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ON THE NEED TO ALLOW FOR THE POSSIBILITY THAT GOVERNMENTS MEAN WHAT THEY SAY: INTERPRETING THE TARGET-ZONE MODEL OF EXCHANGE-RATE BEHAVIOR IN THE LIGHT OF EMS EXPERIENCE

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ABSTRACT

Empirical work on exchange-rate behavior under a target-zone regime has used data produced by the European Monetary System (EMS) and has found that the data contradict important predictions made by the standard target-zone model. We argue that the contradictions reflect a misinterpretation of policies pursued by the EMS countries. They intervened intramarginally, to keep exchange rates well within the target zone, rather than intervening at the edges of the zone to prevent rates from crossing them. In the Basle-Nyborg Agreement of 1987, however, the EMS countries agreed to make fuller use of the band, and the effects of the agreement show up strongly in the data. Exchange rates behave differently after the agreement than they did before. The effect appears clearly in the behavior of the French franc and less decisively in the behavior of the Italian lira. The paper concludes by examining and rejecting alternative explanations for the observed differences in exchange-rate behavior.

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Introduction

Governments adhering to the exchange-rate rules of the European Monetary System (EMS) are required to keep the spot exchange rates for their currencies inside hard and narrow bands. These are defined with reference to predetermined central rates for the bilateral exchange rates connecting the EMS currencies. During the period studied in this paper, the band for the French franc *vis-à-vis* the Deutschemark (DM) had a width of 4.5 per cent (2.25 percent on each side of the central rate), and the band for the Italian lira had a width of 12 percent. But Figures 1A and 1B show that the actual rate for the franc remained in a narrower range during most of the period, while the actual rate for the lira was always within a narrower range. Why was this so? Why does it matter?

This paper argues that the behavior of those rates reflected a deliberate decision by the governments concerned to keep them well within their bands. This strategy was implemented by official intervention in the foreign-exchange market and, at times, by using interest-rate policies. The development of the strategy is described by Ungerer et al. (1986, p. 5):

> Over the years, a marked shift in views has taken place regarding the relative merits of exchange rate flexibility and stability within the margins vis-à-vis other participating currencies. On the one hand, the flexibility provided by the fluctuation margins was regarded as a cushion to absorb or dampen some external shocks without the need for immediate changes in basic policies or central rates. Full use of the fluctuation margins would also help to limit exchange market intervention and thus avoid some of its potentially undesirable consequences. On the other hand, there are arguments in favor of keeping the exchange rate stable against other, particularly strong currencies in the system, if need be by intervening and by shifting interest rate differentials. By doing so, the authorities hope to influence market sentiments and exchange rate expectations by showing determination and by preventing the building up of a momentum for exchange rate movements. A related argument is that domestic monetary stability, in terms of actual developments and expectations, may be better served by exchange rate stability against key participating currencies.

> Over time, the latter view has gained favor, and a number of EMS central banks have adopted a strategy of keeping their exchange rates well within the band of the EMS and minimizing movements against key currencies of the EMS. At times, this has required substantial intervention in the foreign exchange market and the maintenance of higher interest rates than might have been desirable from the point of view of domestic policy.

When central banks intervened intramarginally, however, they could not draw on the credit facilities of the EMS but had to use their own reserves. Furthermore, they had frequently to act unilaterally, because the Bundesbank did not intervene intramarginally to support the franc or lira against the DM.[1]

In 1987, however, agreement was reached on the limited use of EMS credit facilities for financing intramarginal intervention and, as a *quid pro quo*, on making fuller use of the exchange-rate band. Under the Basle-Nyborg Agreement of September 12, 1987, EMS members undertook "to lay emphasis on the use of interest rate differentials to defend the stability of the EMS parity grid, to use the permitted fluctuation margins flexibly in order to deter speculation and to avoid prolonged bouts of intramarginal intervention" (Communiqué quoted in Ungerer, et al., 1990, p. 88).

This paper sets out to show that governments sometimes mean what they say. We demonstrate that the Basle-Nyborg Agreement was taken seriously, by showing that actual exchange-rate behavior was significantly different after that agreement than it was before, particularly in the case of the franc. From this result, moreover, we infer that the earlier behavior of exchange rates reflected the effects of extensive intramarginal intervention aimed at achieving the objective described in the passage previously quoted.

Why should anyone care? There are two reasons. First, it is important to know that governments *can* mean what they say. Second, it is important to know that the behavior of EMS exchange rates reflected the effects of intervention,

because those exchange rates have been studied closely in recent empirical work on the so-called target-zone model.

We begin with a brief presentation of the target-zone model itself and of previous empirical work on the behavior of EMS rates. Thereafter, we examine that behavior closely and show that there was a regime change in the wake of the Basle-Nyborg Agreement. Finally, we defend our interpretation of the change in exchange-rate behavior against a different interpretation--that markets, not governments, were responsible for the observable change in behavior.

The Target-Zone Model

The rapidly growing literature on exchange-rate behavior in a target zone originated with Krugman (1987). It was formalized and refined by Froot and Obstfeld (1989), Flood and Garber (1989), and Krugman (1991). The model uses a minimalist log-linear equation to link the log of the exchange rate, e_t, with a univariate representation of the fundamentals determining the rate, f_t, and with the expected rate of change of the rate, $dE_t e_t/dt$:

$$(1) \qquad e_t = f_t + \alpha \frac{d}{dt} E_t e_t.$$

Krugman identified the fundamentals with those that we typically associate with the monetary model of exchange-rate determination--the domestic money supply and shocks to velocity. Other authors have been less precise; they say merely that f_t is a linear function of variables that influence money-market equilibrium.[2] If the fundamentals are identified with those that appear in the monetary model, α can be interpreted as the semi-elasticity of money demand with respect to the interest rate. More generally, α measures the sensitivity of the exchange rate to its own expected change.

For analytic convenience, the fundamentals are assumed to follow Brownian

motion with drift:

$$(2) \qquad df_t = \mu dt + \sigma dw_t,$$

where μ is the drift rate, σ is a positive constant, and w_t is a Wiener process. Few would argue that the fundamentals--whatever they may be--are represented adequately by a random process. The assumption, however, allows the analysis to focus on the exchange-rate dynamics produced by the target zone, rather than those produced by predictable changes in the fundamentals.

