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Currency Substitution in European Financial Markets

MICHAEL J. ARTIS

EUI Working Paper RSC No. 95/34

European University Institute, Florence

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Introduction

That currency substitution exists in European financial markets might, at one level, seem obvious. The Bank for International Settlements (BIS), in its *International Banking and Financial Market Developments*, regularly publishes data on the holdings of bank deposits by non-bank residents of European countries denominated in domestic currency but held abroad or denominated in foreign currency, whether held with domestic or with foreign-sited banks. Such "cross border deposits" may surely be regarded as potential "currency substitution" deposits. Expressed as a proportion of domestic money supplies, such deposits grew very fast for most of the major European countries during the period of the "New EMS", between the late '80s (as capital controls were phased out) and the early '90s. For example, in France, the proportion rose from 2.5% at the end of the first quarter of 1987 to 6.45% by the end of the second quarter of 1992; comparable figures for Germany, Italy and the Netherlands involve growth from 7.6 to 15.3%; from 1.92 to 7.82%; and from 33.61 to 54.93%, respectively. In the case of the United Kingdom there was a slight fall, from 16.83 to 15.04%. (The domestic money supply definitions used here are: M3 for France and Germany; M2 for Italy and the Netherlands; M4 for the United Kingdom). Of course, not all of these cross Border deposits could represent potential substitutions between *European* currencies of denomination - indeed a large, if not the greater part, of foreign currency-denominated deposits are in dollars; the published BIS data do not give the full details of currency of denomination which would allow us to determine what proportion represents intra-European currency substitution. Nevertheless, there is a clear presumption that the proportion of such deposits is both large and growing.

That large amounts of bank deposits, relative to conventionally defined money supplies, are held abroad or in currencies of non-domestic denomination is not enough, however, to determine that there are policy problems associated with currency substitution which are of substantial magnitude for European policy-makers. It need not follow that such deposits render domestic demands for money, conventionally defined, unstable or that they seriously undermine the implementation of monetary policy in Europe. It might be possible, for example, to relate the growth of such deposits simply to the evolution of trade and to determine that they have relatively little potential for destabilizing behaviour; it might be that they should be regarded as indicative of diversification rather than substitution.

It is, however, concern for precisely such a destabilizing potential which has guided much of the empirical work in this area. In particular, much the greater part of the extant literature reviewed below has been concerned with

what might be termed an 'indirect' approach to the existence of currency substitution. This approach has sought to establish the existence and stability of a European-wide money demand function in implicit (or explicit) contrast to the behaviour of money demand functions at the national (especially German) level. This line of investigation could be said to amount to a strategy for implementing the insight of Ronald Mckinnon in this area (see e.g. Mckinnon, 1982). Currency substitution causes observed instability in domestic money demand functions. Errors in domestic money demand functions are negatively correlated due to their origin in currency substitution, whilst aggregation to a higher (global or subglobal) level internalizes currency substitution shocks and presents the opportunity to measure - and for policy-makers to rely on - a stable money demand function at this level. (It is implicit that currency substitution terms in domestic money demand functions are difficult to estimate). The strategy is obviously highly complementary to the conception of the formation of a monetary union in Europe since, in the limit, currency substitution would, on this argument, render an area-wide monetary policy optimal. EMU would, so to speak, be a market-driven phenomenon.

A second line of empirical investigation follows a further insight of McKinnon's, viz., that in the presence of currency substitution, the area aggregate will be more relevant than the individual national monetary aggregates to the determination of prices in the area. Causality studies have been used to test this proposition.

A third line of investigation, which we term here the 'direct' approach, has attempted to deploy the analytical insights of other writers on currency substitution. Partly for reasons of lack of data, one suspects, the volume of recent literature in this area is very thin - amounting essentially to two published papers by Mizen and Pentecost (1994) and by Milner, Mizen and Pentecost (1996).

The subject area of currency substitution is a controversial and sometimes confusing one (see Giovanninni & Turtelboom (1993) for a pithy comment to this effect.). It comprises, on the one hand, some very tightly specified theoretical models in the 'New Monetary Economics' tradition where, however, the major difficulty presented is the apparent distance between the theory model and the empirical and policy interpretation[1]; whilst, on the other hand, there is a volume of more loosely formulated analysis which seems to have more direct policy and empirical implications. In other words, analysts do not always appear to agree on what "currency substitution" means or how it could be recognized

[1] Cf. Canzoneri et al (1993) who frankly state that "the state of monetary economics nowadays is such that the trip from the policy questions to the theory and back tends to leave the traveller too tired at the end of it" (*ibid.* p. 330).

in practice. In the present context, it is especially important to note that some of the findings we review are susceptible of alternative interpretations to the one that they necessarily represent the effects of currency substitution; though, for all that, they may still have far-reaching implications for monetary policy.

