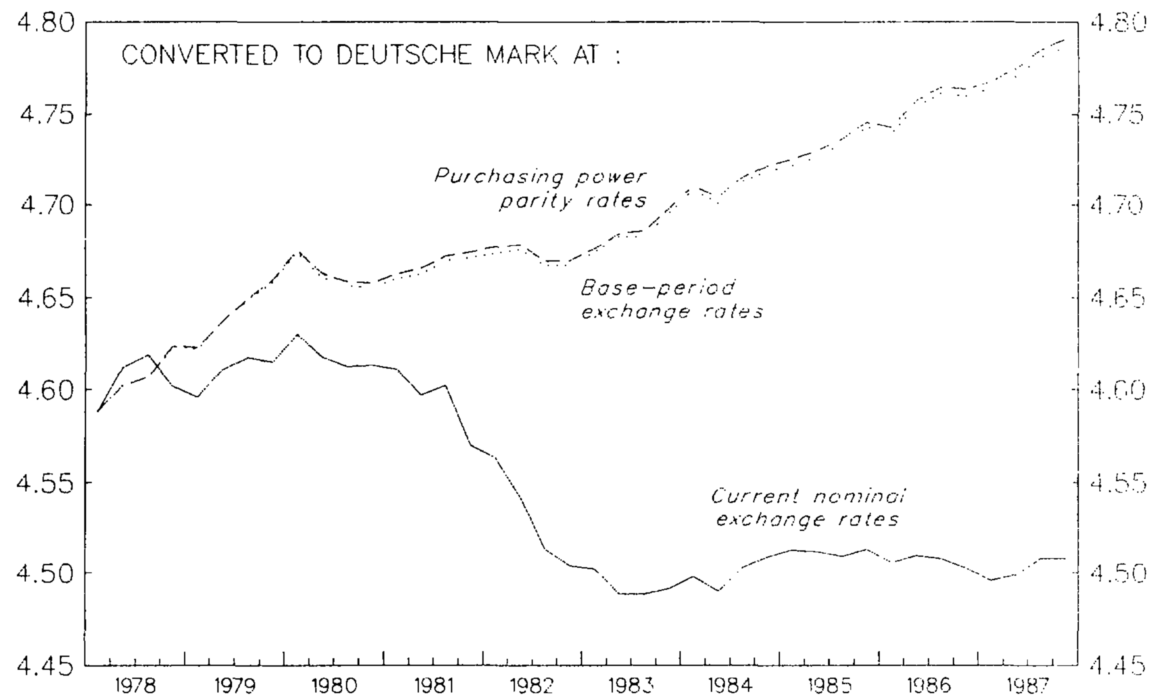
The model of Bekx and Tullio is unusual in that it excludes any dynamics. It thus resembles the kind of relation that may exist between money, prices, income and interest rates in the long run. Indeed, the recent literature on cointegration has recommended static regressions as a vehicle for uncovering long-run economic relationships. The idea underlying cointegration is to study the behavior of variables moving apart in the short run, but brought together again by market forces or government policy, or both, in the longer run. 1/ A variable is defined to be integrated of order one (denoted I(1)) if it must be differenced once to induce stationarity (denoted I(0)). A set of variables, each I(1), is said to be cointegrated if a linear combination of them is I(0) (i.e., if they move together in the longer run).

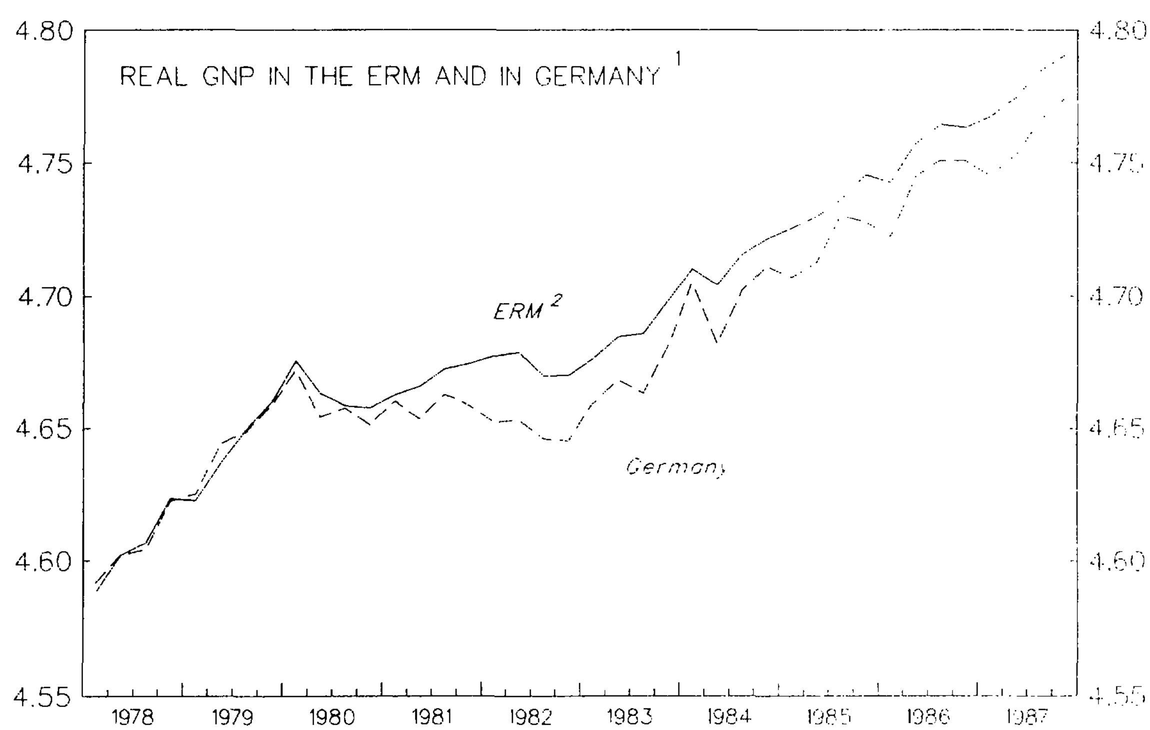
The practical merit of the empirical methods that have been developed in this area is that they provide a way of distinguishing empirically between short-run and long-run features of economic time series. In the present context, there is considerable interest in disentangling the long-run tendencies of money demand in the ERM from its short-run fluctuations. This will be done below by making use of the theorem, established by Engle and Granger (1987), that cointegration between a set of variables implies that their short-run dynamics are influenced by feedback returning them to their long-run equilibrium. The converse is also true: if such feedback exists then the variables must be cointegrated.

1/ See Granger (1986), Hendry (1986), and Engle and Granger (1987) for introductions to cointegration.

CHART 1

REAL GNP IN THE ERM[1]