The solution for eq. (1), given eq. (2), is obtained by first invoking Ito's Lemma to solve for the expected rate of change of the exchange rate:

$$(3) \qquad \frac{d}{dt}E_t e_t = \mu g'(f_t) + (\frac{\sigma^2}{2})g''(f_t),$$

where $e_t = g(f_t)$ and the function g is assumed to be continuous and twice differentiable. Substituting eq. (3) into eq. (1),

$$(4) \qquad g(f_t) = f_t + \alpha\mu g'(f_t) + (\alpha\frac{\sigma^2}{2})g''(f_t).$$

The general solution for eq. (4), a second-order differential equation, is

$$(5) \qquad g(f) = f + \alpha\mu + A_1\exp(\lambda_1 f) + A_2\exp(\lambda_2 f),$$

where

$$\lambda_1 = -\frac{\mu}{\sigma^2} + \frac{\sqrt{\mu^2 + 2\sigma^2/\alpha}}{\sigma^2} > 0, \quad \textit{and} \quad \lambda_2 = -\frac{\mu}{\sigma^2} - \frac{\sqrt{\mu^2 + 2\sigma^2/\alpha}}{\sigma^2} < 0.$$

The integration constants A_1 and A_2 are determined by the specific form of the intervention rule adopted by the monetary authorities. If they never intervene or, equally, the market pays no attention to their operations, then $A_1 = A_2 = 0$. If they always intervene whenever the exchange rate hits the top or bottom of the

target-zone band, but not intramarginally, and the market fully expects them to do so, then $A_1 < 0$ and $A_2 > 0$. These latter conditions on the constants are required for "smooth pasting" at the top and bottom of the band, which prevents the exchange rate from changing in response to anticipated (infinitesimal) intervention at the edges of the band. Without smooth pasting, the instantaneous rate of profit would be infinite at the intervention point.

If the intervention rule is not completely credible, the constants are unconstrained. That is what happens in the model developed by Bertola and Caballero (1990), where the authorities may invoke either of two policy rules when the exchange rate hits the edge of the band. They may intervene to defend the current band or realign the band itself. Under these conditions, the signs of the constants determine whether the market's expectation of a realignment dominates its expectation of intervention to defend the current band. If the expectation of a realignment dominates, $A_1 > 0$ and $A_2 < 0$; if the expectation of intervention dominates, the signs of the constants are reversed to satisfy the smooth-pasting requirement.

Empirical Implications of the Standard Target-Zone Model

In the target-zone model described above, with a fully credible commitment to intervention at the edges of the band, an S-shaped curve connects the exchange rate, e_t, with the fundamentals, f_t, as shown in Figure 2. The curve is flat at the edges of the band, e_U and e_L, so that a range of possible values for f_t map into the same value for e_t. More generally, if the unconditional distribution of the f_t is uniform within the bands, then the unconditional distribution of the e_t will be bi-modal, with a high frequency of observations at each edge of the band. The S-shaped relationship between e_t and f_t also implies that the variance of the exchange rate should fall as it approaches the edges of the band. This can

be explained intuitively: the flatter the relationship between the exchange rate and the fundamentals, the smaller the response of the exchange rate to a given change in the fundamentals. This intuitive explanation likewise says that the variance of the fundamentals should be larger than the variance of the exchange rate within the band.

The EMS provides a natural proving ground for the target-zone model. There have been several realignments since the EMS was inaugurated in 1979, but the bands themselves are narrow and have been defended firmly between realignments.[3] Yet the two empirical implications of the model are violated by the EMS data. There is little evidence that the variance of EMS exchange rates is reduced as the rates approach the edges of the band (i.e., that an S-shaped relationship connects e_t and f_t). Furthermore, Figures 3A and 3B show clearly that the franc-DM and lira-DM exchange rates are more often clustered in the middle of the band than at the edges.

Although these observations suggest that the standard target-zone model is not an appropriate representation of EMS arrangements, a number of empirical studies have nevertheless set out to test the validity of the target-zone model by using EMS data. Broadly speaking, these studies fall into two groups.

Studies in the first group, including those by Bodnar and Leahy (1990) and Flood, Rose, and Mathieson (1990), take the standard target-zone model quite literally. They employ the general solution given by eq. (5) to obtain a measure of the unobserved fundamentals that drive the model. This can be done using actual spot exchange rates and estimated values for the parameters μ, σ, α, A_1, and A_2. They then use their measure of f_t to test directly for the nonlinearity (S-shape) of the relationship between the actual e_t and the estimated f_t. Not surprisingly, these studies find little support for the target-zone model in the

EMS data.[4]

Studies in the second group, including those by Edison and Kaminsky (1990), Klein and Lewis (1990), Bertola and Caballero (1990), and Bertola and Svensson (1990), test modified versions of the target-zone model, paying close attention to the representation of official intervention. In the original formulation by Krugman (1987, 1991), the authorities sought to keep the exchange rate within the band by committing themselves to intervene at the edges of the band. This simple specification was sufficient for Krugman's main purpose--to show that a credible band would induce stabilizing speculation that could keep the exchange rate within the band without any official action (i.e., that stabilizing speculation would substitute for official intervention). In reality, however, the authorities intervene non-infinitesimally at the edges of the bands, and they also intervene intramarginally. Furthermore, they realign the bands, which means that their commitment to defend them cannot be perfectly credible. Therefore, the studies listed above use intervention rules suggested by actual EMS experience to test whether the stabilizing properties of the target-zone model survive when the authorities adopt more complicated strategies.

Edison and Kaminsky (1990), for example, introduce implicit bands within the official bands to represent the influence of intramarginal interventions.[5] Bertola and Caballero (1990) and Bertola and Svensson (1990) allow for the possibility of realignments and thus devaluation risk when the exchange rate reaches the edge of the band.[6] These studies are far from decisive, however, providing only weak empirical support for use of the target-zone model, even when modified, to account for actual exchange-rate behavior in the EMS.

For much of the period under study, the French and Italian authorities seem to have followed the strategy described by Ungerer et al. (1986) in the passage quoted earlier. An account of that strategy was given by the Bank of France in a paper quoted by Edison and Kaminsky (1990, p. 7):

> Within the framework of the European exchange rate mechanism full use of the 2.25 percent fluctuation margin may, if the intervention points are reached, lead market participants to think that a realignment is imminent. It is therefore not surprising that most interventions are intramarginal. Action of this kind does not entail any exchange rate objective, within a fluctuation margin which is in any case narrow. In certain circumstances, however, it may be desirable not to go beyond, at least temporarily, the exchange rate considered by the market to be a psychological threshold. On other occasions, and particularly at times of acute crisis, it may, on the other hand, be useful to move swiftly to the exchange rate level at which the speculation in the market on a realignment would no longer be profitable.