In what follows, then, we first review the line of work which can be thought of as seeking indirect evidence of the existence of currency substitution - the estimation of area-wide money demand functions. We incorporate a new estimate of our own in this review. In the following section we then consider the evidence from corollary causality studies regarding the significance of area-wide money aggregates for prices and inflation. In the third section we advert to direct studies of currency substitution in Europe. A final section provides some conclusions.

Indirect evidence of currency substitution

Area-wide money demand estimates

The motivation for conducting area-wide money demand estimation is worth rehearsing and elaborating. Essentially, the idea is that currency substitution will result in instability in national money demand functions, but that this source of instability can be internalized by aggregating up to a suitable global or sub-global level. Thus, the first requirement is that it should be possible to obtain stable area-wide money demand functions, in which this internalization has taken place. Problems of instability in national money demand functions are a 'stylized fact' of the 1980s, so it seems correspondingly bold to assume that stable estimates can be recovered simply by aggregation.

A very useful review of EC-wide money demand estimation has already appeared in Van Reit (1993); so the function of this section is to update that work. In addition, we are able to present here a further estimate of our own, updating that of Artis et al (1993). It is helpful to introduce this fresh estimate first, since many of the technical details apply *mutatis mutandis* to the other studies reviewed. Results pertaining to the new estimate appear in Tables 1-3 below, whilst Table 4 excerpts from, and updates, the summary table given in Van Reit (1993).

Aggregation method

Estimation of an area-wide money demand function obviously involves some method of aggregation. For interest rates it is common, as in this new estimate, to aggregate interest rates across the member countries according to ECU-weights; for prices also this weighting is used in Monticelli (1995) although relative GDP/GNP weights - as in the present estimate - are more commonly used. The conversion method applied to the quantity variables -

output and money - is more controversial, ranging from fixed base-date exchange rates (as in the present case where 1990 exchange rates are used), to fixed or continuous PPP exchange rates, to current exchange rates (Monticelli, 1995) for example uses the latter, with a replication on PPP exchange rates).

Aggregation Area

The present estimate covers the original ERM-7 (Luxembourg included), which is relatively standard. However, Cassard et al. (1996) concentrate on a 'core' group of countries (EC(7) minus Italy) whilst Artis et al. (1993) sought to explore the sensitivity of their overall estimate by selectively adding the UK and deleting, individually, France, Germany and the UK. Tullio et al. (1996) also probe the sensitivity of their group estimate to the inclusion of particular countries in this way.

Specification

The specification of EC money demand functions has been strikingly 'simple'; as in the present case, the standard specification relates money to prices, output, interest rates and a trend or a currency substitution term for substitution between the dollar and the Ecu. In the present case this is proxied by the current real $/ECU exchange rate. A dummy variable is included in the current study for the effects of German unification; after 1990 Q2 the series for GDP continues to represent former West Germany whilst the monetary series represent combined Germany. Other recent studies have to attempt to control for this episode also. Money supplies are, variously, M1 (as in this estimate) M2 or M3; in Monticelli (1993 and 1995), measures based on the aggregation of nationally defined money supplies are supplemented by various measures of "cross-border" deposits, drawn from BIS sources[2]. Compared to many national money demand estimates in this period, these specifications are strikingly simple 'text-book' formulations. Only in Cassard et al (1996) do we find even a measured own rate of interest being included in the estimation (Monticelli (1995) also experiments with both short and long rates and their differential, however).

Period of estimation

The present estimate is based on a sample period which starts with the beginning of the ERM (1979 Q2), as do most, and ends in 1992 Q4.

[2] The papers by Giucca and Levy (1992) and by Lane and Poloz (1992) are instructive regarding the definitions and potential significance of cross-border deposits.

Method of estimation

Right from the first estimate listed in Table 4 (due to Bekx & Tullio, 1989), studies of EC-wide money demand have uniformly deployed cointegration methods, either using (as here) the two-step Engle-Granger (1987) approach or, more recently and as in Cassard et al (1995), the one-step Johansen-Juselius (1990) approach. In either case, a prior screening of the data for their order of integration is standard.

