Monetary Authorities' Reaction Functions and the European Monetary System

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1. Introduction

This is the third piece of research in a project aimed at modeling foreign exchange rates determination and monetary authorities' policy reaction functions for a representative set of countries belonging to the European Monetary System.[1] Relative to our preceding contributions[2], the present one is characterized by three main features. First, the theoretical model is modified by considering that imperfect international assets substitutability—represented by a risk factor in the relation between the forward exchange rate and the rationally expected future spot rate—requires the introduction of an additional reaction function for the monetary authorities. Second, we enlarge the number of countries considered—which in our previous work on the EMS were only three (Germany, Italy, and Belgium)—to a larger set. To keep using the same suggestive terminology of our last paper, the present larger set of countries is made up of the "leader of the system," of two large and possibly "unfaithful members" of the system, and of two small and likely more "faithful followers" of the rules of the game and of the leader's policy.

Third, the present work introduces new variables in the specification of the reaction functions and attempts to improve on the measurement of those already used in the previous work. Moreover, we hope that the econo-

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[1]The basic exchange rate model that underlies the reaction functions analyzed here was presented at the conference on Exchange Rate Theory and Practice organized by the National Bureau of Economic Research in Bellagio, January 26-28, 1982, and is to be published by the University of Chicago Press in a conference volume edited by J. Bilson and R. Marston. A first set of results on European monetary authorities' reaction functions were presented at conferences on The Political Economy of Monetary Policy in Western Europe held at the University of Illinois, Urbana-Champaign on November 18-20, 1981, and on Exchange Rates in Multicountry Econometric Models, held at the University of Leuven on November 26-28, 1981; these are to be published by Macmillan in a conference volume edited by P. De Grauwe and T. Peeters.

[2]Basevi and Calzolari (1981), (1982).

metric treatment of the model is improved by considering two different sample periods for the change of regime due to the passage from the European snake experience to the EMS experience. We still leave to future research consistent estimation of each country's two reaction functions.

Finally, the present paper provides new material for testing the various hypotheses made in our previous work: the extension of the sample period to more recent months, the enlargement of the set of countries, and what we consider improvements in model building and measurement of variables, should provide a sounder basis for judging the validity of our theoretical framework, behavioral assumptions, and design of institutional characteristics.

2. Theoretical Framework

The theoretical framework used in our preceding papers in order to model the determination of exchange rates was based on a multilateral version of the Dornbusch-Frankel theory (Dornbusch (1976), Frankel (1979)). In addition, however, we did not make the extreme assumption of perfect international bond substitutability: instead of imposing equality between closed and open interest rates parity—or, in other words, instead of assuming that the forward exchange rate equals the expected future spot rate and this is an unbiased predictor of the actual future spot exchange rate—we allowed for a wedge between the two rates. This, however, was left exogenous in our preceding work. Modern international portfolio theory identifies this wedge as a risk premium, whose magnitude and evolution depends upon the relative supply of outside assets on the part of the governments whose currencies are involved in the exchange rate. While at the theoretical level research along this line is fruitfully developing, econometric work has not yet provided to our knowledge very satisfactory results. (Frankel (1982), Colombo (1983)).

In order to determine the risk factor as a function of the relative supplies of outside assets, we follow the approach chosen in our first paper on the monetary authorities' reaction functions, and we now attempt to endogenize not only the determination of the internal supply of base money (or of its "price," i.e., the short-term rate of interest), but also of its external supply which originates from the authorities' intervention in the foreign exchange markets (or of its "price," i.e., the actual change in the spot exchange rate).

In other words, our version of the Dornbusch-Frankel model remains valid for the determination of the exchange rates, provided these are taken to be the forward exchange rates. However, because of the risk element (imperfect substitutability), forward exchange rates are no longer representative of rationally expected future spot rates. Thus, in order to determine the latter, and hence implicitly the risk factor which makes them diverge from the former, we introduce a second reaction function—in addition to the one already specified for the short-term rates of interest.[3] This reaction function is meant to capture the authorities' behaviour in the foreign exchange markets, and therefore their contribution to the supply of outside assets through the foreign exchange window.