This strategy was not adopted right away. Returning to Figure 1A, note that the franc was at or near the lower limit of its band for many weeks in 1980 and in the first quarter of 1981 and at or near the upper limit for many weeks in 1981 and 1982. Thereafter, however, it stayed well within the limits until the fourth quarter of 1987, apart from brief periods just before the realignments of March 1983, April 1986, and January 1987, and in the weeks following the first two of those realignments. After the Basle-Nyborg Agreement, however, the franc began to fluctuate more freely, and it came close to the upper limit of the band several times in 1988 and 1989, although there was no realignment.

The exchange rate for the lira, shown in Figure 1B, has been allowed to touch both limits of its band, but not very often. Fewer than 0.4 percent of the exchange-rate quotations were less than 2 percentage points from the upper limit, and fewer than 5.1 percent were as close to the lower limit. (Both countries' monetary authorities appear to have been more tolerant of large strong-currency

deviations than large weak-currency deviations. In the case of the franc, some 9.1 percent of the quotations were less than 0.75 percentage points from the upper, weak-currency limit, but 15.1 percent were as close to the lower, strong-currency limit.) In 1988 and 1989, however, the exchange rate for the lira seems to have spent more time than before in the upper portion of its band.

Are the apparent changes in exchange-rate behavior shown by Figures 1A and 1B sufficiently large and significant to represent regime changes? Did the Basle-Nyborg Agreement make a difference? To answer these questions, we look first at exchange-rate behavior in the several subperiods marked off by exchange-rate realignments, then at exchange-rate behavior before and after the Basle-Nyborg Agreement.

There were five realignments affecting the franc-DM exchange rate and seven realignments affecting the lira-DM rate. Distributions of daily exchange-rate quotations for the periods between those realignments are shown in Tables 1A and 1B.[7] The data exclude quotations for the weeks adjacent to the realignments, because the Bank of France, by its own testimony, shifted temporarily to a different strategy on the eve of a realignment and appears to have pursued a different strategy right after a realignment.[8] (For the franc, the omitted quotations account for 7.4 percent of all quotations closer than 0.75 percentage points to the upper limit of the band and for 5 percent of all quotations closer than 0.75 percentage points to the lower limit. For the lira, they account for 67 percent of all quotations closer than 2 percentage points to the upper limit but for less than 4 percent of all quotations closer than 2 percentage points to the lower limit.)

There are visible differences among the distributions in Tables 1A and 1B, but are they significant? First, we ask whether they have different means.

Second, we use the Kolmogorov-Smirnov criterion for maximum differences which furnishes a test for differences between distributions when those distributions cannot be parameterized. Suppose we have samples from two populations and use H(t) and J(t) to denote the (unspecified) cumulative density functions for those populations. We can estimate the functions H and J from the empirical distribution functions $H_m(t)$ and $J_n(t)$, where m and n are the numbers of observations in the samples.

Table 1A Percentage Distributions of Deviations from Central Rates for Periods Bounded by Realignments: French Franc

Size of Deviation	Period					
	I	II	III	IV	V	VI
Beyond -2.25	0.91	0.00	0.00	0.13	0.00	0.00
-2.25 to -1.50	29.22	15.53	22.95	15.67	33.52	0.00
-1.50 to -0.75	22.83	29.81	4.92	6.91	6.04	7.13
-0.75 to 0.00	14.61	17.39	45.90	44.75	9.34	19.52
0.00 to 0.75	13.70	2.48	24.59	32.54	45.60	16.82
0.75 to 1.50	9.13	7.45	0.00	0.00	3.30	40.78
1.50 50 2.25	7.99	27.33	1.09	0.00	2.20	15.75
Beyond 2.25	1.60	0.00	0.55	0.00	0.00	0.00
Number	438	161	183	753	182	743

Table 1B Percentage Distributions of Deviations from Central Rates for Periods Bounded by Realignments: Italian Lira

Size of Deviation	Period							
	I	II	III	IV	V	VI	VII	VIII
Beyond -6.0	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00
-6.0 to -4.0	0.00	0.00	0.00	0.00	21.35	0.00	0.00	0.00
-4.0 to -2.0	0.00	0.00	1.86	42.08	17.88	2.40	12.64	0.00
-2.0 to 0.0	19.33	11.72	58.39	51.37	45.66	50.30	87.36	15.88
0.0 to 2.0	60.33	86.72	18.63	3.83	10.59	47.31	0.00	40.65
2.0 to 4.0	20.00	1.56	21.12	2.73	4.34	0.00	0.00	43.20
4.0 to 6.0	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.27
Number	300	128	161	183	576	167	182	743

If the null hypothesis, H = J, is true, then there should be close agreement between $H_m(t)$ and $J_n(t)$ for all values of t. The Kolmogorov-Smirnov two-sample test asks whether the maximum difference between $H_m(t)$ and $J_n(t)$ is sufficiently large to reject the null hypothesis. The test statistic is

$$D_{mn} = \max_t |(H_n(t) - J_m(t))|,$$

and the critical value for the 0.01 level of significance is approximated by

$$1.63\sqrt{\frac{n+m}{nm}}$$

Tests based on the Kolmogorov-Smirnov statistic are sensitive to all types of departures from the null hypothesis H = J and are therefore not sensitive to the particular type of difference between H and J.[9]

Tables 2A and 2B show the two sets of test results. In Table 2A, for the franc-DM rate, there are several significant differences between pairs of means,

and most of the Kolmogorov-Smirnov statistics exceed their critical values. But the third, fourth, and fifth distributions differ less among themselves than from the first, second, and sixth. In Table 2B, for the lira-DM rate, all but two differences between pairs of means are statistically significant, and all of the Kolmogorov-Smirnov statistics are significant. But the differences between the fourth, fifth, sixth, and seventh distributions are typically smaller than the differences between them and the eighth, measured by the size and significance of the test statistics.