The present study

In the present study, the results of this screening are given in Table 1. Here the unit root tests are conducted for three sample periods, beginning in 1979 Q2 but ending in 1988 Q4, 1990 Q2 and 1992 Q4. The top half of the table reports the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests on the levels of log values of the variables shown, whilst the bottom half of the table reports values of the same test statistics for the log difference of the variable in question. With the exception of consumer prices (p), it appears that all the variables shown can be considered as I(1) variables in each of the three periods considered. This goes for real money balances (m1-p) as well as for nominal money (m1 definition), output (y), the long term rate of interest (r) and the real \$/Ecu exchange rate. Prices could be I(2); however, homogeneity of money in prices is an acceptable restriction and we can work with real money balances which appear to be I(1).

The form of equation to be estimated follows that originally set out by Kremers and Lane (1990) and replicated with an updated sample period in Artis et al (1993). The appearance of slavish replication can be justified by the fact that, in replicating, the exercise contributes a genuine ex-ante stability test. The cointegrating equation is to be estimated (in logs) as:

$$(m1\text{-}p)_t = \alpha_0 + \alpha_1 y_t + \alpha_2 ecu_t + \alpha_4 D1 + \alpha_5 D2 + \mu_t$$

The dummy variable D1 is included to control for the effects of data distortion following German unification. From 1990 Q2 the money supply in Germany reflects the unification of former East and West Germany. Measured GDP, however, continues to be that of West Germany alone. The dummy D2 controls for the recent recession, which was unusually deep; this dummy seems to be necessary to remove serial correlation from the residuals. An appendix lists variable definitions and aggregation procedures.

The Results

The results are shown in Table 2; the estimation period is 1979 Q2-1988 Q4 in the first panel of this table, where in the second and third, first eight and then sixteen more quarters of data are added. The effect of including the \$/ECU

exchange rate and the two dummy variables is illustrated in versions B, C and D of each equation. The estimated coefficient values for income and the rate of interest are correctly signed, reasonable in value and stable across estimation periods. Table 3 provides the corresponding diagnostic tests. This table makes clear that in the first and second estimation periods the inclusion of the 'ECU' term (as in equation version B) is necessary to remove serial correlation; for the full period, versions C and D introduce additionally the two dummy variables. The presence of both is needed to ensure an absence of problems of serial correlation. All the equations have residuals which are stationary and all represent valid cointegrating vectors. In this study, we employ the Engle-Granger two-step procedure rather than the Johansen-Juselius (1990) approach; using the residual from the preferred equation 3D as the error correction term, the corresponding second-stage dynamic equation is

$$\Delta(m1\text{-}p)_t = .2093\ \Delta(m1\text{-}p)_{t-1} + .2500\ \Delta(m1\text{-}p)_{t-2} + .6091\ \Delta y_t - .0701\ \Delta r_t - .6968\ \hat{\mu}_{t-1}$$

(.1155) (.1058) (.2045) (.0266) (.1353)

Period: 79Q2-92Q4 $\bar{R}^2 = .4195$ D-W = 1.977 $\hat{\sigma} = .878$

Diagnostic
:

AR[1] = .01 (3.84) AR[4] = 2.48 (9.49) AR[8] = 5.78 (15.51)
NORM[2] = 5.68 (5.99)
HET[1] = .22 (3.84)
FORM[1]=1.39 (9.49)

Note 1. The figures in brackets in the ECM equation are standard errors.
Note 2. The figures in brackets in the diagnostics are the 95% critical values.

This equation shares with our previous estimate of an ECM for European money demand (Artis et al., 1993) a relatively high speed of adjustment and has a somewhat lower standard error. There are no additional dummies or other variables incorporated at the second stage.

Discussion

How do these results compare with earlier ones? Are there general conclusions that can be drawn from studies of area-wide money demand?

Table 4 incorporates the present estimate with other recent estimates in a version of Van Reit's (1993) Summary Table (where space constraints compelled us to delete some of Van Reit's original entries)[3].