3. Institutional Characteristics

As we already pointed out in our previous work, it is honest to recognize that in empirical cross-country comparisons of monetary authorities' reaction functions a compromise has to be struck between the need to portray the specific features of every country's political, economic, and institutional characteristics, and the constraint of designing the countries' functions in a way similar enough to allow for international comparisons. While faced with this problem, in our compromise specification of the functions we also want to preserve the features that are of particular interest to our purpose, namely the general specification of the multilateral constraints under which the set of countries here examined have had to operate, if and when they were members of the European "snake" arrangements and, currently, of the European Monetary System.

Before going into the details of the specification for the authorities' reaction functions, we thus want to emphasize that we do not view every country in our system as being on the same level with respect to such functions. We envisage the existence of five subsets in our set of countries and currencies. The first consists of the "nth country," which we take to be the United States. For this country's authorities we do not specify any reaction function and thus, at least theoretically, we consider them free to set their own control variables at unspecified levels, presumably with a view to either nationalistic or worldwide objectives, or both.

The second subset of countries also contains only one element, which is taken to be Germany. We consider this country as the monetary leader of the regional (European) subsystem: a leader which "de facto" if not "de jure" has been in charge of the subsystem exchange rate policy vis-à-vis the rest of the world (essentially with respect to the currency of the overall system leader, i.e., the dollar).[4]

[3]We are grateful to R. Filosa for having clarified this point in his discussion of our previous work.

[4]This leader role that Germany may be alleged to have played was indeed behind much of the debate that accompanied the conversion from the bilateral-only exchange rate constraints of the "snake" to the bilateral plus the ECU-based indicator of divergence constraints that characterize the European Monetary System. For more details on the EMS, see Deutsche Bundesbank (1979).

The third level of countries in our system contains the "faithful" members of the snake and the EMS. They are a set of relatively small countries, belonging in practice to a D-mark area. The Netherlands, Belgium-Luxembourg, and Denmark have, with some reservations for the latter two, been part of this group, which is defined by the fact that its members have generally and continuously played according to the rules of the game.

The fourth set contains the other three main countries of Western Europe—France, Italy, and the United Kingdom. These countries have never or not continously been members of the successive European exchange rate arrangements, and the two of them who now are full members of the EMS are relatively more inclined to use the exceptional rule of the game (i.e., a parity change), rather than the normal ones (monetary policy and exchange market intervention).

Finally, there is the rest of the world, which in our exchange rate model is left exogenous.

Having thus chosen on the basis of "a priori" knowledge of historical and institutional elements a stratification of our set of countries, we then had to compromise between other country-specific characteristics and the need for cross-country homogeneity in the specification of reaction functions.

4. The Reaction Functions.

As already pointed out in section 2, two reaction functions are necessary to close our model under the assumption of imperfect assets substitutability and managed foreign exchange markets. The first one refers to the control of the domestic source of the monetary base, or alternatively to the control of the short-term rate of interest. The convenience of cross-country homogeneity has induced us to choose for all countries here analyzed the same type of dependent variable, i.e., the short-term rate of interest, even though we are aware that different institutional characteristics may suggest different monetary control variables for the various countries of our model.

On the other hand, with respect to the reaction functions describing foreign exchange market intervention, we first considered using changes in international reserves as the dependent variable in these functions. However, even with carefully constructed series on foreign exchange intervention based on data for the various components of international reserves as published by the International Monetary Fund, *International Financial Statistics*, the results of our preliminary estimates based on such series were very poor. This is not surprising, as it is well known that actual figures on foreign exchange intervention are far from being represented by published data on changes of international reserves. The use of foreign exchange obtained through compensatory loans, intra-period swaps between central banks, exchange rate valuation problems, etc. are just a few of the many conceptual and statistical pitfalls that make it practically impossible in our view to arrive at a reasonable series of data on foreign exchange intervention without the inside knowledge of central banks' figures. Thus, while waiting for the day when these data might be consistently published by the central banks of the main countries, we had to choose an alternative way, and one analagous to that followed for the first set of reaction functions—i.e., the interest rate functions. In other words, we selected the "price" rather than the "quantity" variable as dependent or control variable. In the case of the first set of reaction functions this meant using the interest rate; in the present case, this means taking the change in the exchange rate rather than the change in reserves as the dependent variable.

The next question is what exchange rate to consider in this set of reaction functions. Both a priori theoretical considerations and preliminary results obtained on the various possible alternatives, induced us to a choice which makes use of the stratification of countries described in the preceding section with respect to their different roles in the European monetary arrangements.