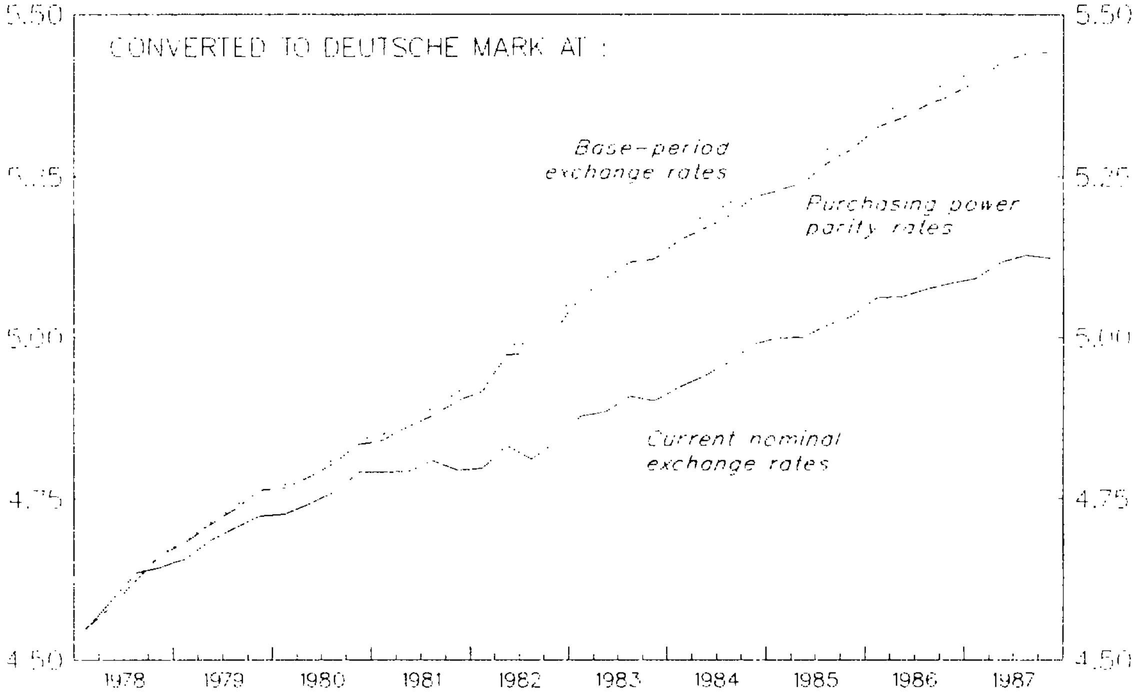


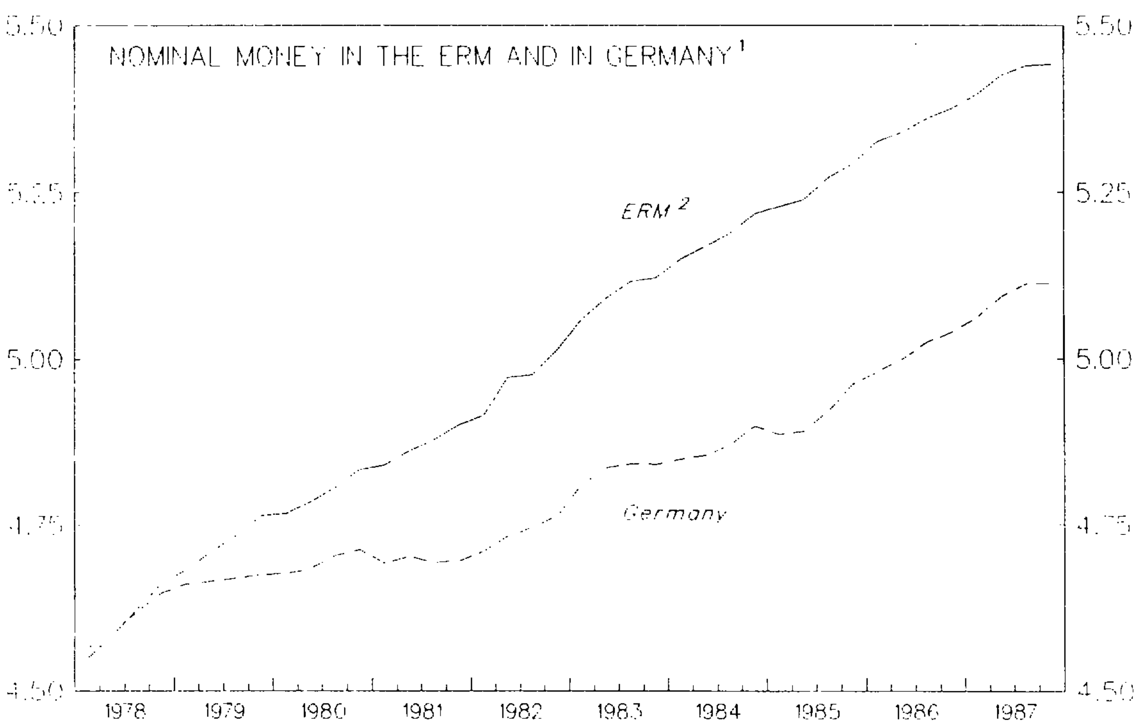


Source: Appendix B.
[1]Natural logarithm of real GNP in deutsche mark at 1985 prices (indices scaled to 1978=100).
[2]Converted to deutsche mark at purchasing power parity rates.

CHART 2

NOMINAL MONEY IN THE ERM[1]





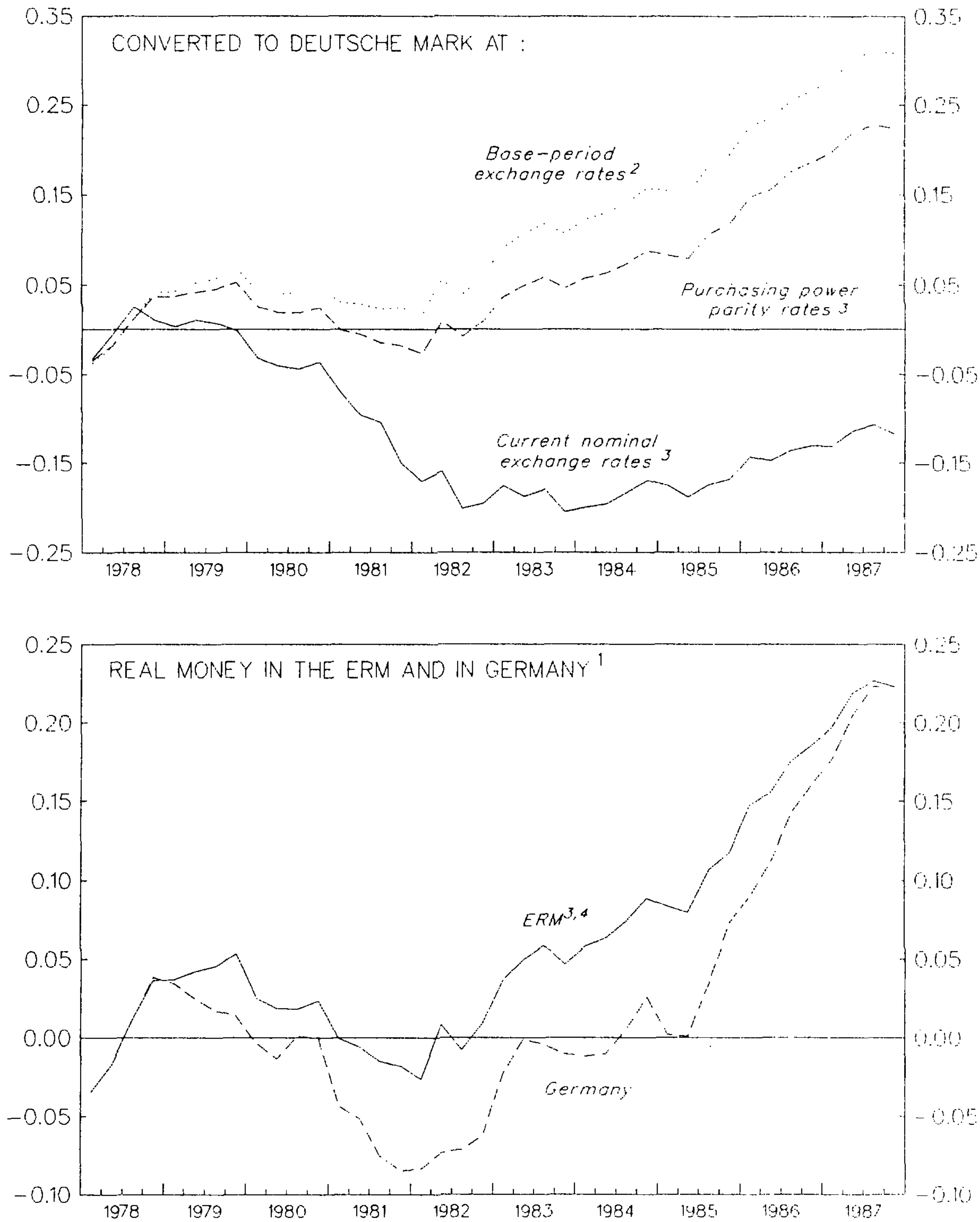
Source: Appendix B.