The estimates shown in the table yield certain dominant impressions. First, the specifications are of strikingly simple, text-book form; second, the coefficient estimates are reasonably stable between studies and time periods, with 'correct' signs and plausible values. That stable cointegrating equations of a relatively simple kind should be found to characterize area-wide money demand has itself some "surprise value". It is, one can say, quite arresting. These are the - substantial - positive factors. There are a number of qualifications to be made, however, which are hardly less substantial. First, virtually every study except that by Cassard et al. (1996) - [5] in Table 4 - incorporates what is labelled in the table "a currency substitution term". In Kremers and Lane (1990), the earlier study by Artis et al. (1993) and the present one, the level of the $/ECU rate is used (nominal in the first case, real in the other two) to represent currency substitution ; but it is in fact difficult to consider it as such. Moreover, the term is very important - in the present study, as the results given in Table 3 show, it is crucial to the good diagnostic performance of the equation. One may hazard that the not-dissimilar term in Tullio et al. (1996) and the trend and partial trend terms appearing in Monticelli's estimates (reported in Table 4 as [4] and [7]) are picking up the same effect - whatever it is. Only the Cassard et al estimate is free from the criticism that the performance of the equation depends on difficult-to-explain "currency substitution" or trend terms. Also in the critical vein it must be noted that the results seem to hold for a variety of alternative aggregation procedures, varying from the case of current exchange rates to the use of fixed-base PPP exchange rates. The seeming robustness of the results to this wide variety of aggregation procedures might seem at least as unsettling as it is reassuring. Table 4 also demonstrates a wide variety in the range of countries incorporating in the aggregate: it may be telling that the Cassard et al. study, which is for the ERM "core", is the only one that proceeds without the inclusion of trends or "currency substitution" terms. A final point that might be held to militate against the interpretation of these results as clear evidence of currency substitution is the fact that the aggregation of national money supplies does *not* in fact internalize

[3] The table omits to present any estimates drawn from Monticelli (1995) which provides results for the period 1979/1 to 19992/1 for a wide variety of money-definitions (including Divisia) and specifications (buffer stock models are estimated alongside more conventional formulations) and for a large country-grouping (all EU countries except for Portugal, Greece and Luxemburg which were excluded for data reasons). At least for the wider monetary magnitudes, the evidence of stable cointegrating equations and robust correspondent dynamic models is strongly reinforced by this study.

currency substitution deposits. For the most part these are omitted from the national aggregates or are only partially incorporated (new M3 'harmonized' figures include some such deposits on a comparable basis). When cross border deposits of various definitions are included in the estimation, it appears that the overall performance of the resultant equation is weakened, not strengthened: Monticelli's (1993) study provides exhaustive evidence to this effect[4].

Thus the results of the effort expended so far on area-wide money demand estimation leave an overall impression of ambiguity. However, even on a favourable interpretation of the issues of specification raised above, it is clear that the success of aggregation does not necessarily imply that currency substitution *per se* is what accounts for it. More work remains to be done, especially with the cross-border deposit data, to establish this.

Causality Studies

Corresponding to the insight that an area-wide monetary aggregate might, by internalization, prove more stable than national money demand functions is the insight that such an area-wide aggregate might also prove more relevant to the causation of inflation in particular national economics than the corresponding national aggregates.

In the European context causality studies have been undertaken to test the validity of this insight: these include the papers by Bayoumi and Kenen (1993), Monticelli (1993) and Cassard et al. (1996).

In the first of the papers mentioned, Bayoumi and Kenen report the results of Granger causality tests and of tests based on estimating cointegrating vectors. The Granger causality tests pit ERM money supply against national money supplies in the prediction of national price levels in each of the ERM countries (the original ERM-7, excluding the UK, Spain and Portugal). It turns out that the ERM money supply growth is a more frequently sigificant predictor (in 5 out of 7 cases) of inflation than is domestic monetary growth (3 out of 7); in particular, the ERM aggregate is a significant predictor for each of the major ERM member states (France, Germany and Italy). By contrast, the ERM money supply is not significant for either the UK or Spain. Trivariate (m,p,y) cointegrating vectors are estimated following the Engle-Yoo (1987) three-step procedure, with m defined as either ERM-wide or national in scope, for each of the ERM-7 economies. The results are quite striking in that the ERM money supply has the expected positive sign for six out of seven countries and is significant in all but one of these cases; domestic money supplies produce the

[4] This is not conclusive evidence *against* currency substitution either: the prediction that it should be easier to recover stable estimates of money demand at the aggregate level still holds even if not all currency substitution deposits are internalized by the aggregation.

expected positive sign in only four cases, though all four are significant. Monticelli (1994) also employs Granger-causality tests with VARs in log differences of p,y,m and y + p augmented by trend terms and the ECM terms from the corresponding cointegrating regressions. He finds strong evidence of Granger causality for area-wide monetary aggregation in respect of national price levels. In Cassard et al (1996), Geweke's linear feedback (Geweke (1992) measure is used instead of Granger causality. Two sample periods are distinguished as 1979 Q1-1990 Q2 and 1983 Q1-1990 Q2; the former includes the "crawling peg" phase of the EMS. In the first sample period there is significant linear dependence of French inflation on French, but not on German, monetary growth; and of German inflation on German (but not on French) monetary growth. In the second sample, for each of the two countries, not only domestic monetary growth but also that in the other country and in the rest of the ERM is shown to be highly significant for inflation.