In principle, at least four interesting choices of exchange rates could be used as dependent variables. The first one is each country's exchange rate vis-à-vis the dollar; this choice could be implemented for every one of the five countries that are currently present in our model with own reaction functions, i.e., Germany, France, Italy, Belgium-Luxembourg, the Netherlands.

The second choice is to use each country's effective exchange rate, such as measured by the IMF-MERM rate. This also could be done for all five countries in the model.

A third choice, apparently more in line with the institutional characteristics and economic realities of the European monetary arrangements, would make use of the exchange rate vis-à-vis the D-mark, for all countries except Germany, and of the D-mark/dollar rate for Germany. This choice is clearly an extreme one in terms of the leader's role that it attributes to Germany and its currency. It does not seem to us realistic; moreover, it does not make full use of the changes in institutional characteristics and constraints that occurred during the sample period, which spans from the early seventies and the "snake" experience, to the early eighties and the EMS experience.

A fourth choice, and our preferred one, is to split the sample period into two subperiods in order to take into account the likely change in behavior due to change in institutional regimes. The first subperiod goes up to the inception of the EMS (March 1979); the second one corresponds to the EMS and reaches the end of 1982. For both subperiods we present a first version of reaction functions, where the equations for France and Italy (the "unfaithful" members) are specified with the respective exchange rates in terms of the dollar, whereas the equations for Belgium and the Netherlands (the "faithful" members) are specified with their exchange rates vis-à-vis the D-mark as dependent variables.

In both periods, we intend to attribute to Germany's monetary authorities an exchange rate reaction function specified in terms of the D-mark/dollar rate. While this choice clearly emphasizes the leading role of Germany in setting the overall European relation vis-à-vis the dollar, it does not prejudge one of the hypotheses that were already submitted to test in our previous work, namely that the mechanism of the indicator of divergence based on the ECU has reduced the freedom that Germany might have enjoyed during the snake period to set the dollar policy for the whole of the snake area. However, for reasons of time and space, we have decided to leave to further research the estimation of the German reaction function vis-à-vis the U.S. dollar. This in fact, as it involves perhaps the most important exchange rate in the whole international monetary system, clearly requires an explicit treatment of at least one reaction function for the U.S. authorities—i.e., the one concerning its short-term interest rate—and possibly two for the periods in which the American authorities seemed to have abandoned their traditional attitude of benign neglect with respect to their exchange rate. In any case, the model would be enlarged beyond its present limited scope, which is to throw light on some aspects of the working of the European Monetary System.

Finally, a fifth choice, which we actually followed as a second version of the four countries' reaction function here analyzed, is to use for all of them their currency rate vis-à-vis the ECU as dependent variable. While not arguing that the authorities really take this rate as their actual control variable when intervening, we present for the period of the EMS a set of estimates expressed in these terms in order to allow a more homogeneous four-country comparison of their respective reaction to the EMS constraints.

5. Specification and Estimation of the Interest Rate Reaction Functions.

As already explained in section 2, our model requires two reaction functions describing the behavior of each country's monetary authorities. The first set of these functions are specified with the short-term rate of interest as the dependent variable, and have already been studied in our previous work. The new estimates here presented are applied to a larger set of countries (five instead of three), have been updated to the end of 1982, and incorporate a few improvements in specification. Since we did it already elsewhere, we do not go here again into the details of their theoretical underpinnings. The general form of these functions is the following:

$$\log(1+i) = \alpha_0 - \alpha_1 \log(R/M) + \alpha_2 \log(1+\mathring{p}) + \alpha_3 \log(y/\bar{y})$$

$$+ \alpha_4 \log(1+i^*) - \alpha_5 \log(1+s) - \alpha_6 \log(RSV)$$
$$+ \alpha_7 \log(MARGIN) - \alpha_8 \log(100+EMS) - \alpha_9 PAR$$

The first three variables refer to the three basic objectives of each country's monetary reaction function: the relative stock of international reserves (with R, the reserves, deflated by the value of imports), the rate of price inflation ($\mathring{p}$), and the pressure of aggregate demand ($y/\bar{y}$). The fourth variable is the foreign short-term rate of interest.