[1] Natural logarithm of nominal M1 in deutsche mark (indices scaled to 1978=100).

[2] Converted to deutsche mark at purchasing power parity rates.

CHART 3

REAL MONEY IN THE ERM[1]



Source: Appendix B.

[1] Natural logarithm of nominal M1 deflated by CPI, in deutsche mark (indices for M1 and CPI scaled to 1978=100).

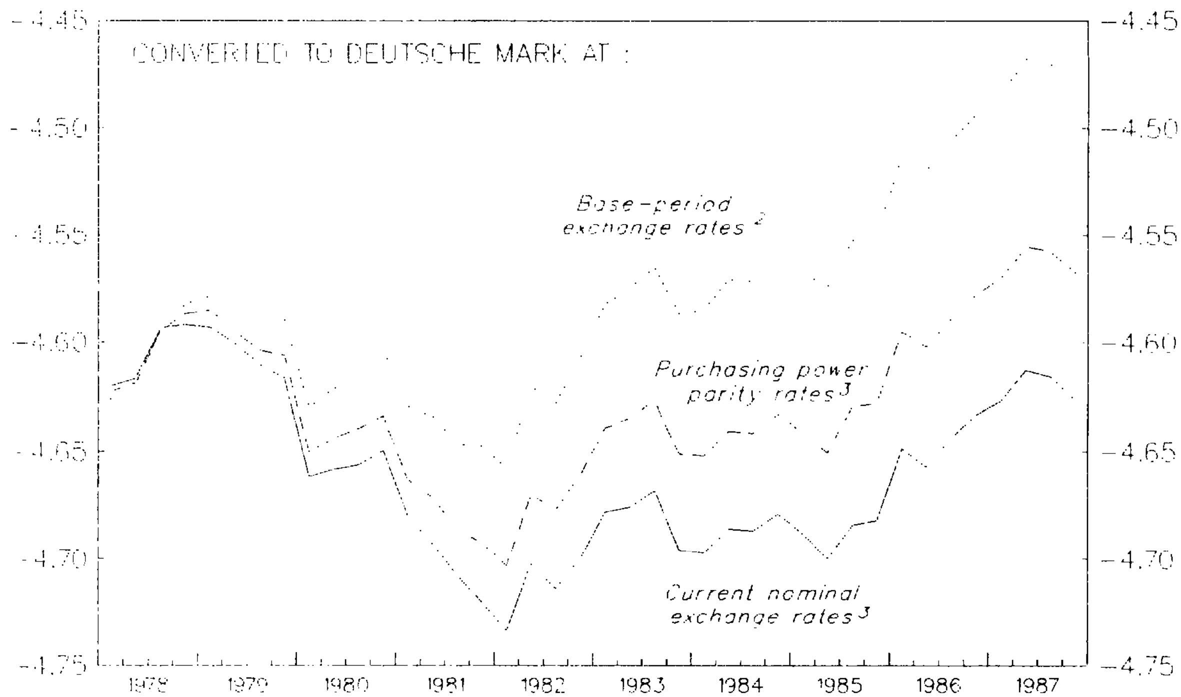
[2] CPI based on ECU weights.

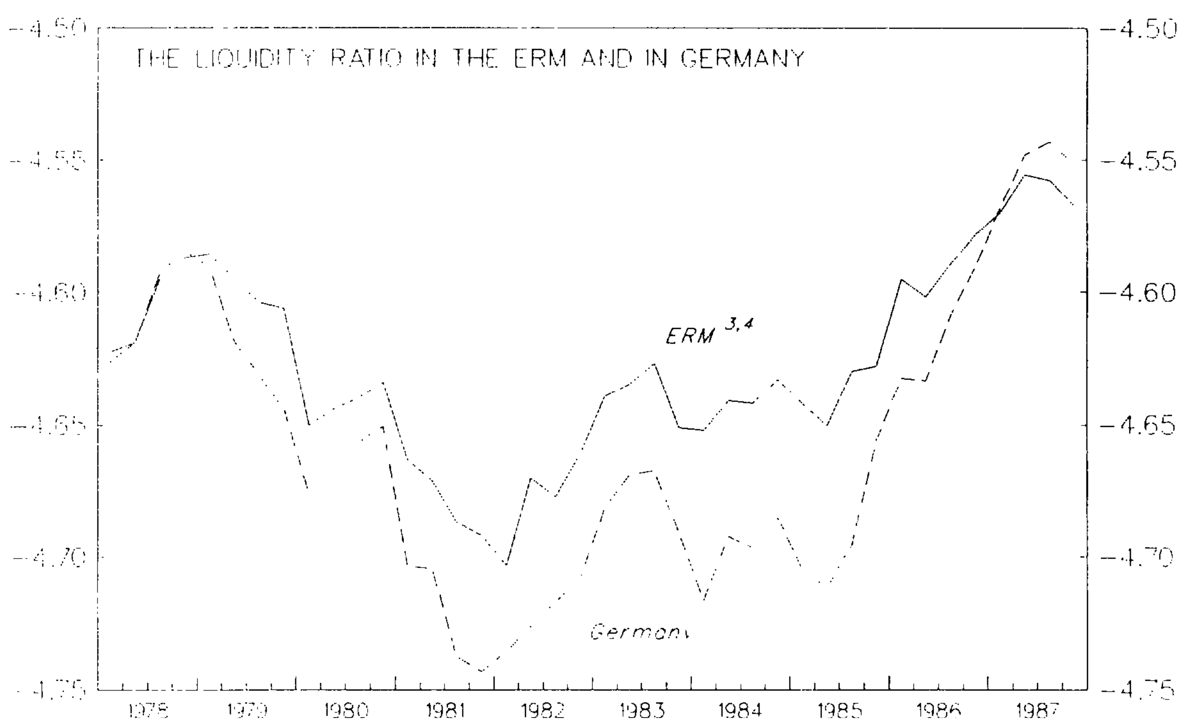
[3] CPI based on real GNP weights.

[4] Converted to deutsche mark at purchasing power parity rates.

CHART 4

THE LIQUIDITY RATIO IN THE ERM[1]

