A note on the European Monetary System, and the Determination of the DM-dollar Exchange Rate

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Cette note présente quelques tests de l'approche monétaire de la détermination du taux de change pour le DM-dollar sur la période 1978-1986.
Il est démontré que :
- un changement institutionnel majeur comme la création du Système Monétaire Européen (SME) en 1979 a fondamentalement changé les déterminants du taux de change DM-dollar et doit donc être pris en compte dans l'explication de celui-ci;
- les déterminants du taux de change DM-dollar doivent être aggrégés pour l'ensemble des pays du SME pour une meilleure explication des mouvements de ce taux;
- le pouvoir explicatif de l'équation du taux de change augmente si on tient compte de la substitution de monnaies des pays du SME dans les fonctions de demande de monnaie sous-jacentes à l'équation du taux de change.

I. Introduction

This note focuses on the determination of the Deutsche Mark-US dollar exchange rate from mid-1978 to end 1986. It has three objectives :

a) to show that a major institutional change like the creation of the European Monetary System (EMS) in 1979, to which the Federal Republic of Germany adhered, has altered fundamentally the determinants of the DM-US dollar rate and cannot therefore be neglected;

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b) to show that to explain the DM-dollar exchange rate since mid-1978, the variables determining the exchange rate have to be aggregated across the countries participating in the exchange rate mechanism (ERM) and that if the German variables alone are used, the explanatory power of the regression is reduced;

c) to show that by taking into account currency substitution in the demand for money between the currencies of the countries participating in the exchange rate mechanism and the dollar, the explanatory power of the exchange rate equation improves.

The above propositions have some intuitive appeal, since in between realignments the DM is linked to the other currencies participating in the ERM. In between realignments the DM-dollar exchange rate is therefore not reflecting changes in German fundamentals but changes in ERM-fundamentals. In principle the three propositions should hold whatever the exchange rate theory one adheres to. No theory of exchange rates has clearly emerged as superior in the empirical literature of the last decade or so (MEESE and ROGOFF, 1983) and an eclectic view has emerged emphasizing at times some variables and at times some others. Nevertheless we shall take a version of the monetary approach to exchange rate determination which assumes rapidly adjusting exchange rates and slowly adjusting prices (and hence short-run departures from purchasing power parity) as a starting point to test propositions a) to c) above. This choice is justified on several grounds.

First, casual daily observations of changes in the DM-dollar exchange rate during the period suggest a high sensitivity of the exchange rate to announcements of official preliminary estimates and later revisions of real US GDP figures in the direction predicted by the monetary approach. For instance the dollar peaked in the first quarter of 1985 more or less when the very positive figures on US GDP growth in the last quarter of 1984 became available and the figures for the whole of 1984 were revised upwards; it started falling from its peaks when it became clear that US output growth in the first quarter of 1985 was sluggish and fell further when the figures were

revised successively from a flash estimate of 2.9 per cent to a final one of 0.3 per cent [1].

Second, US monetary policy seems to have exerted an important influence on the DM-dollar exchange rate in the period under analysis in the sense that a sustained increase in the US money supply has led to a depreciation of the US dollar, as predicted by the monetary approach. However, the short-run sensitivity of the exchange rate of the dollar to the publication of US money supply figures is more difficult to ascertain, both because there is more noise in the weekly figures, and markets seem to have become aware of it, and because in the presence of monetary targeting a large unexpected increase in the stock of money gives rise to expectations that the Federal Reserve will let interest rates increase to bring the stock of money back on track. As a result a rise in the money stock may cause a "perverse" short run effect of the money supply on the exchange rate, an increase leading to an appreciation, contrary to what is predicted by the monetary approach.

As to the effect of monetary and real GDP developments this side of the Atlantic on the DM-dollar rate, it seems plausible to assume that, at least between realignments, the mark is influenced more by the behaviour of the money supply of all the countries participating in the ERM rather than by the behaviour of the German money supply alone. Similarly, real GDP and interest rate developments in the whole ERM [2] area should be more relevant than German interest rates and real GDP. In other words it could be that the currencies of countries participating in the ERM become highly substitutable among each other on the demand side in the portfolios of the short run international investors as long as stability of exchange rates within the area is expected to continue. The high substitutability on the demand side would justify the aggregation across member countries of money stocks, real GDPs and interest rates for the purpose of analysing the exchange rate of the mark with respect to the dollar. Substitutability on the supply side following from intervention obligations to maintain established parities also contributes to justify aggregation across member countries.