The next two variables refer to the objective of gaining competitiveness within the limits allowed by favorable developments between third currencies exchange rates. Thus the variable "s" measures the spread between the country's effective real exchange rate and its trend: a positive value means a relatively overvalued currency, which explains the negative sign of the coefficient under the assumption that the authorities relax monetary policy (i.e., lower the interest rate) when their currency is overvalued. This policy is reinforced when the foreign exchange rates move in a way that enlarges the spread between the currencies of the country's export markets and those of the country's import markets. Such a development is measured by RSV, which is the ratio of the effective exchange rate weighted with export shares and the effective exchange rate weighted with import shares. The negative sign of its coefficient means that the widening of this spread allows the authorities to relax monetary policy in order to gain competitiveness through the resulting exchange depreciation. From our reading of the Italian, and possibly of the French experience, it seems that, in the opinion of the authorities, this strategy does not conflict with the objective of fighting inflation, as they tend to give more weight to the reduction of imported inflation brought about by appreciation vis-à-vis currencies important on the import side than to the pressure of demand on prices induced by depreciation vis-à-vis currencies important on the export side.

The final three variables refer to the institutional constraints of the European "snake" and the EMS, and the sign of their respective coefficients must be understood in light of their definitions as explained in the notes to Tables 1–5.

We have assumed that, except for the introduction of a new variable for the EMS period, the reaction functions for the short-term rates of interest are not structurally affected by the institutional change due to the inception of the EMS. Thus, contrary to what we do for the exchange rates reaction functions, we estimate this first set over the whole sample period from 1972 to 1982.

The results presented in this table generally confirm those already obtained in Basevi and Calzolari (1981). With respect to the internal objectives of controlling price inflation and the gap in aggregate demand, we may notice that the coefficient of $\mathring{p}$ ranks highest for Germany and lowest for Italy, with the Dutch estimate statistically insignificantly different from

Table 1
Monetary authorities' reaction functions in domestic money markets (1972.1–1982.12). Monthly observations.

Explanatory variables / Countries	C	MARGIN	PAR	EMS	s	i*	R/M	$\mathring{p}$	$y/\bar{y}$	RSV	R^2	RHO	D.W.
Germany	2.533	−0.002	(−)	−0.549	−0.025	0.213	(−)	9.128	0.334	(−)	0.82	0.40	1.96
	(2.6)	(0.1)		(2.6)	(0.5)	(2.6)		(6.1)	(4.2)				
The Netherlands	2.339	0.0005	−0.133	−0.484	−0.344	−0.025	−0.042	(−)	0.094	(−)	0.80	0.79	2.50
	(1.1)	(0.2)	(2.5)	(1.0)	(1.9)	(0.2)	(2.1)		(2.1)				
Belgium	0.329	0.015	−0.0005	−0.047	(−)	0.115	−0.094	3.089	0.298	(−)	0.85	0.63	1.98
	(1.3)	(1.3)	(0.1)	(0.8)		(1.4)	(4.3)	(2.6)	(3.3)				
France	4.777	−0.003	−0.006	−1.016	−0.102	0.112	−0.002	5.468	0.075	−1.582	0.96	0.99	1.56
	(3.7)	(0.6)	(2.4)	(3.7)	(1.6)	(1.8)	(0.5)	(2.6)	(0.6)	(2.2)			
Italy	−0.633	−0.004	−0.001	−0.163	−0.275	0.059	−0.011	2.890	0.151	−0.450	0.98	0.98	1.46
	(0.4)	(0.7)	(0.7)	(0.5)	(4.1)	(0.9)	(2.3)	(4.2)	(2.2)	(1.7)			

Table 2
Monetary authorities' reaction functions in foreign exchange markets — Period of the European "snake": (1972.1–1979.2). Monthly observations.

Explanatory variables / Countries and dep. variable	C	MARGIN	PAR	$(\dot{DM}/\$)$	s	(i − i*)	R/M	R^2	RHO	D.W.
France	0.015	−0.133	0.011	0.727	0.113	(−)	−0.010	0.70	0.33	1.91
$(\dot{FF}/\$)$		(2.5)	(0.8)	(1.1)	(12.5)	(2.2)		(1.9)		
Italy	0.019	(−)	(−)	0.362	0.093	−0.070	−0.006	0.44	(−)	1.42
$(\dot{LT}/\$)$		(2.2)			(5.6)	(1.2)	(1.0)	(1.7)		
The Netherlands	(−)	−0.120	0.014	−0.145	0.025	−0.083	−0.010	0.49	0.23	1.84
$(\dot{Fl}/DM)$		(1.9)	(4.0)	(4.9)	(0.7)	(3.3)	(0.9)			
Belgium	0.017	−0.068	0.007	−0.145	−0.042	−0.115	−0.019	0.47	0.24	1.82
$(\dot{BF}/DM)$	(1.5)	(0.8)	(1.8)	(5.5)	(0.9)	(3.3)	(1.5)			

Table 3
Monetary authorities' reaction functions in foreign exchange markets — Period of the EMS: (1979.3–1982.12). Monthly observations.