Direct tests for currency substitution

Few recent studies can be found which are devoted directly to the estimation of currency substitution effects. If one reason is the comparative lack of appropriate data, the other may be problems of specification. Indeed, it is arguably implicit in much of the line of work discussed above that it will be very difficult, if not impossible, for econometricians to capture the effects of currency substitution at the national level: hence the emphasis on estimating the area-wide money demand function. This may not be an unreasonable hypothesis: a world of widespread currency substitution would be one in which it would be very easy, at little or no cost, to shift from one currency to another. The provocation for such shifts may hardly be discernible in the data; the portfolio shifts, however rational from the individual's point of view, might appear to the outsider to be somewhat capricious[5]. But these considerations may be entirely premature and there are quite enough difficulties with the indirect approach to warrant attempting to estimate currency substitution effects directly. This can be done, either using conventional money stock data whilst allowing for a CS term in the specification of the demand for it or, better still, by focusing directly on

[5] Artis & Lewis (1991) suggest an analogy in which apples and pears are such close substitutes that buyers - who by hypothesis just want "fruit" - would substitute their purchases from one to the other on the mere suggestion of minor blemishes in the appearance of one of the two fruits. (Ibid. pp. 254-255).

the explanation of cross-border or what we have termed here "potential currency substitution" deposits.[6]

The study by Mizen and Pentecost (1994) - hereafter MP - exploits both types of data, which are however limited to sterling-denominated deposits. Thus MP study both the demand by non-residents for sterling (where non-resident holdings are known in detail for each of seven European countries - the original ERM seven group) and the demand for M1 in the UK. The former is studied with the aid of a model originally proposed by Bergstrand and Bundt (1990). The specification has $\ln(M_F/P) = \alpha_0 + \alpha_1 r + \alpha_2 \ln Y_F + \alpha_3 r_F$ where M_F is the foreign demand for £-denominated money, Y_F is the level of income in the foreign country, and r and r_F are the rate of interest in the UK and in the foreign country, respectively; expected coefficient signs are $\alpha_1 < 0$; α_2 , $\alpha_3 > 0$. This specification corresponds to the model of direct currency substitution described in Artis and Lewis (1991), where a top level decision is made first about the division of wealth between money and bonds, and a subsequent decision is taken about the division of money (and bonds) between currencies of denomination. The money services production function model suggests that an optimum distribution of the money holding between the alternative currencies of denomination is reached when the 'marginal product' is equal to the rental cost - the latter represented by the associated rate of interest. MP find no support for this model on their data set. No cointegrating vector can be identified, whilst point estimates of the interest rates elasticities are of the wrong sign, though mostly insignificant.

MP's alternative model starts from Cuddington's (1983) portfolio balance model adjusting the variables specification in the light of preliminary results. The basic model is given as $\ln(M_D/P) = b_0 + b_1 r_t + b_2 (r^* + x) + b_3 x_t + b_4 \ln Y_t + v_t$ where x is the expected rate of depreciation of the exchange rate, initially identified with the forward discount and subsequently with the relative inflation differential. The former identification is conceptually problematic since in the presence of covered interest parity (CIP) $(r^* + x)$ is expected to equal r and the two terms would cancel out. Moreover, CIP is widely recognized to be a basic trading arbitrage condition that can be expected to hold identically on the appropriate data set and does in fact do so (Taylor, 1987). However, the forward discount is known not to be a good estimate of x in practice and its replacement by the relative inflation differential (MP assume perfect foresight over this) could be justified on these grounds alone (although MP prefer to regard the

[6] Cross border deposits, as normally defined, include not only deposits denominated in foreign currency but also delocalized deposits - deposits of domestic currency of denomination held at foreign-sited banks. Currency substitution is centrally concerned with the former category of deposit, though delocalized deposits might prove a close substitute.

replacement as a model amendment in the direction of incorporating a transactions motive). However this may be, the result of applying this model to the M1 data, with seven alternative foreign partner countries, cannot be said to be encouraging for the CS view. The inflation differential term carries the wrong sign in every case and it does not seem possible to establish valid cointegrating vectors: whilst MP proceed to the second stage and provide estimates of the dynamic equation the EC terms there are uniformly insignificant.