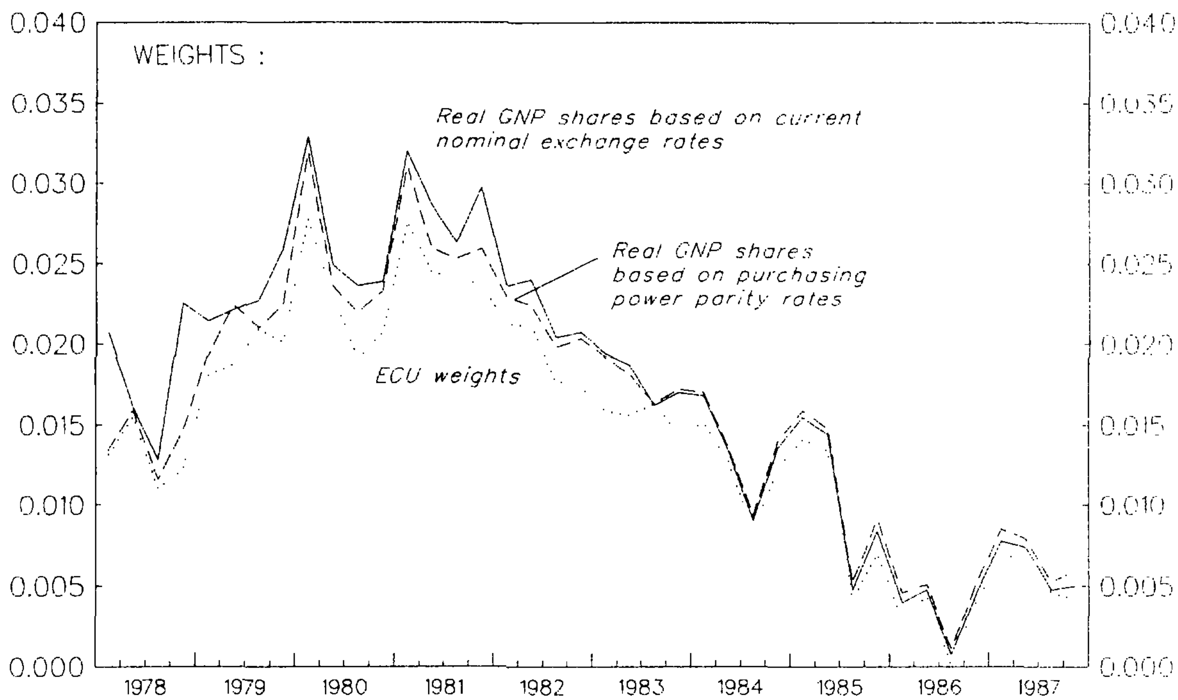


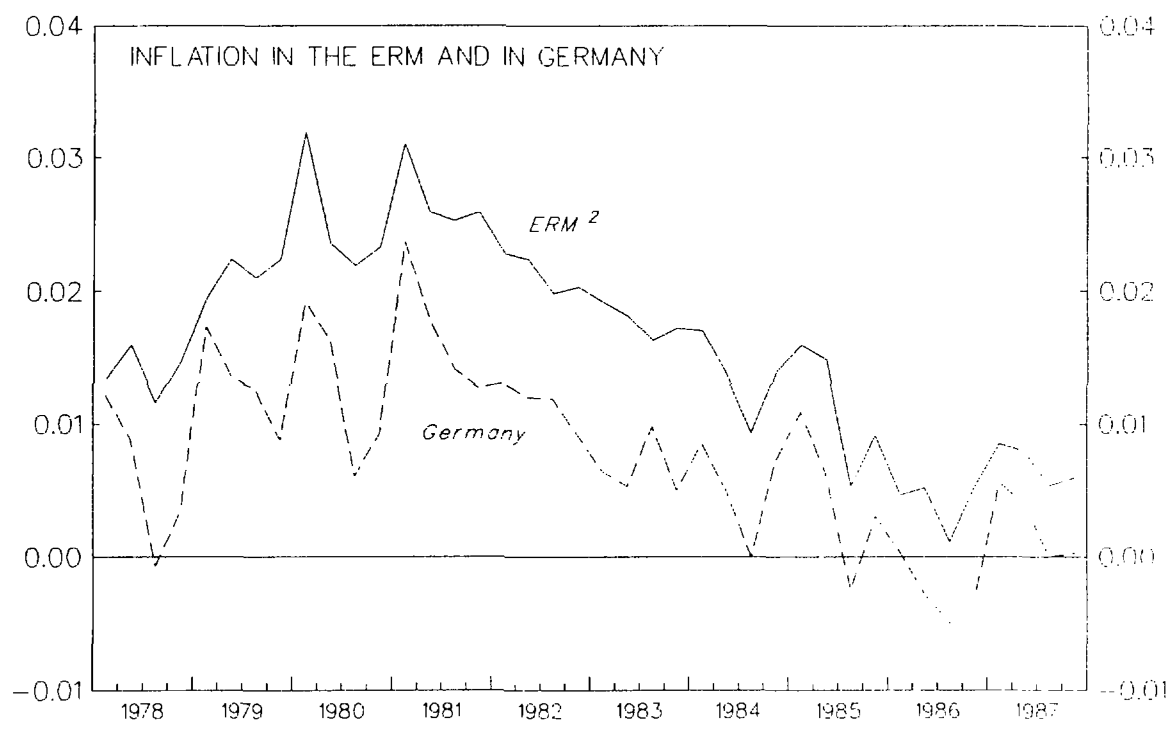


Source: Appendix B.
[1]Natural logarithm of real M1 (nominal M1 deflated by CPI) divided by real GNP in 1985 prices, in deutsche mark (indices for M1, CPI and real GNP SCALED TO 1978=100).
[2]CPI based on ECU weights.
[3]CPI based on real GNP weights.
[4]Converted to deutsche mark at purchasing power parity rates.

CHART 5

INFLATION IN THE ERM[1]

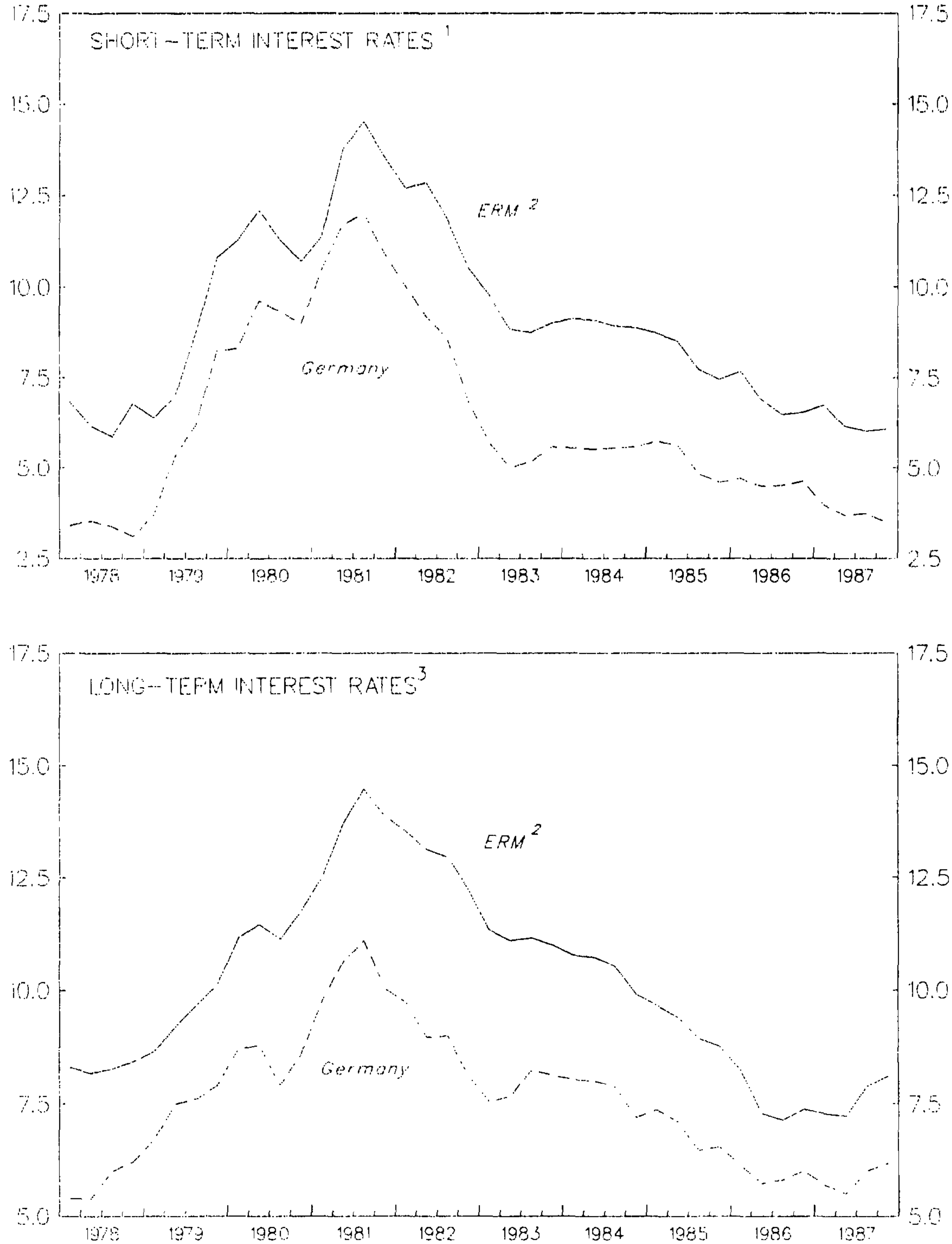




Source: Appendix B.
[1] Quarterly change in the natural logarithm of CPI indices.
[2] Weights based on real GNP shares relying on purchasing power parity rates

CHART 6

INTEREST RATES



Source: Appendix B.