Explanatory variables / Countries and dep. variable	C	MARGIN	PAR	EMS	$(\dot{\text{DM}}/\$)$	s	(i − i*)	R/M	R^2	RHO	D.W.
France	(−)	−0.004	0.025	0.005	0.929	−0.022	−0.044	−0.014	0.96	−0.45	2.13
$(\dot{\text{FF}}/\$)$		(0.7)	(7.9)	(2.1)	(25.4)	(0.8)	(0.9)	(1.8)			
Italy	(−)	−0.018	0.007	0.003	0.773	0.189	−0.138	−0.009	0.93	(−)	2.16
$(\dot{\text{LT}}/\$)$		(2.2)	(2.3)	(4.6)	(17.1)	(2.6)	(2.7)	(4.0)			
The Netherlands	(−)	−0.001	(−)	0.0005	−0.056	0.056	−0.206	(−)	0.49	0.63	1.97
$(\dot{\text{Fl}}/\text{DM})$		(2.4)		(1.4)	(3.1)	(1.3)	(3.7)				
Belgium	(−)	−0.015	0.008	0.015	−0.109	0.030	−0.229	−0.104	0.38	0.32	1.96
$(\dot{\text{BF}}/\text{DM})$		(1.6)	(2.1)	(2.0)	(2.0)	(0.4)	(2.2)	(1.7)			

Table 4
Elasticities of each currency exchange rate in terms of U.S. dollar with respect to the D-mark exchange rate in terms of the U.S. dollar.

Countries Period	France	Italy	Netherlands	Belgium
"Snake" period	0.73	0.36	0.85	0.85
EMS period	0.93	0.77	0.94	0.89

zero in earlier estimates and thus dropped from the one here presented. The coefficients for $y/\bar{y}$ are all significant at the 5 percent confidence level, except for France, and rank highest for Germany and lowest for the Netherlands.

These results suggest that Germany tends to bend its monetary control instruments more towards the objectives of internal equilibrium as compared to what her European partners do.

Four variables describe external objectives in this first set of reaction functions. With respect to the foreign interest rate (which is the U.S. rate for Germany, France, Italy, and the German rate for the Netherlands and Belgium) the estimated coefficients are statistically significant only for Germany and France, with the German coefficient about twice the value of the French one. As for the ratio of international reserves to the flow of imports, the coefficients are significant except for Germany and France. With further data refinement, this variable may however acquire a more significant role. The (s) variable has significant coefficients for France, Italy, and the Netherlands. The RSV variable was introduced only in the Italian and French equations because our "a priori" information that it has been an important objective for these countries' authorities. Its coefficient is statistically more significant and higher in value for France than for Italy.

Finally, a set of three variables is meant to capture the external institutional constraints. The distance from the bilateral margins of maximum admissible fluctuation between a country's currency and each currency of its partners in the "snake" and in the EMS exchange rate agreements is measured by MARGIN. This variable, however, in no case appears with a statistically significant coefficient, thus suggesting that the monetary instrument was generally not used for the purpose of keeping the exchange rate within its margins. On the other hand, when the EMS variable starts to play its role during the latter part of the sample period, it affects significantly the reaction functions of Germany and France, but not those of the other three EMS partners. This is a first suggestion that the new constraint imposed by the EMS relative to the "snake" arrangements has put some significant pressure on Germany's monetary policy, and less so on France's policy; while either because not a deviating country (the Netherlands and less so Belgium) or because of more readiness to change parity (Italy), the indica-

Table 5
Monetary authorities' reaction functions in foreign exchange markets — Period of the EMS: (1979.3–1982.12). Monthly observations.