Table 2A Significance Tests for Differences Between Distributions of Deviations from Central Rates for Periods Bounded by Realignments: French Franc

Period	Period				
	I	II	III	IV	V
Differences Between Means (z statistics):					
II	3.68*				
III	0.24	3.50*			
IV	1.30	3.32*	0.96		
V	0.83	3.69*	0.63	0.06	
VI	18.60*	6.89*	18.00*	28.40*	12.00*
Differences Between Distributions (Kolmogorov-Smirnov statistics):					
II	0.18*				
III	0.25*	0.26*			
IV	0.30*	0.27*	0.07		
V	0.13	0.25*	0.12	0.02	
VI	0.46*	0.38*	0.47*	0.41*	0.36*

*Statistically significant at the 0.01 level.

The formula for the critical value of the Kolmogorov-Smirnov statistic is given in the text; it depends on the sizes of the sample distributions, shown in Table 1A.

Table 2B Significance Tests for Differences Between Distributions of Deviations from Central Rates for Periods Bounded by Realignments: Italian Lira

Period	Period						
	I	II	III	IV	V	VI	VII
Differences Between Means (z statistics):							
II	9.18*						
III	6.79*	1.69					
IV	21.85*	16.80*	10.41*				
V	28.18*	23.19*	13.97*	3.43*			
VI	18.35*	11.08*	4.34*	9.28*	14.60*		
VII	38.53*	34.24*	13.59*	0.61	4.21*	17.80*	
VIII	2.98*	13.59*	8.79*	24.86*	31.92*	23.20*	47.95*
Differences Between Distributions (Kolmogorov-Smirnov statistics):							
II	0.19*						
III	0.41*	0.49*					
IV	0.74*	0.82*	0.40*				
V	0.66*	0.73*	0.38*	0.22*			
VI	0.33*	0.41*	0.21*	0.41*	0.37*		
VII	0.81*	0.88*	0.40*	0.29*	0.27*	0.47*	
VIII	0.23*	0.42*	0.44*	0.78*	0.69*	0.43*	0.84*

*Statistically significant at the 0.01 level.

The formula for the critical value of the Kolmogorov-Smirnov statistic is given in the text; it depends on the sizes of the sample distributions, shown in Table 1B.

We are therefore encouraged to set up a second set of tests. We set aside the first two subperiods for the franc and the first three for the lira (those ending with the realignment of June 1982). The distributions for these subperiods differ appreciably from all of the others (apart from the ones for the first and eighth in the case of the lira), and they may perhaps be deemed to represent a

learning period, early in the history of the EMS.[10] Next, we regroup the rest of the exchange-rate quotations into the distributions shown in Table 3, for the period before the Basle-Nyborg Agreement of September 1987 and the period after it. (The same distributions are depicted in Figures 4A and 4B and Figures 5A and 5B.) Because of indications noted earlier, moreover, that the French and Italian authorities were less tolerant of positive than negative deviations, we also show the distributions of the positive, weak-currency deviations before and after the agreement.

Table 3 Percentage Distributions of Deviations from Central Rates Before and After the Basle-Nyborg Agreement

French Franc			Italian Lira		
Deviation	Before	After	Deviation	Before	After
Positive and Negative Deviations					
Beyond -2.25	0.08	0.00	Beyond -6.0	0.08	0.00
-2.25 to -1.50	17.21	0.00	-6.0 to -4.0	9.65	0.00
-1.50 to -0.75	9.58	0.35	-4.0 to -2.0	16.25	0.00
-0.75 to 0.00	43.07	5.20	-2.0 to 0.0	53.22	6.93
0.00 to 0.75	29.05	21.66	0.0 to 2.0	18.45	37.09
0.75 to 1.50	0.47	52.51	2.0 to 4.0	2.35	55.63
1.50 to 2.25	0.47	20.28	4.0 to 6.0	0.00	0.35
Beyond 2.25	0.08	0.00	Beyond 6.0	0.00	0.00
Number	1284	577	Number	1274	577
Positive Deviations Only					
0.00 to 0.75	96.63	22.94	0.0 to 2.0	88.68	39.85
0.75 to 1.50	1.55	55.60	2.0 to 4.0	11.32	59.78
1.50 to 2.25	1.55	21.47	4.0 to 6.0	0.00	0.37
Beyond 2.25	0.26	0.00	Beyond 6.0	0.00	0.00
Number	386	545	Number	265	537

The results of significance tests for these distributions are shown in Table 4. The differences between the means are highly significant, and the z-statistics are much larger than those in Tables 2A and 2B for the differences between the final and previous subperiods (save for one involving the lira). The differences between the means of the positive (weak-currency) deviations are likewise very large. Furthermore, the Kolmorogov-Smirnov criterion rejects decisively the null hypothesis that there was no significant change in exchange-rate behavior after the Basle-Nyborg Agreement.[11]

Table 4 Significance Tests for Differences Between Distributions of Deviations from Central Rates Before and After the Basle-Nyborg Agreement

Currency	Differences Between Means (z statistics)	Differences Between Distributions (Kolmogorov-Smirnov statistics)
Distributions of Positive and Negative Deviations:		
French franc	47.41*	0.718*
Italian lira	48.75*	0.699*
Distributions of Positive Deviations:		
French franc	35.2*	0.737*
Italian lira	19.1*	0.488*

*Statistically significant at the 0.01 level.

The formula for the critical value of the Kolmogorov-Smirnov statistic is given in the text. It depends on the sizes of the sample distributions, shown in Table 3.

Who Done It?

We conclude by examining two objections to our main result, concerning the effects of the Basle-Nyborg Agreement. The first has to do with the effectiveness of intervention. If intervention is ineffective, especially when sterilized, differences between the distributions of exchange rates cannot possibly reflect a change in the strategy governing intervention. The second objection is more general. The wider fluctuations of EMS exchange rates after the Basle-Nyborg Agreement may reflect the influence of market forces rather than the influence of intervention.

It is not hard to defend the basic target-zone model against the first objection. Because it relies on a monetary model of exchange-rate determination, in which governments can influence exchange rates only by acting on the fundamentals, it avoids the debate about the effectiveness of intervention. If the fundamentals affect the exchange rate, then governments can affect it too, by using nonsterilized intervention to alter the fundamentals. But intervention in the EMS has not always acted on the fundamentals identified by the monetary model, because some of it has been sterilized (see, e.g., Mastropasqua, Micossi, and Rinaldi, 1988).