[1] Short-term interbank money market rate, annual return.

[2] Based on ECU weights.

[3] Long-term government bond yield, annual return.

Specifically, it will first be examined whether the residuals from a static regression of the ERM money stock (denoted m_t) 1/ on the price level (denoted p_t), real GNP (denoted y_t), the interest rate, inflation, and the exchange rate of the ECU (excluding the United Kingdom and Luxembourg) vis-à-vis the U.S. dollar are stationary. Based on the results of some alternative regressions not reported here, a short-term, rather than a long-term, interest rate is specified (denoted RS_t); this is consistent with the idea that narrow money is held largely for transactions purposes and that the time horizon relevant for decisions regarding the amount held is accordingly rather short. The nominal exchange rate of the ECU in terms of U.S. dollars, ecu_t, is also included in the static equation. 2/ This is consistent with the Bundesbank's (1988) finding that strength of the deutsche mark has tended to be associated with a stronger demand for German money (especially notes and coins), and with similar results found for the ERM by Bekx and Tullio (1987). This link between the exchange rate and the money demand may reflect currency substitution. 3/ For example, the exchange rate may embody information about the future course of monetary policy and other "fundamentals" affecting the future exchange rate, and any new information would be incorporated in the exchange rate as well as affecting the demand for money. An anticipated easing of monetary policy in Europe, for instance, would lead to an expected depreciation of the ECU and thus lead immediately to a lower ECU; the same expectations could also lead the demand for European money to decrease due to currency substitution, and perhaps also via the effect of anticipated inflation. The "long run" demand for money would be affected if the new information is "permanent," i.e., if it is as likely to be revised in one direction as the other; this would be the case under rational expectations. 4/ In the absence of an explicit model of expectations, this interpretation of the role of the exchange rate in money demands remains, of course, a tentative one.

Other specific features of the model are the following. The aggregate data are based on purchasing power parity rates. The rate of inflation is included as a (negative) return on money. Preliminary estimates also suggested that imposing long-run homogeneity in the price level and restricting the income elasticity to unity does not significantly reduce the sum of squared residuals; these restrictions,

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1/ All lower case variables are in natural logarithms.

2/ The corresponding real exchange has a very similar pattern throughout the EMS period.

3/ Substitution between the deutsche mark and the dollar as parallel currencies in some Eastern European countries may be especially important.

4/ This interpretation implies that the exchange rate is an endogenous variable, so that the static equation does not satisfy the assumptions of the general linear regression model; however, as discussed by Granger (1986), OLS yields consistent estimates of a cointegrating relationship among a set of non-stationary (I(1)) variables, even if some of these variables are endogenous.

essentially reformulating the long-run equilibrium in terms of the liquidity ratio, were thus imposed and subsequently tested again in the dynamic model that follows; as reported below, they could not be rejected.

Incorporating these features, the static regression is reported in (1). 1/ All the empirical results were obtained with the program PC-GIVE by D.F. Hendry and the Oxford Institute of Economics and Statistics; see Hendry (1989). Directly under the regression are reported the sample period, the multiple correlation coefficient, the estimated equation standard error, and a set of misspecification tests (for autocorrelation, non-normality, and heteroscedasticity of the residuals, and for parameter instability--see Appendix C for brief descriptions of the tests). Test failures at a significance level of 5 percent will be indicated by asterisks. 2/

$$(m-p-y)_t = \underset{(0.01)}{-5.92} \; - \underset{(0.15)}{0.67}\, RS_t \; - \underset{(0.53)}{1.40}\, \Delta p_{t-1} + \underset{(0.007)}{0.079}\, ecu_t \qquad (1)$$

$T = 1978{:}4\text{-}1987{:}4$ $\quad R^2 = 0.91$ $\quad \hat{\sigma} = 1.00$ percent

$AR(8)_1^{\ 8}=3.30$ (15.51) $\quad AR(4)_1^{\ 4}=1.66$ (9.49) $\quad AR(1)_1^{\ 1}=0.14$ (3.84)

NORM(2)=0.39 (5.99) HET(6,26)=0.35 (2.47) ARCH(4,25)=0.76 (2.76)

CHOW(12,21)=1.00 (2.25) CHOW(4,29)=0.88 (2.70)

Turning to a test of whether this regression can indeed be held to capture the long-run relation between money, income, the interest rate, inflation, and the exchange rate in the ERM, this is confirmed by a Sargan and Bhargava (1983) test rejecting the null hypothesis that the residuals of (1) are non-stationary (the null maintains that they are a random walk; the test statistic is 1.86 compared with a 5 percent critical value of 1.74). This outcome indicates that a long-run

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1/ The price level is the 4-quarter moving geometric average of the ERM-wide CPI (the current quarterly value and the first through third lags). This smoothed measure appeared to produce the most satisfactory specification overall, particularly in the light of tests for possible misspecification; using such a moving average does not affect the asymptotic properties of the cointegration tests or the consistency of estimates of the static equation. It was confirmed that the variables in the static regression are I(1).

2/ The use of ΔP_{t-1} rather than ΔP_t does not affect the consistency of estimates of equation (1), but produces somewhat more satisfactory diagnostic test results in the relatively short sample available. This formulation is equivalent to including ΔP_t in equation (1) and adding $\Delta\Delta P_{t-1}$, which is I(0), to the dynamic equation (2) below.

relation between these variables indeed exists and that modelling the dynamic feedback toward that long-run equilibrium is worthwhile. A comparison with the static regression of Bekx and Tullio (see Appendix A) shows that the estimated variance of the regression residual is reduced by more than 30 percent. Although this static regression is not intended as a well-specified model of money demand (this follows in the dynamic analysis), it is remarkable that residual autocorrelation seems to be absent; moreover, the estimated residual variance is of the same order of magnitude as that found in the money demand equations customarily estimated for the ERM countries individually. 1/ The parameter estimates appear to be stable, as witnessed by the reported Chow tests. In order to illustrate this, Chart 7 displays the actual and fitted values of the liquidity ratio corresponding to the model estimated up to 1984:4, and the actual and conditionally forecast values for 1985:1-87:4; the static model tracks quite well the rise in the European liquidity ratio beginning in 1985.

In Chart 8 the movements in the long-run equilibrium relation are decomposed into the respective contributions of the explanatory variables. The downward movement of the equilibrium liquidity ratio in 1979-81 reflected the sharp rise in interest rates in combination with the rise in inflation and the strengthening of the dollar. The latter influence continued until 1985, but between 1981 and 1985 it was counterbalanced by the decline in interest rates and inflation. With the fall of the dollar after 1985 and the continuing decrease in inflation and interest rates, the hypothetical equilibrium of the liquidity ratio subsequently returned to a level close to that prevailing at the beginning of the EMS.