Explanatory variables / Countries and dep. variables	C	MARG	PAR	EMS	(DṀ/$)	PPP	(i – i*)	R/M	R^2	RHO	D.W.
France (FF/ĖCU)	(–)	–0.006 (1.0)	0.017 (5.0)	0.003 (1.4)	0.054 (1.6)	0.032 (0.9)	–0.044 (0.5)	–0.011 (1.4)	0.52	(–)	2.15
Italy (LT/ĖCU)	(–)	–0.010 (1.6)	0.002 (1.0)	0.002 (2.2)	–0.059 (1.7)	0.160 (2.7)	–0.129 (1.5)	–0.004 (1.8)	0.24	(–)	1.84
The Netherlands (FI/ĖCU)	(–)	–0.002 (2.1)	0.003 (2.0)	0.0001 (0.1)	0.063 (2.6)	0.095 (2.4)	(–)	–0.003 (0.4)	0.50	0.31	1.99
Belgium (BF/ĖCU)	(–)	–0.015 (1.9)	0.006 (2.1)	0.012 (1.9)	0.015 (0.3)	0.086 (1.3)	–0.224 (2.6)	–0.101 (1.9)	0.41	0.41	1.91

Notes to Tables 1-5

OLS estimates; t-values in parentheses; a dot over a variable indicates a rate of change.

Definition of variables:

Dependent variable in Table 1 = short-term rate of interest, averages of period. In interpreting the coefficient of $\dot{p}$ it must be considered that the inflation rate is per month.

Dependent variables in Tables 2, 3, and 5 = rates of change of market exchange rates, averages of period. In interpreting the coefficient of the interest rate differential it must be considered that the exchange rate changes are per month rates.

MARGIN = $\left[\prod_{j \neq i}(e_{ij}/\bar{e}_{ij})\right]^{\frac{2}{n-1}}$ with e_{ij} and $\bar{e}_{ij}$ being the market exchange rate and parity between currencies i and j.

EMS = indicator of divergence of the ECU market rate from the ECU central rate of each currency participating in the European Monetary System, expressed as a percentage of the maximum permissible difference.

s = standardized errors of actual from fitted values of a time-trend regression of the real effective exchange rate of each currency in terms of that country's wholesale prices.

i^* = U.S. short-term interest rate, for Italy and France; German short-term interest rate, for the Netherlands and Belgium; ECU-weighted interest rate for all countries in table 5; averages of period.

R = net foreign reserves of monetary authorities plus commercial banks (for Belgium, and Germany, central bank's reserves only); in terms of domestic currency, end of period values.

M = domestic currency value of merchandise imports, corrected for trend.

p = consumer price index.

y = index of industrial production, seasonally adjusted.

$\bar{y}$ = time-trended index of industrial production.

RSV = ratio of export-weighted to import weighted effective exchange rates.

PAR = dummy variable taking a value of +1 when the currency's parity is increased (a devaluation), and a value of −1 when the parity is decreased (a revaluation).

The variables MARGIN, R/M, $\dot{p}$, $y/\bar{y}$ influence the dependent variables with distributed lags; the reported coefficients are the sums of the lagged coefficients.

tor of divergence did not influence much the monetary policy of these three countries. This interpretation, however, is not fully supported by the PAR variable, which is a dummy for changes of parities vis-à-vis the ECU, and whose coefficient is significant only for France and the Netherlands.

6. Specification and Estimation of the Exchange Rate Reaction Functions

Our main interest in the present work is, however, the analysis of a second set of reaction functions, namely those for the authorities' intervention in exchange markets. For reasons already explained, these are expressed in terms of the "price" variable, i.e., the exchange rate, as the control variable. The general specificiation is the following:

$$\dot{e} = \beta_0 - \beta_1 \log (R/M) \pm \beta_2 \dot{e}^* - \beta_3 \log \left(\frac{1+i}{1+i^*}\right) + \beta_4 \log (1+s)$$
$$- \beta_5 \log (\text{MARGIN}) + \beta_6 \log (100+\text{EMS}) + \beta_7 \text{PAR}$$

This equation is estimated over two separate sample periods: the first one (1972.1-1979.2) refers to the "snake" period, the second one (1979.3-1982.12) refers to the EMS period. During both subperiods, we have grouped the four countries into two subsets. For the first one—which is made up of France and Italy—the dependent variable is the rate of change in their exchange rate vis-à-vis the U.S. dollar. This implies that for these two countries the interest rate differential is referred to the U.S. interest rate; in addition, the exogenous exchange rate ($\dot{e}^*$, i.e., the rate of change of the DM/$ rate) should normally enter with a positive sign. This means that the lira and the French franc generally appreciate vis-à-vis the dollar when the same happens to the DM; however, the size of the coefficient is expected to be smaller than unity, as these currencies generally follow the D-mark only part of the way in its movements vis-à-vis the dollar.