The monetary model itself, however, depends on assumptions that have been called into question by empirical work. For a recent survey, see Boughton (1988). Even if that were not so, moreover, there would be reason to believe that intervention, even when sterilized, can influence exchange-rate behavior in the short run. First, it can influence some of the fundamentals. Second, it can influence expectations, including, but not exclusively, expectations about the fundamentals. For evidence concerning both possibilities, see Dominguez (1990), Dominguez and Frankel (1990), and the survey of earlier work in Kenen (1987).

The second objection is harder to answer. We have no way to *prove* that the large and frequent weak-currency deviations shown by the French franc in the years after the Basle-Nyborg Agreement were not due to market forces--that the franc was not weaker intrinsically in those years than it was before. On that hypothesis, however, one would expect less evidence of large-scale intervention in the years before the Basle-Nyborg Agreement than in the years following.

What can one say, then, about the amounts of intervention before and after the Basle-Nyborg Agreement? Reserve statistics do not tell us very much, because reserves can change for other reasons and may not always change when intervention does take place. The problem is illustrated vividly by Mastropasqua, Micossi, and Rinaldi (1988), who report changes in reserves (net of valuation changes) and amounts of intervention by France, Germany, and Italy in 1983-1985 (figures in billions of US dollars):

Country	Cumulative Intervention	Increase in Reserves
France	2.7	9.6
Germany	-19.3	1.6
Italy	-3.1	0.8

But Edison and Kaminsky (1990) have gathered data on the *frequency* of French intervention during the subperiods studied in this paper, and we reproduce them in Table 5. These data do not say anything about the volume of intervention (and do not segregate instances of intervention related to conditions in the EMS from instances related to other objectives, such as the aims of the Plaza and Louvre Agreements). Nevertheless, they are suggestive. Intervention was far less frequent in Period VI (which includes but does not coincide precisely with the period after the Basle-Nyborg Agreement examined in Tables 3 and 4) than it was in Periods III through IV, before the Basle-Nyborg Agreement.[12] Thus, the data

indicate compliance with both objectives of the Basle-Nyborg Agreement--the avoidance of "prolonged bouts of intervention" as well as making full use of the band. The franc was allowed to display more weakness than it had before, by way of the change in regime.

Table 5 The Frequency of French Intervention in Periods Between Realignments

Period	Days on Which			Percentage of Days On Which	
	Bought Dollars	Sold Dollars	Did Not Buy or Sell	Bought	Sold
I	173	101	256	32.6	19.1
II	62	56	62	34.4	31.1
III	62	74	64	31.0	37.0
IV	419	141	235	52.7	17.7
V	97	23	80	48.5	11.5
III-V	578	238	379	48.4	29.9
VI	190	84	619	21.3	9.4

Source: Edison and Kaminsky (1990)

All periods include weeks adjacent to realignments (and Period I begins on September 24, 1979, while Period VI ends on June 13, 1990). Data do not include instances of intervention in currencies other than the U.S. dollar.

FIGURE 1A

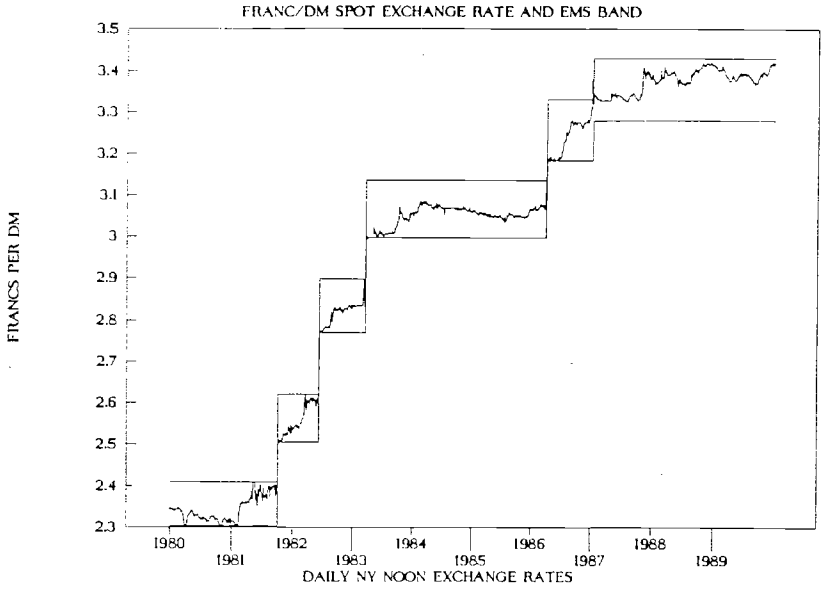

FRANC/DM SPOT EXCHANGE RATE AND EMS BAND
FRANCS PER DM
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
DAILY NY NOON EXCHANGE RATES

FIGURE 1B

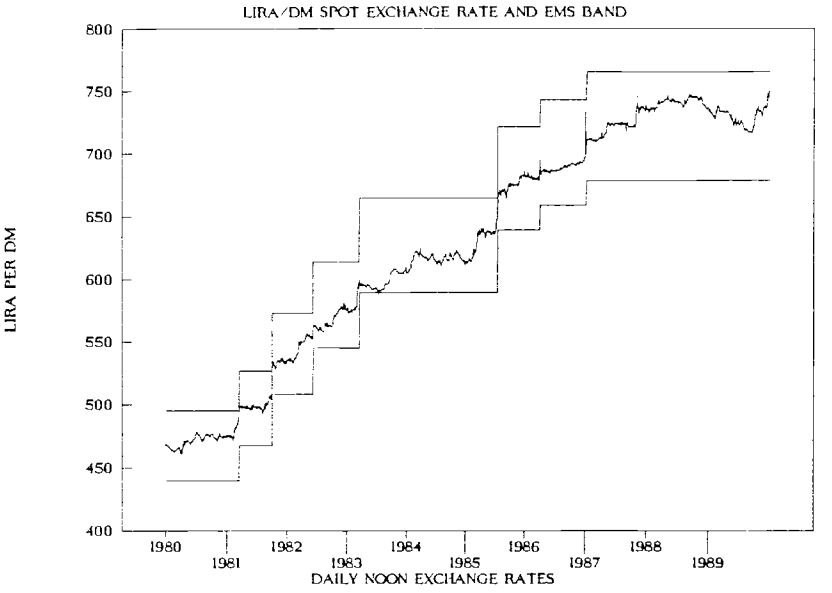

LIRA/DM SPOT EXCHANGE RATE AND EMS BAND
LIRA PER DM
800
750
700
650
600
550
500
450
400
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
DAILY NOON EXCHANGE RATES