Following the procedure recommended by Engle and Granger (1987), the lagged residuals of (1), called EC_{t-1}, are included in a dynamic model as a representation of disequilibrium feedback toward the long-run money demand equilibrium. In addition, the dynamic model, formulated in terms of the rate of change of the real ERM money stock, includes as explanatory variables the rate of change of real income and changes in interest rates. The specific dynamics were chosen upon inspection of more general estimates that included several lags of income growth, inflation, and changes in interest rates, selecting lags that were plausible from a theoretical perspective, significant, and satisfactory in the light of the misspecification tests. This procedure yielded a

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1/ The dynamic model of the demand for M1 in Germany published by Atkinson et al. (1985) has an estimated equation standard error identical to that of (2) (sample 1973:2-83:1), and the dynamic model of M1 velocity in Germany published by von Hagen and Neumann (1988) produces a much larger standard error (1.27 percent, sample 1964:2-84:4). Buscher (1984) obtains standard errors for M1 between 0.8 percent and 1.3 percent (sample 1965:1-1982:4), and Heri (1985) achieves values between 1 percent and 1.8 percent (monthly data samples varying within the period 1966:1-83:12). All these studies are based on the national definition of M1.

relatively straightforward money demand function:

$$\Delta(m-p)_t = \underset{(0.002)}{0.002} + \underset{(0.32)}{0.67}\, \Delta y_t - \underset{(0.31)}{0.86}\, \Delta RL_t - \underset{(0.29)}{0.46}\, \Delta RS_{t-3} - \underset{(0.18)}{0.95}\, EC_{t-1} \qquad (2)$$

T= 1979:1-87:4 $R^2 = 0.66$ $\hat{\sigma} = 0.82$ percent

$AR(8)_1{}^1$=5.36 (15.51) $AR(4)_1{}^4$=3.99 (9.49) $AR(1)_1{}^1$=2.18 (3.84)

NORM(2)=0.24 (5.99) HET(8,22)=0.84 (2.40) ARCH(4,23)=0.35 (2.80)

CHOW(12,19)=0.82 (2.31) CHOW(4,27)=2.21 (3.47)

The unity restriction on the rate of inflation could not be rejected and was therefore imposed, linearly transforming the regression into a model of real money growth.

This money demand function for the ERM is satisfactory in several respects. First, it passes the tests for possible misspecification, and, as shown in Chart 9, it tracks real money growth rather well. Moreover, judged by the Chow tests and by the forecast performance depicted in Chart 10, it does so in a stable fashion. 1/ The estimated equation standard error compares favorably with those found for the national money demand functions customarily estimated. 2/

Second, the coefficient on real income growth, though not estimated very precisely, seems plausible, as do the coefficients on the changes in the short-term and long-term interest rates. The significant presence of the long-term interest rate may embody the influence of interest rate expectations on money demand.

Third, the error correction feedback term is quite significant; 3/ the linear restriction embodied in this variable (i.e., the linear combination estimated in regression (1)), including the long-run income

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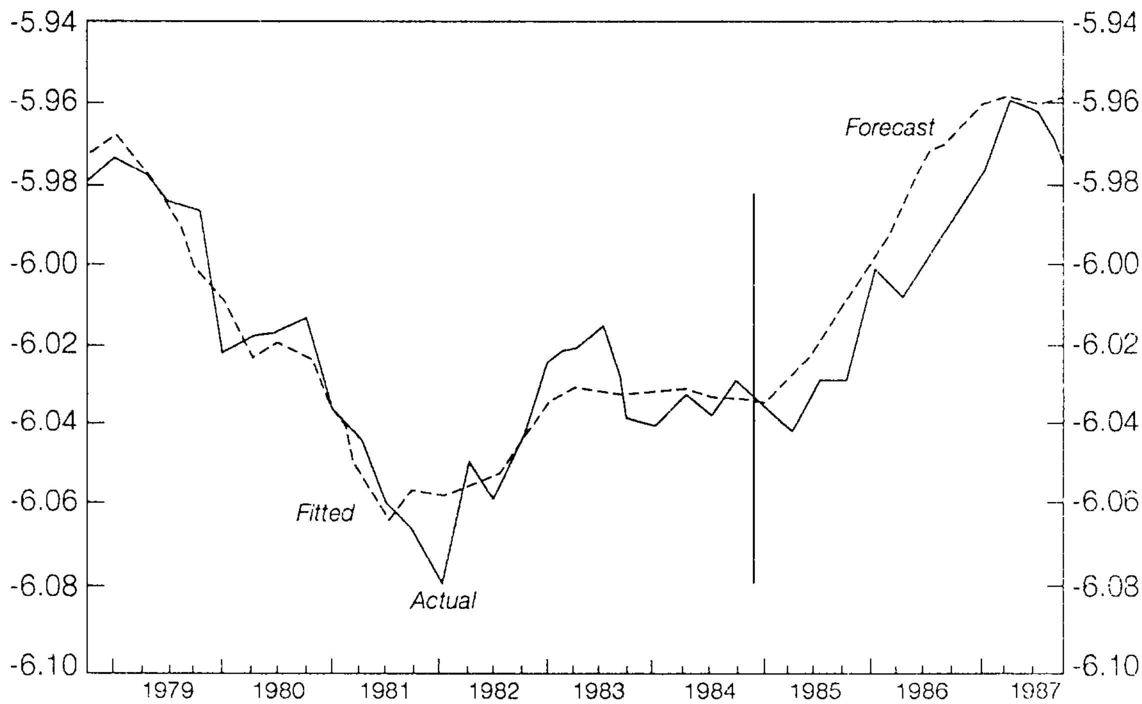
1/ Further evidence for the stability of the parameters was acquired with the recursive regression feature of PC-GIVE, which, starting with the first few observations of the full sample, successively adds one observation and re-estimates the model, offering various graphical assessments of the stability of all the parameter estimate (including an extensive series of Chow tests--see Hendry (1989) for a comprehensive description). The sequence of recursive residuals and estimated equation standard errors is displayed in Chart 11.

2/ See the comments following regression (1) for several comparisons.

3/ Kremers, Ericsson and Dolado (1989) argued that, given differences in power, it is preferable to test for non-cointegration in the dynamic error correction framework.

CHART 7

THE LIQUIDITY RATIO: ACTUAL AND LONG-RUN EQUILIBRIUM[1]