[1] The flash estimate and successive revisions relied probably too heavily on domestic aggregate demand data and underestimated the negative effect on growth of the increasing US current account deficit.

[2] The United Kingdom is a member of the EMS but does not participate in the ERM.

Formal exchange rate arrangements like the snake or the EMS may or may not possess a high degree of credibility. If markets believe that formal exchange rate arrangements will be strictly adhered to by all member countries the degree of currency substitution on the demand side will be enhanced. In the extreme case of permanently fixed exchange rates the member currencies will become perfect substitutes. On the other hand if a higher degree of substitutability develops because of higher integration of capital and goods markets, and of a common exposure to external shocks, formal and credible exchange rate arrangements may be "forced" by the market on monetary authorities. In other words a mutually reinforcing effect of high substitutability on formal arrangements and vice versa could develop. It follows that aggregation of money supplies, interest rates and GDP's of member countries may be justified either already before the entry into force of formal exchange rate arrangements - in the case of the EMS, March 1979 - or only after the formal arrangements become credible enough. The sample period for the tests of the next section starts with the third quarter of 1978 first because European Community governments had already agreed to enter into a formal exchange rate arrangement at the European Council meetings of Copenhagen (April 1978) and of Bremen (July 1978) and second because preliminary estimates of the monetary approach with a switching function show that the shift in regime had already occurred before March 1979 .

The emphasis of this note is on the exchange rate of the dollar vis-à-vis the DM rather than vis-à-vis other currencies of the ERM because Germany is the largest economy among the member countries, it has free capital mobility and a currency which is to some extent a reserve currency. These factors make the DM the natural "link" between the currencies participating in the ERM and the dollar.

II. The model and empirical tests of the DM-dollar rate during the EMS period

For the purpose of testing the hypothesis that, since the creation of the European Monetary System, ERM-variables are more important in the determination of the DM-dollar exchange rate than the corresponding German ones, a very simple monetary model of exchange rates was estimated.

Assume first that in the current period the exchange rate changes only by a fraction of the difference between its long-run equilibrium level (S_t^*) and its starting level (S_{t-1})

(1) $\Delta \log S = \lambda (\log S^* - \log S_{-1}); \; 0 \leq \lambda \leq 1$

where S* is defined as :

(2) $S^* = \frac{M_i}{m_i^d} / \frac{M_{US}}{m_{US}^d}$ $\qquad i = EMS, DE$

where M stands for the nominal money stock, EMS, DE and US stand for the aggregate of the ERM, for Germany and the US respectively, and m_i^d for the real demand for money. The latter is determined as follows :

(3) $\log m_i^d = \text{constant} + \alpha \log Y_i + \beta r_i$

where Y_i stands for real output and r_i for the nominal interest rate. The US demand for money function is assumed to be determined similarly by output and the rate of interest. Equation (2) does not imply that S is determined by purchasing power parity theory in the sort run [3]. Currency substitution between the EMS or the DM and the dollar is for the moment neglected in equation (3).

Substituting equations (2) and (3) into (1) one obtains the exchange rate equation to be tested :

(4) $\log S = \text{constant} + a \log S_{-1} + b \log (M_i/M_{US})$

$+ c \log (Y_{US}/Y_i) + d (r_i - r_{US}) \qquad i = EMS, DE$

where $a = 1-\lambda$, $b = \lambda$, $c = \alpha\lambda$, $d = \beta\lambda$ and where the income elasticities of the demand for money and the interest rate semi-elasticities are assumed to be equal across country.

[3] Purchasing power parity would hold in the short run only if prices in the two areas adjust to monetary disturbances at the same speed as the exchange rate. For a model in which both prices and the exchange rate are endogenous see SOMMARIVA and TULLIO (1987). Here prices are guided towards equilibrium through the adjustment of portfolios of holders of nominal cash balances. The adjustment postulated implies that equilibrium is reached only when existing stocks of balances are willingly held.

Equation (4) has been tested using alternatively the German money supply and German real output instead of the corresponding variables aggregated over ERM member countries. Owing to the possible bi-directional causality between the exchange rate and interest rates, the equation has been estimated by 2-stage least squares using inflation rates as instrumental variables. Table 1 contains the estimates of equation (4) using quarterly data from 1978.3 to 1986.4. The description and the source of the data are contained in Appendix 1.