FIGURE 2

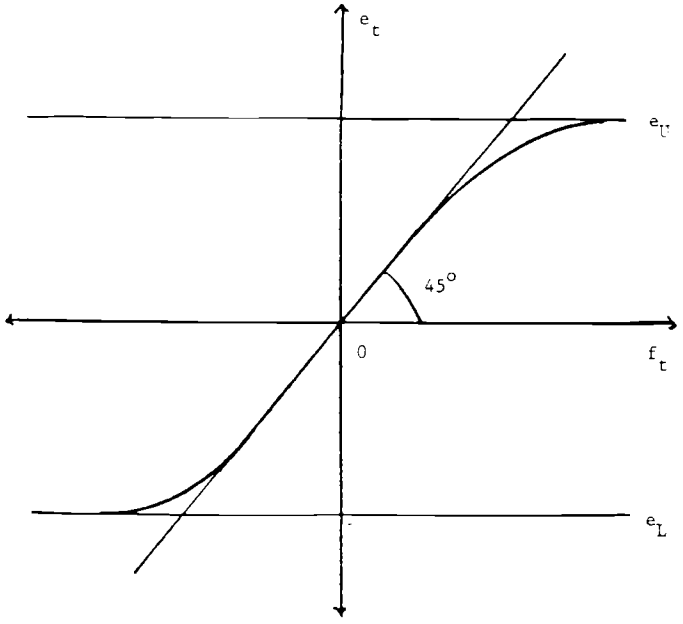


FIGURE 3A

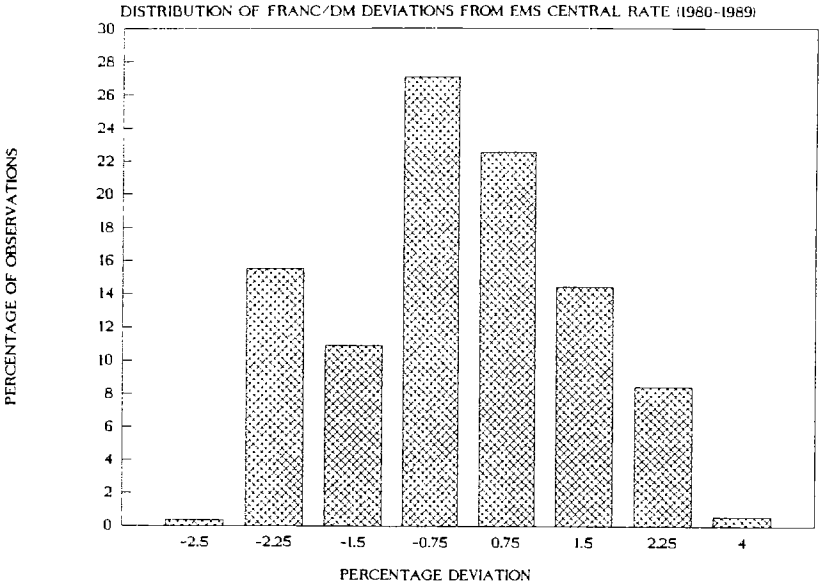

DISTRIBUTION OF FRANC/DM DEVIATIONS FROM EMS CENTRAL RATE (1980-1989)
PERCENTAGE OF OBSERVATIONS
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2.5
-2.25
-1.5
-0.75
0.75
1.5
2.25
4
PERCENTAGE DEVIATION

FIGURE 3B

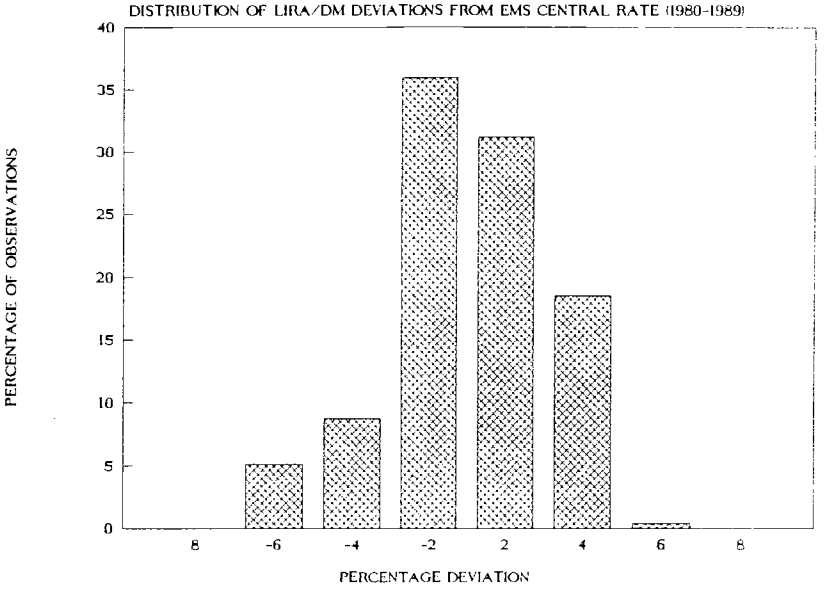

DISTRIBUTION OF LIRA/DM DEVIATIONS FROM EMS CENTRAL RATE (1980-1989)
PERCENTAGE OF OBSERVATIONS
40
35
30
25
20
15
10
5
0
-8
-6
-4
-2
2
4
6
8
PERCENTAGE DEVIATION