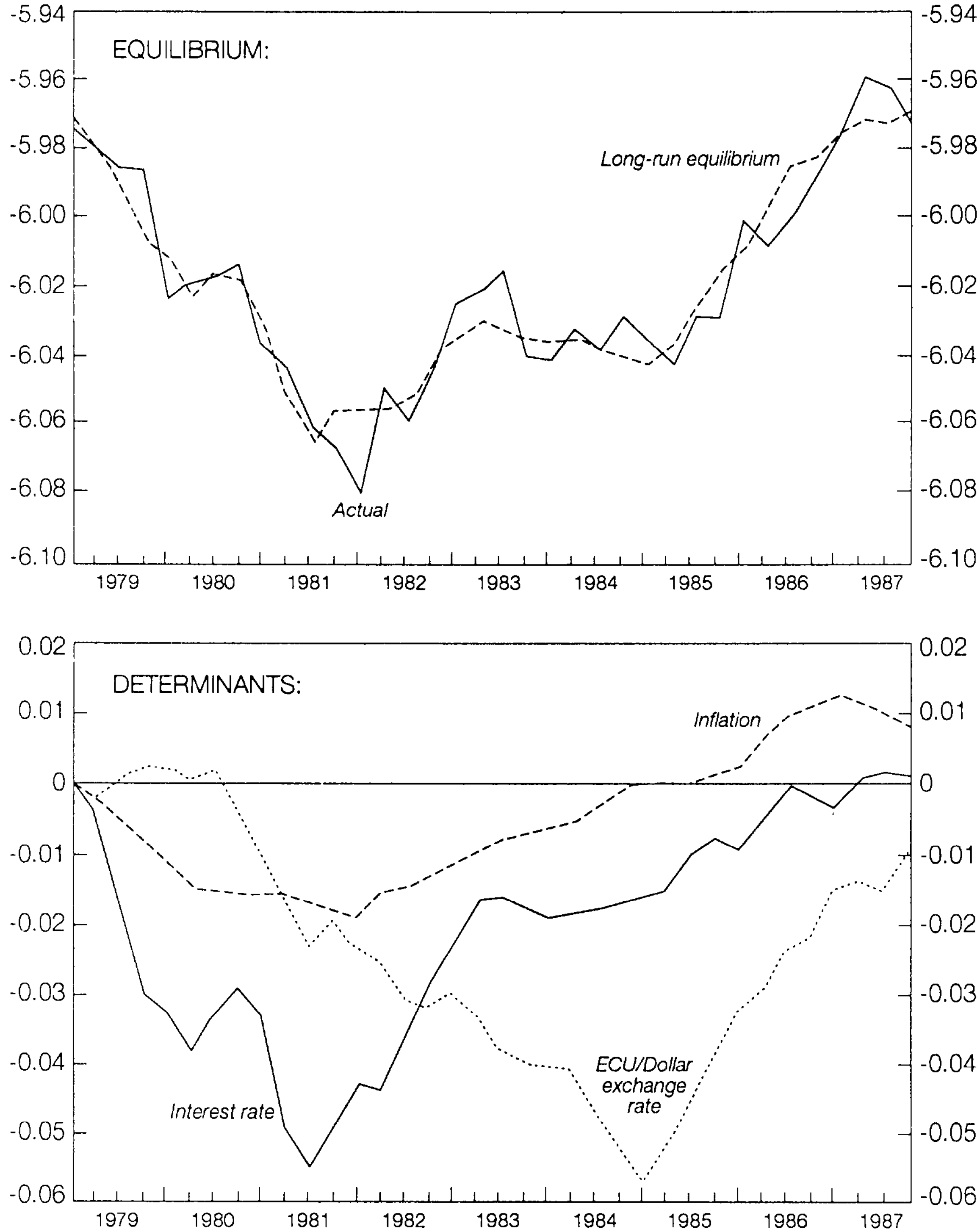


Source: Regression (1) and Appendix B.

[1] In natural logarithm. Estimation period is 1978:4 - 1984:4; conditional forecast period is 1985:1 - 1987:4.

CHART 8

THE LIQUIDITY RATIO: EQUILIBRIUM AND ITS DETERMINANTS[1]

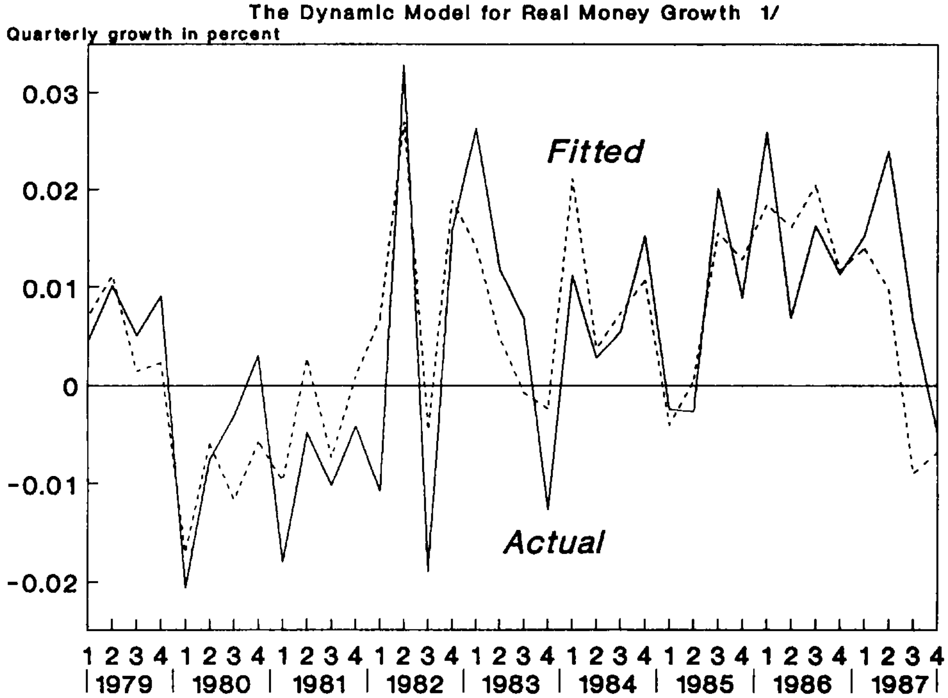


Source. Regression (2) and Appendix B.

[1] In natural logarithm. Estimation period is 1978:4 - 1987:4. The bottom panel decomposes changes since 1979:1 in the long-run equilibrium liquidity ratio into the contribution of inflation, the interest rate, and the nominal exchange rate (variables multiplied by their coefficients in regression (1) and shifted so that the value for 1979:1 equals zero).

Chart 9

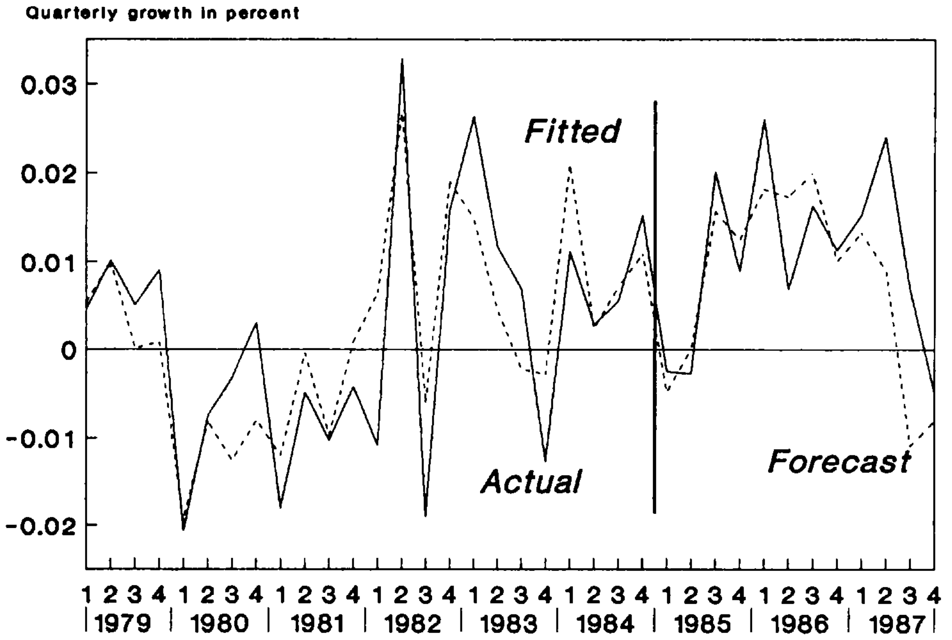
The Dynamic Model for Real Money Growth 1/



Source: Regression (2).

1/ Estimation period is 1979:1 - 1987:4.

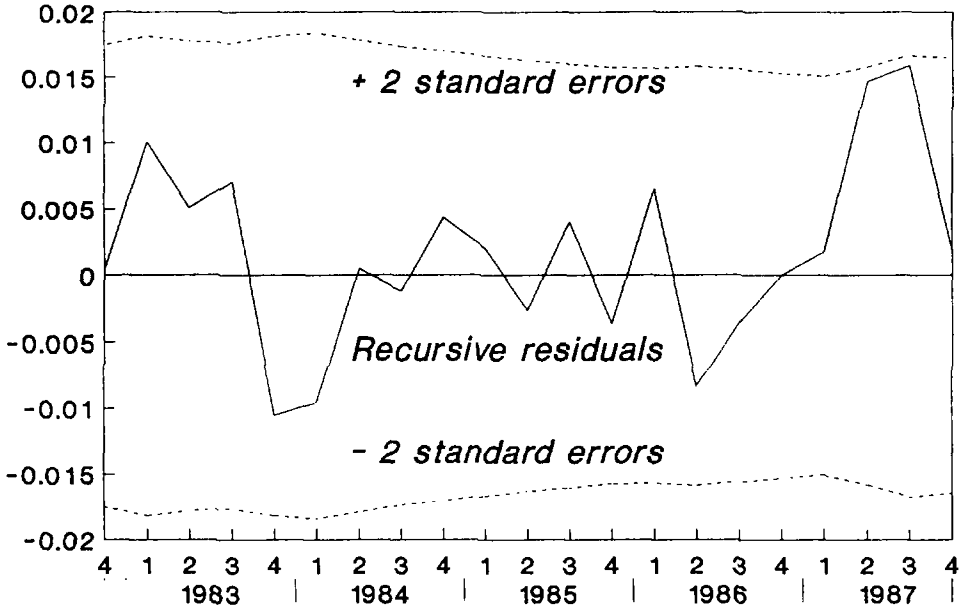
Chart 10
The Dynamic Model for Real Money Growth: Stability 1/



Source: Regression (2).