The comparison of the first and the second regression in the table gives some support to our basic hypothesis. In the equation using German data, both the relative money supply and relative output have coefficients that are insignificantly different from zero. Using EMS-data, both coefficients are significantly different from zero. In addition the significancy of the interest rate coefficient is much higher.

TABLE 1
The DM-dollar exchange rate - partial adjustment model, quarterly data, 1978.3 to 1986.4
(inflation rates as instrumental variables)

$$\log S = \text{constant} + a \log S_{-1} + b \log (M_i/M_{us}) + c \log (Y_{us}/Y_i) + d(r_i - r_{us})$$

i	constant	a	b	c	d	R^2	DW	ρ
EMS	0,83 (2.22)	0,82 7.85)	0,24 (2.27)	0,98 (2.00)	0,02 (2.58)	93,2	2,10	0,31 (1.74)
DE	-0.06 (-0,17)	0.82 (6,89)	0.49 (1,59)	0.49 (1,06)	0.02 (2,00)	92.5	2.08	0.31 (1,70)

ρ is the coefficient of first-order autocorrelation of the residuals estimated by the Cochrane-Orcutt method

The coefficient of the lagged dependent variable indicates that about one fifth of the discrepancy between the partial equilibrium level of the exchange rate and its level in the previous quarter is eliminated within the same quarter. This implies a plausible mean adjustment lag of about five quarters.

In the EMS equation the long run elasticity of the exchange rate with respect to the relative money supply is not significantly different from 1, as expected, while the estimate of the income elasticity of the demand for money is implausibly high. Furthermore, we seem to be confronted with an autocorrelation problem : the results in Table 1 were obtained applying the Cochrane-Orcutt procedure for autocorrelation correction. This could be a sign that important variables are missing like the US current account, as suggested by the portfolio balance model. However, the point we want to make in this note is not that the monetary approach is superior to other theories to explain the DM-dollar exchange rate during the period under study, but that the neglect of economic developments in ERM countries, other than Germany, is not justified after the creation of the ERM.

In the next section the demand for money function (equation (3)) will be modified to take into account currency substitution. It will be shown first that it is an important determinant of the demand for money in both areas and second that the introduction of currency substitution into the demand for money improves the explanatory power of the exchange rate equation.

III. The demand for money and currency substitution

We redefine equation (3) by including currency substitution and by removing the assumption that the nominal demand for money is homogeneous of degree one in prices.

(3') $$\log M_i = \text{constant} + a \log Y_i + b \log P_i + c\, r_i + d\,(r_i - r_f)$$

$$i = \text{EMS, DE, US}$$

where $a, b > 0$, $c, d < 0$, P indicates the price level and r_f the foreign interest rate. The degree of currency substitution is measured by the uncovered interest rate differential. Under high capital mobility, interest parity holds and hence the uncovered interest differential reflects the forward discount or premium in the foreign exchange market.

The latter measures the depreciation or appreciation of the exchange rate expected by the market. The uncovered interest rate differential has been used to measure the degree of currency substitution in estimates of demand for money or velocity by BRITTAIN (1981) and HAMBURGER (1977) among others. Estimates of equation (3') for the US, the ERM countries and Germany are presented in Table 2.

The money demand equations are estimated simultaneously by 3-stage least squares. In the US and EMS money demand the differential between an average ERM interest rate and the dollar interest rate was used to measure currency substitution and in the US and German money demand the DM-dollar interest rate differential was used. The coefficients of the differential are restricted to be equal across country in both pairs of equations.

TABLE 2
US, EMS and German demand for money functions, quarterly data, 1978.3 to 1986.4 (3-stage least squares)

$\log M_i = \text{constant} + a \log Y_{-1} + b \log P_i + c \log P_i + d(r_i - r_f)$

i	f	constant	a	b	c	d	$\bar{R}^2$	DW
US	EMS	-5.02 (-8.10)	0.94 (10.58)	0.81 (30.57)	-0,01 (-10.18)	-0.01 (-3.63)	99.16	1.73
EMS	US	-0.15 (-0.06)	0.91 (15.12)	0.42 (7.11)	-0.01 (-5.73)	-0.01 (-3.63)	92.15	2.23
US	DE	-5.00 (-7.82)	0.94 (10.06)	0.82 (26.18)	-0.01 (-10.13)	-0.01 (1.18)	99.05	1.28
DE	US	-3.22 (-4.28)	0.88 (5.23)	0.68 (12.81)	-0.01 (-3.92)	-0.01 (-1.18)	90.73	0.86

The first pair of equations involving the US and the EMS is quite satisfactory. The coefficient of the currency substitution term is highly significantly different from zero and there is absence of autocorrelation in the EMS demand function for money. The coefficients have the expected sign.