Milner, Mizen & Pentecost (1996) adapt a model of Ratti and Jeong (1994) to investigate currency substitution; the ratio of domestic money to resident holdings of sterling-denominated deposits among the ERM-7 countries forms the explicand. The net bilateral trade balance and real exchange rate appear as regressors, together with relative interest rates and expected depreciation. For a subset of the countries concerned the estimation results suggest the existence of a long-run cointegrating relationship and an error-correction dynamic model. To this extent, the results support the existence of currency substitution.

Conclusions

The hypothesis of demand-side currency substitution has led to the construction of some challenging hypotheses: for example, that an ERM-wide money demand function would be more stable than the national money functions; and that the area-wide money supply might be more important for national price and inflation than traditional national money supplies. Econometric analysis has indeed gone some way to establishing that both these hypotheses are supported by the data. This is at first sight strong support for the CS hypothesis. However, this evidence is susceptible of alternative interpretations. In an exchange rate union which is also a customs union goods market integration is likely to mean that demand conditions in member country x have added relevance for prices in member country y. Thus, money in country x might very well be a good predictor of prices in country y, without any implication of currency substitution. The first of the hypotheses mentioned is perhaps less well-established than the second: the specifications of the area-wide money demand functions, though apparently appealing and "simple", also incorporate some dubious components. The aggregation may spuriously promote the appearance of stability; the implied test for CS is, in the end, an indirect

one[7]. Casual empiricism provides only muted support for the view that CS is an important feature of European finances. Direct tests for CS reinforce a feeling of scepticism in that they fail to give any strong evidence of CS between the European currencies. This is not to deny that there are still strong policy implications in the findings, for there are; it is to inject some caution into the assumption that CS is the explanation - or dominant explanation - of those findings.

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[7] Moreover, strict pursuit of the logic of the approach involved is quite persuasive that it will lead to a dead-end. If one requirement of the approach is that it should be possible to locate a stable area-wide money demand function, the other is that national money demand functions should be shown to be unstable. But with the resources of modern econometrics the latter can be hard to do. Failure of 'simple' (m,p,y,r) demand functions leads to the search for more complicated ones, a search that is usually successful (although, of course, failures tend not to be reported).

Table 1. Unit root tests

	Period: 79Q2-88Q4		Period: 79Q2-90Q2		Period: 79Q2-92Q4	
	AD[Z]	$ADF_{.1}$[Z]	DF[Z]	$ADF_{.1}$[Z]	DF[Z]	$ADF_{.1}$[Z]
m1	-1.33	-1.55	-1.70	-1.39	-0.26	-0.12
p	-1.03	-1.80	-3.14	-2.77	-4.99*	-3.44
y	-0.19	-0.13	-0.36	-0.50	-1.57	-1.97
r	-3.09	-2.89	-1.70	-1.98	-1.72	-2.02
ecu	-0.83	-1.40	-1.11	-1.74	-1.66	-2.19
m1-p	-2.11	-2.55	-2.44	-2.90	-3.11	-3.28
	Period: 79Q2-88Q4		Period: 79Q2-90Q2		Period: 79Q2-92Q4	
	DF[DZ]	$ADF_{.1}$[DZ]	DF[DZ]	$ADF_{.1}$[DZ]	DF[DZ]	$ADF_{.1}$[DZ]
m1	-5.39**	-4.11*	-6.84**	-4.46**	-7.42**	-4.66**
p	-3.50*	-3.60*	-2.88	-2.64	-2.72	-2.31
y	-7.01**	-5.96**	-7.62**	-6.34**	-6.58**	-4.33**
r	-3.67*	-3.72*	-3.86*	-3.60*	-4.39**	-4.17**
ecu	-4.21**	-3.50*	-4.52**	-3.66*	-5.22**	-4.40**
m1-p	-4.98**	-3.79*	-5.88**	-3.87*	-5.80**	-3.59*

Note 1. Significant at 1% level (**) and 5% level (*): Fuller (1976, 373).
Note 2. $ADF_{.1}$ denotes the ADF test with one lag of the dependent variable.
Note 3. The test statistics are computed for the level [Z] and first difference [DZ] in a regression including a constant, time trend and the first lag.