1/ Estimation period is 1979:1 - 1984:4; conditional forecast period is 1985:1 - 1987:4.

Chart 11
The Dynamic Model for Real Money Growth:
Stability of the Standard Error 1/



Source: Regression (2).

1/ This chart depicts the sequence of estimated equation standard errors and one-step residuals obtained by successively extending the sample by a single observation from 1979:1 - 1982:4 to 1979:1 - 1987:4. These residuals consist of the last residual of each of the successive regressions; if they are to be normally distributed with zero mean, they must be close to zero and 95 percent of them must lie within the band delimited by two estimated standard errors.

elasticity of unity, cannot be rejected (the F-test of this restriction is 1.39 against a 5 percent critical value of 2.73). The coefficient on EC_{t-1} embodying disequilibrium feedback is large compared with estimates found in earlier econometric work on individual countries; it implies, for instance, a mean lag of about one month in the response of real money balances to real income, indicating more rapid adjustment at the ERM level than is usually found at the national level. 1/

V. Conclusion

These results are of interest at two levels. First, they shed light on the nature of money demand in European countries. The results are consistent with the view that demand for narrow money is essentially a demand for a transactions medium, holdings of which can be varied at short notice. This view is supported by the role of the short-term interest rate as well as by the rapid adjustment speed implied by the estimate of the error correction coefficient. The latter result is also important because of arguments that the slow adjustment implied by many single-country money demand estimates are theoretically implausible (Laidler (1982), Lane (1990)), and may reflect errors in econometric specification (Goodfriend (1985)). The apparently superior performance of ERM-aggregate money demand estimates may, as argued in Section 2 (and in more detail in Kremers and Lane (1989)), provide some evidence suggestive of currency substitution in the demand for narrow money in Europe. 2/

The results also have policy implications, in connection with recent proposals for Economic and Monetary Union in Europe. The finding that, even at the present stage of European economic and financial market integration, a well-specified ERM-wide demand for money can be identified, is striking: it suggests that monetary policy guided by money supply targets would, at least in principle, be feasible for the ERM countries collectively. With further steps toward the establishment of a single economic and financial area within the European Community in the context of the 1992 Internal Market Program, the coherence of monetary behavior within this quasi-currency area would likely be further enhanced. Moreover, the fact that the ERM-wide money demand equation implies a faster adjustment speed than most single-country

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1/ For example, Hendry (1985) finds a value of the error 0.10 for the United Kingdom, and Baba et al. (1987) find a value of 0.14 for the United States. Buscher (1984), working in a partial adjustment framework, found a mean lag of 4-6 months for Germany. These studies are based on national definitions of M1.

2/ Stable individual country demand functions with similar parameter values in different countries could give rise to a stable aggregate demand function, but would not imply an aggregate equation whose performance was actually superior to that of the individual equations. The latter result would only occur if there were some specification error that could be reduced by working at the aggregate level.

estimates may strengthen the case for formulating monetary policy at the European level, not only because is suggests that the aggregate estimates may be better specified than the the single-country ones, but also because long lags may complicate the formulation and implementation of policy. Further examination of the evidence is clearly necessary before any firm conclusions can be advanced, but the results presented here are suggestive: they indicate the possibility that a European central bank could, in principle, implement monetary control more effectively than the individual national central banks.

Appendix A: The Model of Bekx and Tullio

Bekx and Tullio (1987) estimated a model of the demand for nominal money in the ERM that included the conventional variables: the price level, real GNP, and the level of long-term interest rates (denoted RL_t). They also included the deviation from purchasing power parity of the ERM exchange rate vis-à-vis the U.S. dollar (i.e., the real exchange rate defined as the consumer price level in the ERM relative to that in the United States corrected for changes in the nominal exchange rate of the ECU--excluding the United Kingdom and Luxembourg--vis-à-vis the U.S. dollar) this variable (denoted ecu_t) is intended to capture currency substitution effects (a large value of ecu_t indicates strength of the ECU). As noted in the main text, its behavior over the sample period is very similar to that of the nominal exchange rate used in the error correction model.

The replication of the static money demand function of Bekx and Tullio, estimated over a longer sample period, is:

$$m_t = \underset{(1.60)}{-4.66} + \underset{(0.06)}{1.28}\, p_t + \underset{(0.22)}{0.70}\, y_t - \underset{(0.17)}{1.57}\, RL_1 + \underset{(0.22)}{0.11}\, ecu_t \qquad (3)$$

T = 1978:4-1987:4 $\quad R^2 = 0.998 \quad \hat{\sigma} = 1.21$ percent

$AR(8)_1^8$=10.32 (15.51) $AR(4)_1^4$=5.34 (9.49) $AR(1)_1^1$=3.47 (3.84)

NORM(2)=0.72 (5.99) HET(8,23)=0.80 (2.37) ARCH(4,24)=0.86 (2.78)

CHOW(12,20)=2.45* (2.28) CHOW(4,28)=4.09* (2.71)

Several features are noteworthy. All coefficient estimates have the expected signs. However, given that the coefficient on the price level is significantly larger than unity, this specification rejects homogeneity in the price level. The elasticity of money demand with respect to real GNP is not significantly different from unity (although the estimated standard error is large). Turning to the misspecification tests, it appears that the Chow tests for parameter stability over the last one and three years of the sample are failed, indicating that the money demand function is unstable. This invalidates the inferences on individual parameter estimates, since these turn out to be based on a misspecified model.

Appendix B: Data Sources

All data are quarterly (unless noted otherwise) and taken from the International Monetary Fund, International Financial Statistics (IFS).

Money	Narrow money (M1) (IFS, line 34)
Income	Germany: GNP in 1985 prices (IFS, line 99a.r). France, Italy: GDP in 1985 prices (IFS, line 99b.r). Belgium, Netherlands: GNP in 1985 prices (IFS, line 99a.p). Denmark, Ireland: GDP in 1985 prices (IFS, line 99b.p).

Industrial production (used for quarterly interpolation of GNP/GDP)

Belgium, Ireland (IFS, line 66..b).
Denmark, Netherlands (IFS, line 66..c).

CPI — Consumer price index (IFS, line 64).

Short-term interest rate

Money market rate (IFS, line 60b).

Long-term interest rate

Government bond yield (IFS, line 61)

Exchange rate

Computed via U.S. dollar rate (IFS, period average).

Appendix C: Test Statistics

This Appendix contains brief descriptions of the reported diagnostic tests, with degrees of freedom in brackets. Further background on these tests can be found in Hendry (1989). In the text, each reported statistic is followed (in brackets) by its 5 percent critical value, and starred (*) if the test is failed.

Autocorrelation

$AR(n)_1^j$ — Lagrange Multiplier test for residual autocorrelation from lags i to (j-i+1=n), χ^2 form. Computed by regressing the residuals on all the regressors of the original model and the lagged residuals for lags i to j, and testing the joint significance of the latter.

Normality Residuals

NORM(2) — χ^2 -test. Based on the estimated skewness and kurtosis of the residuals compared to their counterparts for the normal distribution.

Heteroscedasticity

HET(.,.) — Lagrange Multiplier test for heteroscedasticity associated with squares of the explanatory variables. Computed by regressing the squared residuals on the original regressors and all their squares and testing their joint significance.

ARCH(n,.) — Lagrange Multiplier test for n-th order Autoregressive Conditional Heteroscedasticity, F-form. Computed by regressing the squared residuals on the lagged squared residuals up to lag n and testing their joint significance.

Parameter Constancy

CHOW(n,.) — Chow test for parameter stability over the last n observations of the current sample.

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