The next step involves the estimation of the exchange rate equation making use of the demand for money functions estimated in Table 2. It is assumed that the actual exchange rate is determined by the excess supplies of money :

(5) $\log S = \text{constant} + f\, ESM_{us} + g\, ESM_i; \quad i = EMS, DE; f < 0, g > 0$

where ESM is the excess supply of money and S is the actual DM-dollar exchange rate. ESM_{US} is defined as $\log \frac{M_{US}}{\bar{M}_{US}/P_{US}}$

which is equal to $\log M_{US} - \log \bar{M}_{US} + \log P_{US}$ and $\log \bar{M}_{US}$ is the value predicted by the money demand functions [4]. ESM_{EMS} is defined in a similar way. f and g are coefficients which should be equal to 1 in absolute value.

Returning to the basic hypothesis of this note, namely that ERM variables determine the DM-dollar exchange rate rather than Geman ones, we tested this hypothesis by estimating equation (5) alternatively with the German excess supply of money and the EMS excess supply of money. The results of these estimations are presented in Table 3.

[4] Data on the money stock will not in general identify either demand or supply. LAIDLER (1982) argued that the demand for money can be identified if the supply function of money shifts independently of the demand-for-money function, i.e. if the supply function contains at least one variable that does not appear in the demand function. Laidler argues that this is the case, for the level of reserves made available by the central bank to the commercial banking system figures prominently in any theory of the supply of money, and does not appear in any theory of the demand for money. It can therefore be assumed that the estimated value of the dependent variable of equation (3') represents the demand for money, whereas the observed data represents the money supply.

TABLE 3
The DM-dollar exchange rate, quarterly data,1978.3 to 1986.4

$$\log S = \text{constant} + f\,ESM_{us} + g\,ESM_i$$

i	constant	f	g	$\bar{R}^2$	DW	ρ
DE	-0.68 (-1.16)	-0.30 (-0.89)	0.48 (1.42)	91.63	1.02	0.86 (7.93)
EMS	-2.21 (-1.42)	-0.72 (-2.19)	1.27 (2.23)	93.42	1.96	0.86 (6.05)

ρ is the coefficient of first-order autocorrelation of the residuals estimated by Cochrane-Orcutt

Also the results in this table confirm our basic hypothesis. The coefficients of the equation with ERM variables have the right sign and are statistically significant. In addition they are not significantly different in absolute value from the expected value of 1. The coefficients of the equation with German variables are instead statistically insignificant. However, both equations still suffer from high serial correlation. As in the previous paragraph, this is probably caused by the very simple specification of our model and the existence of omitted explanatory variables.

Finally, in Table 4 we present the estimation of equation (5) where the excess supplies of money are calculated from money demand equations which do not include a term reflecting currency substitution.

TABLE 4
The DM-dollar exchange rate without currency substitution, quarterly data,1978.3 to 1986.4

$$\log S = \text{constant} + f\,ESM_{us} + g\,ESM_i$$

i	constant	f	g	$\bar{R}^2$	DW	ρ
DE	0.61 (0.25)	0.36 (0.57)	-0.30 (-0.83)	90.68	0.94	0.94 (15.28)
EMS	-4.06 (-3.51)	0.10 (0.22)	0.92 (2.31)	91.27	1.55	0.70 (5.86)

Comparison of these results with those of Table 3 shows very clearly the importance of currency substitution in the demand for money. Without allowance for currency substitution the coefficient f of the excess supply of money in the US becomes insignificantly different from zero, also when the EMS wide excess supply of money is used as a proxy for monetary developments in the countries participating in the ERM.