FIGURE 4A

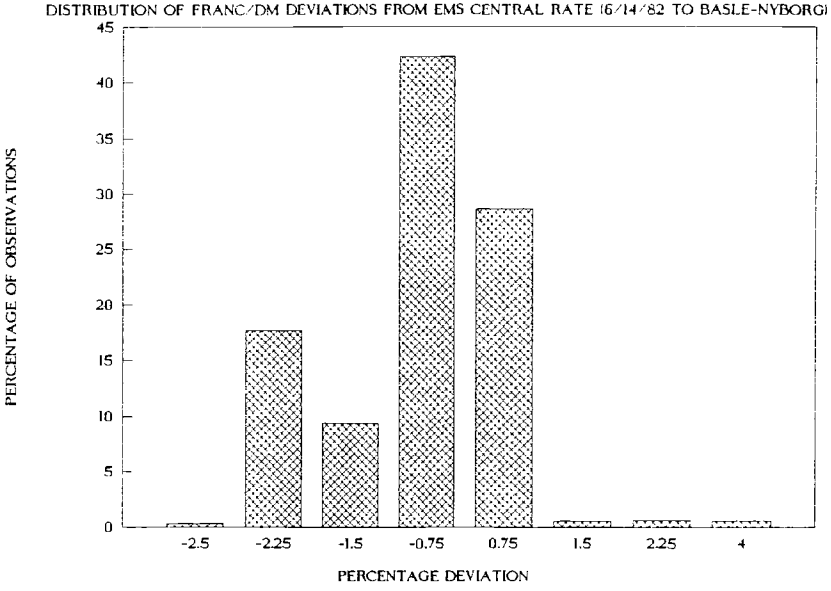

DISTRIBUTION OF FRANC/DM DEVIATIONS FROM EMS CENTRAL RATE (6/14/82 TO BASLE-NYBORG)
PERCENTAGE OF OBSERVATIONS
45
40
35
30
25
20
15
10
5
0
-2.5
-2.25
-1.5
-0.75
0.75
1.5
2.25
4
PERCENTAGE DEVIATION

FIGURE 4B

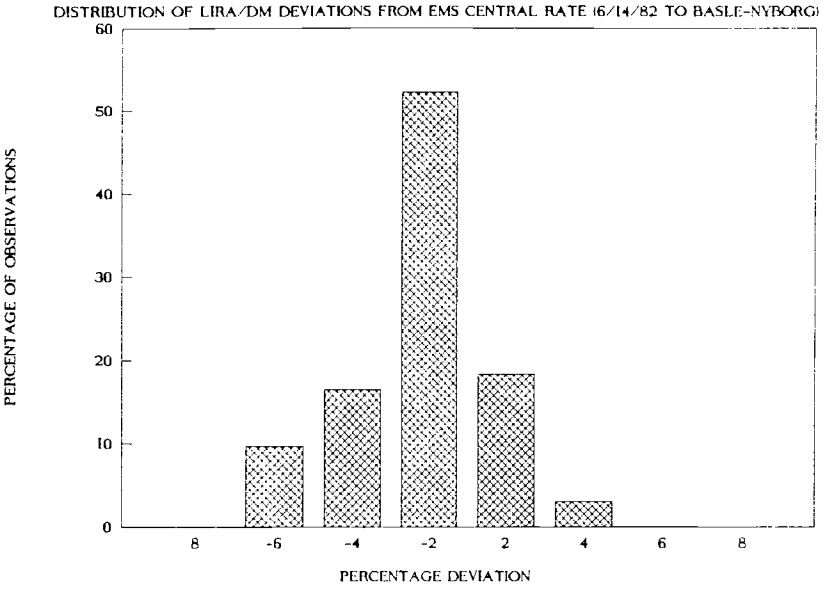

DISTRIBUTION OF LIRA/DM DEVIATIONS FROM EMS CENTRAL RATE 16/14/82 TO BASLE-NYBORG
PERCENTAGE OF OBSERVATIONS
60
50
40
30
20
10
0
8
-6
-4
-2
2
4
6
8
PERCENTAGE DEVIATION

FIGURE 5A

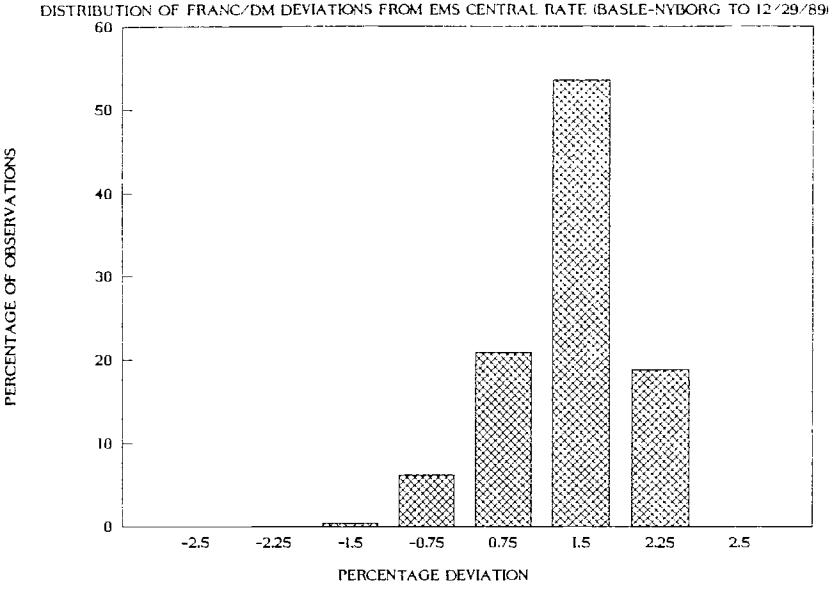
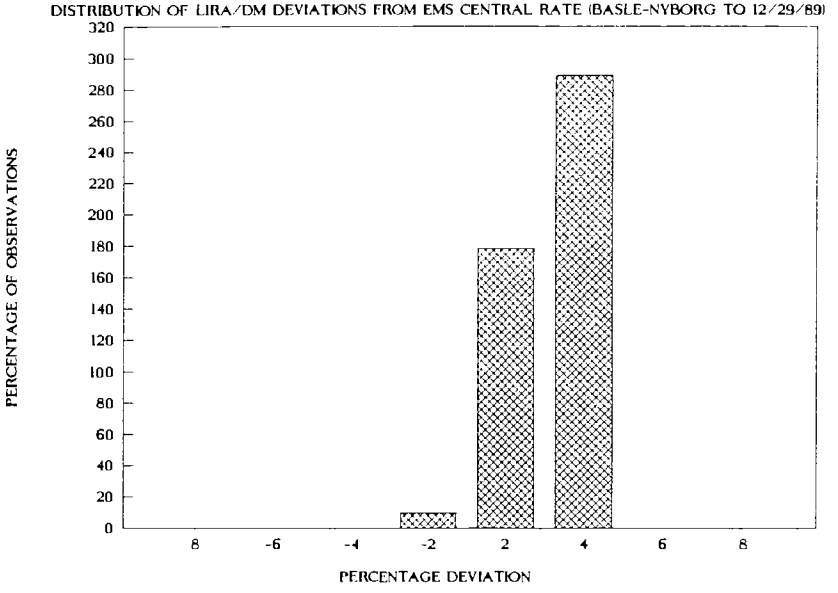

