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Intramarginal intervention in the EMS and the target-zone model of exchange-rate behavior*

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Exchange-rate data produced by the European Monetary System (EMS) contradict important predictions made by the standard target-zone model. We show that the contradictions reflect a misinterpretation of policies pursued by the EMS countries. They intervened intramarginally, to keep exchange rates well within their bands, not at the edges of the bands, to keep rates from crossing them. In the Basle–Nyborg Agreement of 1987, however, they agreed to make fuller use of the band, and exchange rates behave differently thereafter. The effect appears clearly in the behavior of the French franc and less decisively in the behavior of the Italian lira. We conclude by examining and rejecting other explanations for the observed difference in exchange-rate behavior.

1. Introduction

Governments adhering to the exchange-rate rules of the European Monetary System (EMS) must keep the spot exchange rates for their currencies inside narrow bands. During the period 1979–1989, the band for the French franc had a width of 4.5% (2.25% on each side of its central rate), and the band for the Italian lira had a width of 12%. Yet the actual rate for the franc remained in a narrower range during most of the period, and the lira was always within a narrower range.

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We argue that the behavior of those exchange rates reflected a deliberate effort by the governments concerned to keep them well within the bands. The strategy was implemented by official intervention in the foreign-exchange market and, at times, by interest-rate policies. The rationale for the strategy was stated succinctly 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% 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.

When central banks intervened intramarginally they were not permitted to draw on the credit facilities of the EMS. In so doing they had frequently to act unilaterally, because the Bundesbank did not engage in intramarginal intervention 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 intramarginal intervention and, as a *quid pro quo*, 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 offers evidence that the Basle–Nyborg Agreement was taken seriously. Actual exchange-rate behavior was significantly different after the agreement than it was before, particularly in the case of the franc. This finding has two implications. First, governments may mean what they say – a possibility often discounted by economists. Second, intramarginal intervention may explain why EMS exchange rates have not conformed to the principal predictions of the target-zone model.

We begin by reviewing the main features and predictions of the target-zone

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

model and relevant empirical work. We go on to examine the behavior of EMS exchange rates to test for a regime change after the Basle–Nyborg Agreement. Finally, we defend our interpretation of the shift in exchange-rate behavior against a different interpretation – that markets, not governments, were responsible for it.

2. The main features and implications of the target-zone model

The target-zone model of exchange-rate behavior was developed by Krugman (1987) and refined by Froot and Obstfeld (1991), Flood and Garber (1991), and Krugman (1991). It is based on a simple equation linking the log of the exchange rate, e_t, with a univariate representation of the fundamentals determining the rate, f_t, and with the expected change in e_t:

$$e_t = f_t + \alpha \frac{1}{dt} \mathrm{E}_t \, de_t,$$

where f_t is assumed to follow Brownian motion. Whenever e_t reaches the upper or lower edge of the band defining the target zone, the monetary authorities intervene to halt it, and this is done by changing f_t itself (not by acting directly on e_t, *given* f_t).

Under the assumptions of the target-zone model, a credible commitment to intervene at both edges of the band produces an S-shaped curve linking the exchange rate to the fundamentals. If the unconditional distribution of the f_t is uniform within the band, then the unconditional distribution of the e_t will be bi-modal, with a high frequency of observations at each edge of the band.[2]

Several empirical studies have used EMS exchange-rate data to test the target-zone model, because EMS rules appear to resemble the main features of the model. Although there have been several realignments since 1979, the year the EMS was inaugurated, the exchange-rate bands are narrow and have been defended firmly between realignments.[3] But exchange-rate behavior in the EMS fails to conform to the principal predictions of the

[2]The S-shaped relationship also implies that the variance of e_t will fall as the exchange rate approaches the edge of the band; the flatter the relationship between e_t and f_t, the smaller the response of e_t to a given change in f_t.

[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, and EMS central banks are not required to intervene outside Europe. In at least one instance, however, the Bank of France allowed the franc to float on the eve of a realignment [see, e.g., Ungerer et al. (1990, p. 51)]. Furthermore, it has not always intervened on the scale required to force the franc into its new band right after a realignment. (By forcing the franc into the new band, it would have increased the profits of those who had sold francs before the realignment.)

target-zone model. The franc–DM and lira–DM exchange rates have tended to cluster in the middle of the band. Furthermore, econometric tests have failed to establish that the S-shaped relationship between e_t and f_t is in fact nonlinear. [See e.g., Bertola and Caballero (1992), Bodnar and Leahy (1990), and Flood et al. (1991).]