Table 2. Aggregated money demand equations

Equation	Period	constant	y	r	ecu	D1	D2	$\bar{R}^2$	D-W	$\hat{\sigma}$
1A	79Q2-88Q4	-7.125	1.076	-.174	--			.996	.48	1.65
		(.751)	(.096)	(.022)						
1B	79Q2-88Q4	-7.771	1.164	-.145	0.066			.986	1.38	1.05
		(.487)	(.063)	(.015)	(.009)					
2A	79Q2-90Q2	-8.472	1.249	-.141	--	--		.976	.54	1.69
		(.414)	(.054)	(.017)						
2B	79Q2-90Q2	-8.325	1.236	-.129	.070	--		.990	1.44	1.07
		(.263)	(.034)	(.011)	(.009)					
2C	79Q2-90Q2	-8.035	1.198	-.138	.068	.028		.991	1.45	1.01
		(.276)	(.036)	(.011)	(.008)	(.011)				
3A	79Q2-92Q4	-9.190	1.342	-.120	--	--	--	.985	.54	1.68
		(.237)	(.031)	(.014)						
3B	79Q2-92Q4	-8.634	1.277	-.118	.074	--	--	.994	1.27	1.09
		(.167)	(.021)	(.009)	(.009)					
3C	79Q2-92Q4	-8.009	1.196	-.137	.068	.019	--	.994	1.30	1.03
		(.280)	(.036)	(.011)	(.008)	(.007)				
3D	79Q2-92Q4	-8.016	1.196	-.137	.069	.022	-.014	.995	1.46	1.00
		(.272)	(.035)	(.011)	(.008)	(.007)	(.007)			

Table 3. Diagnostic tests

	Cointegration			Serial correlation			Normality	Heteroscedasticity	Functional form	Stability	
Equation	DF	$ADF_{.1}$	$ADF_{.2}$	AR[1]	AR[4]	AR[8]	NORM[2]	HET[1]	FORM[1]	CHOW[n1, n2]	CHOW[n1,n2]
1A	-2.52 (-3.97)	-2.17 (-3.98)	-2.07 (-3.99)	22.12**	26.09**	27.06**	2.03	2.28	17.45**	.65 [5, 36]	.92 [3, 38]
1B	-4.62 (4.40)	-4.43 (-4.41)	-4.56 (-4.56)	3.32	9.32	14.94	2.85	.17	3.20	.35 [5, 35]	.16 [4, 36]
2A	-2.87 (-3.94)	-2.45 (-3.94)	-2.49 (-3.95)	20.28**	23.26**	23.57**	.49	.42	18.30**	.96 [10, 42]	3.16* [3, 46]
2B	-5.17 (-4.36)	-4.54 (-4.36)	-5.10 (-4.37)	1.93	7.57	10.35	1.88	.06	2.64	1.22 [10, 41]	2.53* [4, 47]
2C	-5.27 (-4.74)	-4.87 (-4.75)	-5.03 (-4.76)	2.73	7.85	10.62	2.61	1.72	3.29	1.10 [10, 40]	n.a.
3A	-3.73 (-3.90)	-3.30 (-3.91)	-3.40 (-3.91)	24.60**	26.96**	27.85**	1.42	3.03	12.85**	n.a.	n.a.
3B	-5.38 (4.31)	-4.55 (-4.31)	-5.07 (-4.31)	5.96*	11.52*	16.26*	1.76	.22	.12	n.a.	n.a.
3C	-5.28 (-4.68)	-4.54 (-4.68)	-4.57 (-4.69)	5.86*	9.93*	15.46	2.17	.06	1.79	n.a.	n.a.
3D	-5.80 (-5.03)	-5.11 (-5.03)	-5.20 (-5.04)	3.53	8.26	13.74	1.83	1.03	.07	n.a.	n.a.

Note 1. "*" indicates significance at 5% level; "**" indicates significance at 1% level.
Note 2. The 95% critical values for testing cointegration are reported in brackets; $ADF_{.1}$ and $ADF_{.2}$ indicate the ADF test with one lag and two lags of the dependent variable respectively.
Note 3. The first CHOW is a test of adequacy of predictions; the second CHOW is a test of stability of the regression coefficients.
Note 4. The test statistics of the Lagrange multiplier version for serial correlation, normality, heteroscedasticity and functional form are reported.
Note 5. F-statistics for the test of stability are reported.