The second group of countries—made up of the Netherlands and Belgium—has the change in their exchange rate vis-à-vis the DM as a dependent variable. In this case, therefore, the interest rate differential is with respect to Germany, and the change in the DM/$ rate is expected to have a negative coefficient, meaning that when the DM appreciates vis-à-vis the dollar, these currencies generally depreciate vis-à-vis the DM.

As for the signs of the coefficients of the other variables, the negative one for reserves is clear enough: when these are small, the authorities allow their currency to depreciate (an upward movement in the rate). The interest rate differential should have a negative coefficient. In fact, it must first be clear that the relation between the change in the exchange rate and this differential does not reflect interest rate parity, but the authorities' reaction to foreign interest rates: if it were an interest rate parity, the exchange rate change should be moved forward one period and the coefficient would be positive and close to unity (equal to unity under the assumption of unbiased prediction of future spot exchange rates and no risk premium). Here instead, we assume that the authorities adopt a "leaning against the wind" strategy, contrasting the market anticipation of a future depreciation (as represented by a positive interest rate differential) by intervening and moving the exchange rate in the opposite direction.

The expected sign for the coefficient of the spread from the trend of the real exchange rate (s) implies that, when a currency is overvalued, the authorities allow it to depreciate. As for the MARGIN and EMS variables, the signs of their coefficients in this equation should be opposite to those in the interest rate equation: in fact, the normal rule of the game is to keep their own currency within the margins and/or limits of divergence characterizing the "snake" and EMS regimes. Thus, when the MARGIN or the EMS variables denote that the currency is reaching its upward limit[5], the authori-

[5]Note that because of the way in which the data on the indicator of divergence (EMS) are published in our source, its positive values indicate a strong currency situation. The opposite is true for the MARGIN variable, which is a measure of distance from the bilateral margins, with exchange rates and parities measured in the usual way.

ties may try to reverse this movement by lowering the interest rate (a negative movement) or by intervening in the foreign exchange markets and depreciating the currency (a positive movement).

However, while intervention to defend the parity was the normal rule in the "snake" and still is in the EMS, the "exceptional" option was and is to change the parity. Thus the expected sign for the coefficient of the dummy variable PAR is positive. It should be noted at this point that when this dummy plays its role, the EMS variable is silenced by a corresponding dummy.

The estimation results are presented in Tables 2 and 3. Considering the first period (Table 2) Italy was almost never in the "snake" system, while France moved in and out twice, staying in only for short periods. In addition, the "exceptional" rule of the game (parities realignment) was used a few times by all members. It is therefore understandable that the variable MARGIN does not appear in the Italian reaction function and has low statistical significance for France. However, its significance is low also for Belgium; this seems to indicate that the "normal" rule was not predominant in that period with respect to management of their exchange rates for these latter two countries. As for the Netherlands, the comparison of Tables 1 and 2 seems to indicate, on the basis of the t-values for the coefficients of the MARGIN variable, that the authorities followed the normal rule more by the use of exchange market intervention than by the use of monetary policy. On the other hand, the "exceptional" rule (measured by PAR) is significant for the Netherlands and Belgium, the only two countries of our set which continuously took part in the system during that period.

Considering now the EMS period, the results of Table 3 indicate that the MARGIN coefficient is significant for Italy, the Netherlands and Belgium, and is highest for Italy followed by Belgium. This is possibly due to the fact that the guilder quietly cruised within the band of bilateral margins during most of that period. More interestingly, the indicator of divergence has its highest significance for Italy, followed by Belgium and France; the value of its coefficient is by far the highest for Belgium, thus suggesting that this country has been the one most stringently constrained in its exchange rate policy by the EMS arrangements. The PAR variable is significant for France, Italy, and Belgium, and important particularly in the case of France.