This note has presented various tests of the monetary approach to exchange rate determination for the DM-Dollar exchange rate from the third quarter of 1978 to the fourth quarter of 1986. Its main conclusion is that since the creation of the EMS, the DM-dollar exchange rate is determined by economic developments in the whole ERM area rather than by the German developments only. Between realignments, exchange rates among member currencies were virtually fixed. Hence movements of the exchange rate of the ECU (excluding sterling) with respect to the dollar are de facto coincident with movements of the DM-dollar rate, apart from small fluctuations of member currencies within the bands.

The second conclusion is that the inclusion of a term reflecting currency substitution in the demand for money functions of the US and the EMS area further improves the results.

The strong currencies in the system have probably depreciated more as a result of the existence of the ERM than they would have otherwise, while weak currencies and especially the lira have probably depreciated less than they would have otherwise. The findings of this note may therefore also have implications for the determination of inflation in the ERM area and in each member country : as convergence of inflation improves and realignments become more infrequent the ERM tends towards a system in which national inflation rates are determined more by the aggregated money stock of the ERM than by the national money stock.

Appendix

Description and Sources of Data Used

Original Series Used

M1	=	Money	Source :	International Monetary Fund (IMF), International Financial Statistics (IFS) : line 34
QM	=	Quasi Money	Source :	IMF, IFS : line 35
M2	=	M1 + QM		
GDP	=	Gross Domestic Product 1980 Prices	Source :	IMF, IFS : line 99 b.p. for Denmark; line 99 b.r. for France, Italy
GNP	=	Gross National Product 1980 Prices	Source :	IMF, IFS : line 99 a.r. for Germany, United States, line 99 a.p. for Belgium, Netherlands
CPI	=	Consumer Prices, index, base 1980	Source :	CRONOS and IMF, IFS : line 64
IPI	=	Industrial Production, Season Adj. index number 1980	Source :	Cronos and IMF, IFS : line 66c
INTS	=	Call Money Rate	Source :	IMF, IFS : line 60b
INTL	=	Government Bond Yield	Source :	IMF, IFS : line 61
DM/$	=	Deutsche Mark per US Dollar Market Rate - Period Average	Source :	IMF, IFS : line rf, country 134 (Germany)

Computations with original series

I. Interpolation of annual GDP/GNP series

Where only annual series are available (B, DK, IRL, NL), quarterly series have been obtained by using quarterly changes of the index of industrial production.

II. Calculation of EMS aggregates

a. Money $$M_{EMS} = \sum_{i=1}^{7} (M_i/S_i, 1979)$$

b. GDP $$Y_{EMS} = \sum_{i=1}^{7} (Y_i/S_i, 1979)$$

c. Interest rates $$INT = \sum_{i=1}^{7} (W_i\, r_i)$$

where :

S_i, 1979 :	exchange rate, annual average for 1979 of currency i with respect to the DM.
r_i	interest rate of country i
w_i	weight of currency i in a revised ECU in which the Pound, the Luxembourg Franc and the Drachma have been removed
i	Germany, France, Italy, Netherlands, Belgium, Denmark, Ireland.

A very important question is whether one should use a constant exchange rate or the current exchange rate to aggregate national money stocks and real GDP's of EMS member countries. Considering the aggregation of the money stocks first, using a constant exchange rate implies that the weight of the money stock of high inflation countries (e.g. Italy) increases through time, while the use of the current exchange rate would lead to an increase in the weight between realignments and a discrete fall at the time of a realignment with the DM. The use of current exchange rates has therefore two disadvantages. The first disadvantagae is that it leads to discrete jumps in the aggregate EMS money stock at the time of realignments. The second and most important disadvantage follows from the fact that the system has been managed, especially after the March 1983 realignment, as an anti-inflation device in high inflation countries. As a result the exchange rates (with respect to the DM) of the Lira and French Franc have appreciated in real terms. The disciplinary role of the EMS and the "purchase of credibility" from the Bundesbank has probably led to an increase in the demand for money in Italy and France. Thus not all of the higher monetary expansion in high inflation countries has exerted some influence on the DM-dollar exchange rate : reducing in a discontinuous way the weights of the money stocks of high inflation countries would probably introduce a bias in the coefficients of the EMS money stock against the main hypothesis of the paper, unless the disciplinary effect of the EMS on the demand for money in Italy and France could be explicitly introduced into the model.

As to the aggregation of GDP the use of a constant exchange rate implies that the aggregate GDP is not influenced year by year by deviations of exchange rate from purchasing power parity.

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