In his initial formulation of the target-zone model, Krugman (1987, 1991) allowed official intervention only at the edges of the band. This was sufficient for his purpose – to show that a credible commitment to the band could keep the exchange rate inside it without any actual intervention (i.e., that stabilizing speculation would substitute for intervention). But EMS central banks have intervened within the band, and anyone using EMS data to verify the forecasts of the target-zone model must allow for the influence of that intervention. The work described below suggests that intramarginal intervention may be a major reason for differences between the behavior of EMS exchange rates and the predictions of the model.

3. Another look at EMS experience

The franc was allowed to reach the lower limit of its band for many weeks in 1980 and in early 1981 and was at or near the upper limit for many weeks in 1981 and 1982. Thereafter, however, it remained 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 approached the upper limit of the band several times in 1988 and 1989. The lira has been allowed to touch both limits of its band, but not very often. Fewer than 0.4% of the daily exchange-rate quotations were closer than 2 percentage points to the upper limit, and fewer than 5.1% were that close to the lower limit.[4] In 1988 and 1989, however, the lira appears to have spent far more time in the upper portion of its band.

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

There were five realignments of the franc–DM rate in the 1980s and seven realignments of the lira–DM rate. Table 1 shows distributions of daily

[4]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% of the daily quotations were closer than 0.75 percentage points to the upper, weak-currency limit, but 15.1% were that close to the lower, strong-currency limit.

Table 1

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 to 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

quotations for the franc in the six subperiods set off by the realignments.[5] The data exclude quotations for the weeks adjacent to the realignments, because the Bank of France reports that it shifted temporarily to a different strategy right before a realignment and seems to have pursued another strategy right after a realignment.[6]

There are visible differences among the distributions in table 1 and in their counterparts for the lira, but are they significant? First, we ask if they have different means. Second, we apply 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 independently distributed populations of a variable x and use $H(x)$ and $J(x)$ to denote the (unspecified) cumulative density functions for those populations. We can estimate the functions H and J from the empirical distribution functions $H_m(x)$ and $J_n(x)$, where m and n are the numbers of observations in the samples. If the null hypothesis, $H=J$, is true, there

[5]Tables pertaining to the lira have been omitted for brevity. They can be obtained from the authors and are presented in Dominguez and Kenen (1991). Realignments affecting the franc–DM rate took effect on October 5, 1981, June 14, 1982, March 21, 1983, April 7, 1986, and January 12, 1987, and these were the starting dates for periods II–VI in table 1. Realignments affecting the lira–DM rate took effect on those same dates and on March 23, 1981 and July 22, 1985 (which were the starting dates for periods II–VIII used in corresponding work on the behavior of the lira). The first period for each currency begins on January 2, 1980, although the previous realignment affecting the franc and lira took effect on September 24, 1979. The final period for each currency ends on December 29, 1989.

[6]See the Bank of France quotation in the text above (and comment in note 3, explaining why the franc was allowed to remain below the lower, strong-currency limit of its band right after certain realignments). In the case of the franc, the omitted quotations account for 7.4% of all quotations closer than 0.75 percentage points to the upper limit of the band and for 5% of all quotations closer than 0.75 percentage points to the lower limit. In the case of the lira, they account for 67% of quotations closer than 2 percentage points to the upper limit but for less than 4% of quotations closer than 2 percentage points to the lower limit.

should be close agreement between $H_m(x)$ and $J_n(x)$ for all x. The Kolmogorov–Smirnov two-sample test asks whether the maximum difference between $H_m(x)$ and $J_n(x)$ is large enough to reject the null hypothesis.[7] The test statistic is

$$D_{mn} = \max_x |(H_n(x) - J_m(x))|,$$

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

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

Exchange rates are known to be serially correlated, and the sample distributions of the franc and lira deviations from their central rates violate the Kolmogorov–Smirnov assumption of independence. But Boldin (1982) and Pierce (1985) show that test statistics computed from autoregressive residuals have the same limiting null distributions as statistics computed from independent observations. Hence, we applied the Kolmogorov–Smirnov test to residuals from an ARMA(1, 1) regression of the franc and lira deviations from their central rates.[8]

Table 2 shows the two sets of test results for the franc–DM rate. There are many significant differences between pairs of means, and some 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 distributions. (In the case of the lira–DM rate, all but two differences between pairs of means are statistically significant, as are several of the Kolmogorov–Smirnov statistics. But the fourth, fifth, sixth and seventh distributions tend to differ less among themselves than from the eighth distribution, measured by the sizes of the test statistics.)