Besides the external institutional constraints discussed above, the authorities kept an eye on competitiveness. Given the larger size of France and Italy, we would expect in their case more significant and larger coefficients for the variable (s)—i.e., the "parity spreads" variable—relative to the Belgian and Dutch cases. In other words, we would expect that France and Italy could manage their exchange rate more effectively in order to improve their competitiveness. While this seems to be true for the "snake" period, it is not confirmed by the estimates of Table 3, where only Italy has a significant and high coefficient for the (s) variable.

An interesting cross-country comparison can be made with regard to the exogenous exchange rate between the D-mark and the U.S. dollar. Although the Belgian and Dutch functions are estimated with respect to their DM rates as dependent variables, we can easily compute the implicit elasticity of their dollar rate with respect to the DM/$ rate, and thus compare these results with the corresponding elasticities for France and Italy. These are shown in Table 4 and indicate that Italy has always been the country dragging its feet in following the D-mark movements vis-à-vis the dollar. Belgium and the Netherlands have generally been more inclined to follow the German lead. However, possibly because of the exceptional revaluation of the dollar during most of the EMS period, all countries have tended to cluster more around the D-mark in its dollar policy, relative to what they were doing during the "snake" period. This fact may also be indicative of a stronger coherence of the five countries exchange rate policy during the EMS period (up to the end of 1982) relative to the "snake" period.

In the spirit of cross-country comparisons and EMS evaluation, we also decided to specify all four countries' exchange market reaction functions vis-à-vis one same currency, namely the ECU. The results are presented in Table 5. Comparing the coefficients of the EMS variable, we notice again that the Netherlands do not appear to have had problems with the indicator of divergence, while Belgium reacts more strongly to this variable than France and Italy.

6. Concluding Remarks.

In this paper we have compared two sets of reaction functions for the main EMS participating countries in terms of their monetary and exchange rate policies. While the results obtained generally confirm our "a priori" interpretation of institutional characteristics and rules of the game, more econometric research appears necessary and is on our agenda.

The main extension which ought to be made concerns the need to estimate each country's pair of reaction functions by simultaneous estimation techniques.

On a different but no less important ground, we expect that useful information and possibly more significant estimates should result from having access to reliable data on central banks' intervention in foreign exchange markets. This, in fact, would allow an alternative and probably more satisfactory estimation of the reaction functions describing their behavior in these markets.

Data Sources

All data are from the IFS tapes of the International Monetary Fund, except for the indicator of divergence and parities, which are taken from the Statistical Supplement of the *Monthly Report* of the Deutsche Bundesbank; the weights in RSV are taken from Banca d'Italia (1979) for the Italian variable, and from an unpublished document of that same bank for the French variable.

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Discussion

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I have no basic reservations as to how the paper carries on its main task: namely the comparison of exchange rate and monetary policy of five representative European countries in the "snake" and EMS periods. I think that the authors have successfully fitted the very different institutional and structural characteristics of the countries involved under their basic scheme. They have also overcome difficult problems on data availability devising effective ways of measuring a host of factors that every expert would like to have investigated in a comparison of this sort. Results are informative and appear in accordance with what most observers would accept as the reality of European exchange rate arrangements.

As a result my remarks will be directed to an issue which the authors seem to have not considered explicitly. I am referring to the conceptual nature of the policy reaction functions that the paper attempts to estimate and their proper use in conjunction with the rest of the model.

In the literature there are two basic approaches to the problem of reaction function specification. The first is to follow a "revealed preference" strategy, trying to relate actual policy actions and declared intentions and objectives of the policy authorities. In this case no common knowledge, or belief, of the underlying model of exchange rate determination needs to be assumed between the investigator and the policy authorities themselves. Results may be informative of actual rather than declared objectives of the policy authorities and the simultaneous estimation of structural and policy reactions equations is an effective device to reduce inconsistency in the parameter estimates. The second approach would instead follow an optimization strategy. In this case the specification must be totally dependent on the underlying model. Common knowledge will be assumed. Results may indicate the degree of consistency of actual policy actions and what the underlying model suggests.

Both approaches have their validity. I would assume that the first is more apt for carrying on policy analysis of actual historical periods, while the second is best suited to the construction of models aimed at simulation of policy alternatives.

The present paper takes a middle ground between these two strategies and assumes the ability to serve both. In fact it is largely based on considerations stemming from a revealed preference scheme while, on the other hand, it is meant to be part of a more general policy model of the European countries belonging to EMS. As a result, difficulties in operating and interpreting the results may be expected beyond this stage of research.

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