DISTRIBUTION OF FRANC/DM DEVIATIONS FROM EMS CENTRAL RATE (BASLE-NYBORG TO 12/29/89)
PERCENTAGE OF OBSERVATIONS
60
50
40
30
20
10
0
-2.5
-2.25
-1.5
-0.75
0.75
1.5
2.25
2.5
PERCENTAGE DEVIATION

FIGURE 5B


DISTRIBUTION OF LIRA/DM DEVIATIONS FROM EMS CENTRAL RATE (BASLE-NYBORG TO 12/29/89)
PERCENTAGE OF OBSERVATIONS
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
8
-6
-4
-2
2
4
6
8
PERCENTAGE DEVIATION

Notes

1. This may help to explain why the French authorities abandoned their narrow-band policy at times when the franc was very weak. By allowing the exchange rate to move to the edge of the band, they forced the Bundesbank to intervene (and could use the credit facilities of the EMS to finance their own interventions).

2. In light of the way in which eq. (1) is used below, however, f_t *has* to be associated with the exogenous variables identified by the monetary model. This is because the target-zone model represents official intervention as a change in f_t rather than a change in e_t *given* f_t. In other words, the target-zone model ascribes the influence of intervention to its effect on the money supply. It would perhaps be more realistic to regard f_t as a slowly moving representation of the domestic inflation rate, given the foreign rate, and to model two policy responses: sterilized intervention in the foreign-exchange market to modify the behavior of e_t, given the path of f_t, and the adjustment of monetary policy to modify gradually the path of f_t. This approach might also permit one to model realignments realistically, rather than treat them as purely stochastic events, as in Bertola and Svennson (1990). A realignment would occur when it was not possible to keep e_t within the target zone by the use of intervention without running out of reserves, but too costly to modify f_t in a way that would keep e_t within the zone without the use of intervention.

3. Exchange rates for the franc and lira have crossed the edges of their bands on a few occasions. Some of these instances reflect the fact that our data come from the New York market, not from European markets, and EMS central banks are not required to intervene outside Europe to carry out their obligations. In at least one instance, however, the Bank of France withdrew from European exchange markets on the eve of a realignment, letting the franc float, rather than use its reserves to defend a band that was about to change (see, e.g., Ungerer, et al. 1990, p. 51). Finally, the Bank of France has not always intervened on the scale required to force the franc into its new band immediately after a realignment; had it driven the franc all the way into the new band, it would have increased the profits of market participants who had sold francs before the realignment. This was a way to honor informally a well-known rule, that the new and old bands should overlap, when the actual size of the realignment kept this from happening formally (see, e.g., Kenen 1988, ch. 3). Because the band for the lira was much wider than that for the franc, the Italian authorities have been able to honor the rule formally; the new and old bands have overlapped.

4. Svensson (1990a, 1990b) examines the implications of the target-zone model for interest-rate differentials and goes on to show that Swedish data for 1985-89 provide some support for the model. Bertola and Caballero (1990), however, find that Franco-German and Italo-German interest-rate differentials do not support a version of the model involving a credible commitment to defend the bands; the interest-rate differentials tend to predict a further depreciation of the franc and lira when the exchange rates approach the upper edges of their bands.

5. Klein and Lewis (1990) use DM-dollar and yen-dollar data for the period around the Louvre Accord of 1987 to identify market participants' perceptions regarding the width and position of the implicit target zone adopted for the dollar. They find that the zone perceived by the market fluctuated significantly through time and suggest that this may explain why EMS data do not yield a time-invariant non-linear relationship. Published accounts suggest, however, that the implicit zones for the DM-dollar and yen-dollar exchange rates varied in width as well as position and were less rigidly defended than the EMS zones (see, e.g., Funabashi, 1988, and Dobson, 1991). They were what Frenkel and Goldstein (1986) call "soft" target zones and what Pesenti (1990) calls "permeable" target zones.

6. Bodnar and Leahy (1990) find evidence of an inverted half-S-shaped relation between e_t and f_t consistent with the Bertola-Caballero hypothesis concerning expectations about realignments. They also find, however, that future realign- ments are discounted at a much higher rate than theory would predict.

7. The realignments affecting the franc took effect on October 5, 1981, June 14, 1982, March 21, 1983, April 7, 1986, and January 12, 1987, which are the starting dates for Periods II through VI in Table 1A. The realignments affecting the lira took effect on those same dates and on March 23, 1981 and July 22, 1985, which are the starting dates for Periods II through VIII in Table 1B. The first period for each currency begins with the exchange-rate quotation for January 2, 1980, although the previous realignment affecting the franc and lira took effect on September 24, 1979. The last period for each currency ends with the exchange-rate quotation for December 29, 1989.

8. See note 3 above, which explained why the franc was allowed to remain below its band right after some realignments; the same strategy explains why the Bank of France allowed the rate to remain at or near the lower (strong-currency) edge of the band for several days or weeks after a realignment.

9. For a fuller account, see Pratt and Gibbons (1981, ch. 17). It should be noted that the test described above assumes that the data are independently distributed. That is not true of the exchange-rate data studied here; they are serially correlated.

10. Recall the point made by Ungerer et al. (1986), that central banks did not begin immediately to keep their exchange rates well within the band but adopted that strategy only when they came to believe that it might prevent speculation from building up and might promote monetary stability.

11. It should perhaps be noted that *all* of the results reported above cast doubt on the validity of the procedure commonly used in testing the target-zone model with EMS exchange-rate data. They warn that those data should not be deemed to come from a single distribution. The differences between pairs of means, however, lend some support to the approach adopted by Pesenti (1990), who suggests that the EMS countries have been defending target rates (different from the central rates), rather than defending target zones. (Unfortunately, his hypothesis cannot be tested merely by comparing the mean deviations from the central rates for the various subperiods; inspection of the data in Figures 1A and 1B suggests that the target rates, if they existed, changed within subperiods between realignments.)

12. These data, however, may understate the relative frequency of intervention in recent years, insofar as there has been a shift to the use of EMS currencies rather than the U.S. dollar.

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