We are therefore encouraged to perform another set of tests. We put 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 those subperiods differ appreciably from most of the others, and may represent a learning period, early in the history of the EMS. Next, we regroup the rest of the exchange-rate quotations into the distributions shown in table 3, for the periods before and after the Basle–Nyborg Agreement of September 1987. Since the French and Italian authorities appear to have been less tolerant of

[7]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. For a full account, see Pratt and Gibbons (1981, ch. 17).

[8]The ARMA(1, 1) models of the franc and lira deviations were estimated using non-linear least squares. The AR coefficient were 0.98 and 0.99, and the MA coefficient were 0.13 and 0.11, for the franc and lira, respectively. The four coefficients were statistically significant at the 0.01 level.

Table 2

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[a]				
III	0.24	3.50[a]			
IV	1.30	3.32[a]	0.96		
V	0.83	3.69[a]	0.63	0.06	
VI	18.60[a]	6.89[a]	18.00[a]	28.40[a]	12.00[a]
Differences between distributions (Kolmogorov–Smirnov statistics)[b]					
II	0.10				
III	0.10	0.13			
IV	0.12[a]	0.20[a]	0.07		
V	0.11	0.12	0.04	0.08	
VI	0.13[a]	0.16[a]	0.14[a]	0.10[a]	0.14[a]

[a]Statistically significant at the 0.01 level.

[b]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 1.

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	1,284	577	Number	1,274	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

positive than negative deviations, we also show distributions of the positive (weak-currency) deviations before and after the agreement.

The results of significance tests for these distributions are shown in table 4.

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)[a]
Distributions of positive and negative deviations		
French franc	47.41[b]	0.13[b]
Italian lira	48.75[b]	0.11[b]
Distributions of positive deviations		
French franc	35.2[b]	0.10[c]
Italian lira	19.1[b]	0.09[c]

[a]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.
[b]Statistically significant at the 0.01 level.
[c]Statistically significant at the 0.05 level.

The difference between the means are highly significant, and the z-statistics are much larger than those in table 2 for the differences between the final and previous subperiods. The differences between the means of the positive (weak-currency) deviations are likewise very large. Furthermore, the Kolmogorov–Smirnov criterion rejects decisively the null hypothesis that there was no significant change in exchange-rate behavior after the Basle–Nyborg Agreement.

4. Concluding comments

We close by examining two potential difficulties with our interpretation of the evidence. The first has to do with the effectiveness of intervention. If intervention is ineffective, especially when sterilized, the differences between the distributions of exchange rates cannot possibly represent a change in the strategy governing intervention. The second difficulty is more general. The wider fluctuations of EMS exchange rates after the Basle–Nyborg Agreement may reflect the influence of market forces rather than a change in intervention strategy.

The target-zone model is based on the monetary model of exchange-rate determination. Intervention is represented by a change in f_t, which drives the whole model. But intervention in the EMS has not always taken this simple form. Some of it has been sterilized [see, e.g., Mastropasqua et al. (1988)]. Recent empirical work, however, leads us to believe that sterilized intervention can affect exchange rates. First, it can influence some fundamentals relevant to models of exchange-rate behavior as long as foreign and domestic bonds are not perfect substitutes. 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 earlier work surveyed in Kenen (1987).

The second difficulty is subtler. The large and frequent weak-currency deviations shown by the French franc in the two years after the Basle–Nyborg Agreement may be due to market forces rather than a change in intervention policy. On that supposition, however, one would expect *less* evidence of large-scale intervention in the years before the Basle–Nyborg Agreement than in the years following.

What do we know about the amounts of intervention before and after the agreement? Unfortunately EMS intervention data are not publicly available. However, Edison and Kaminsky (1990) present data on the *frequency* of French intervention during the subperiods between realignments.[9] 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 *more* frequent in Periods III–V than it was in Period VI (which includes but does not coincide exactly with the period after the Basle–Nyborg Agreement).[10] Thus, the data are consistent with compliance with both aims of the Basle–Nyborg Agreement – avoiding 'prolonged bouts of intervention' as well as making fuller use of the band. The franc was allowed to display more weakness than it had before.

[9]Data on reserve changes are publicly available. However, as Mastropasqua et al. (1988) show, changes in reserves are poor proxies for amounts of intervention. They show that changes in reserves differ both in sign and size from actual intervention figures for France, Germany and Italy in 1983–1985.

[10]The data presented in Edison and Kaminsky (1990) do not include instances of intervention in currencies other than the U.S. dollar. Therefore, they may understate the relative frequency of intervention in recent years, insofar as there has been more use of EMS currencies.

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