Table 4 Overview of EC demand for money studies
Characteristics and long-run parameters

Authors	Money concept	Group of countries	Aggregation method[1]	Estimation period	Price level[2]	Real income	Short-term interest rate[3]	Long-term interest rate[3]	Rate of inflation	Currency substitution[4]	Trend[5]	Error correction parameter	Standard error[6]
[1]	M1	EMS-7	er-1979	3/78--4/86	0.42	0.91	-	-1.00	-	1.00	-	-	-
[2]	M1	EMS-7	PPP-1985	4/78--4/87	1	1.00	-0.67	-	-1.40	0.08	-	-0.95	0.82
[3]	M1	EMS-7	er-1980	2/79--2/90	1	0.99	-	-1.21	-	0.09	-	-0.73	1.17
	M2	EMS-7	er-1980	2/79--2/90	1	1.20	-	-0.70	-	0.03	-	-0.38	0.52
[4]	M3	EMS-9	er-1987	1/79--4/89	1	1.53	-0.65	-	-	0.02	0.26	-0.34	0.35
	M3	EMS-9	er-curr.	1/79--4/89	1	1.33	-0.66	-	-	0.01	0.43	-0.37	0.52
	M3	EMS-9	er-curr.	1/77--3/90	1	1.29	-0.72	-	-	0.02	0.46	-0.44	0.50
[5]	M3	EMS-6[7]	PPP-curr.	2/79--2/90	1	1.48	-	-0.10[8]	-	-	-	-0.10	0.54
[6]	M1	EMS-7	er-curr.	2/79--2/89	1	1.08	-1.16	-	-	-0.13	-	-0.47	0.60
	M3	EMS-7	er-curr.	2/79--2/92	1	1.26	-0.68	-	-	-0.09	-	-0.25	0.35
[7]	M3	EC	ec-curr.	1/79--1/92	1	1.25	-0.49	-	-	-	n.a.	-0.55	0.47
[8]	M1	EMS-7	er-1990	2/79--4/92	1	1.20	-	-0.14	-	0.07	-	-0.70	0.88

Authors:
[1] = Bekx and Tullio (1989)
[2] = Kremers and Lane (1990)
[3] = Artis et al. (1993)
[4] = Monticelli and Strauss-Kahn (1993)
[5] = Cassard et al. (1996)
[6] = Tullio et al. (1996)
[7] = Monticelli (1993)
[8] = present study

Notes:
1. er = exchange rate.
2. Other than in (1), homogeneity is imposed.
3. Except for [8] where the coefficient is an elasticity, the estimates are semi-elasticities.
4. In [1] = long term interest differential US - EMS-7; in [2] = $/ECU exchange rate; in [3], [8] = real $/ECU exchange rate; in [4] = change in $/ECU rate; in [6] = $/ECU deviation from PPP.
5. In [4] = a segmented trend and in [7] - a segmented and complete trend.
6. Standard error from ECM x 100.
7. EMS-7 minus Italy.
8. Long rate minus own rate.

Appendix. Weights of aggregation

Weights of aggregation

Variable	Country /Exchange rates		Weights /Exchange rates
M1 and Y	Change to US$ at 1990 exchange rates		
	DM/US$		1.6157
	FF/US$		5.4453
	IL/US$		1198.1
	NG/US$		1.8209
	DK/US$		6.1886
	BF/US$		33.418
	IP/US$		.60459
P	National GDP weights at 1990 US$ exchange rates		
	Germany		34.287%
	France		26.934%
	Italy		24.661%
	Netherlands		5.896%
	Denmark		2.932%
	Belgium		4.280%
	Ireland		1.011%
ECU & R	Germany	0.6242 DM	37.614%
	France	1.332 FF	23.816%
	Italy	151.8 IL	12.336%
	Netherlands	0.2198 NG	11.752%
	Denmark	0.1976 DK	3.109%
	Belgium	3.431 BF	9.996%
	Ireland	.008552 IP	1.377%

There are seven ERM exchange rates, which are measured against the US dollar. They are denoted in the table as the Deutsche mark (DM/US$), the French franc (FF/US$), the Italian lira (IL/US$), the Netherlands guider (NG/US$), the Danish krone (DK/US$), the Belgian franc (BF/US$) and Irish punt (IP/US$).

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