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THE EUROPEAN MONETARY SYSTEM: CREDIBLE AT LAST?

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ABSTRACT

We update tests of the credibility of the EMS exchange rate target zones. Our main methodological innovation is to use a survey of exchange rate forecasts, as well as interest differentials, in measuring exchange rate expectations. We investigate the hypothesis -- suggested by the apparent stabilization of the EMS and by recent institutional developments -- that the EMS target zones have experienced an increase in credibility since their 1987 realignment. The evidence tends to support this hypothesis for most currencies. We also examine the empirical failure of standard target zone models, but find no evidence that it can be attributed to mismeasurement of expectations. Finally, we consider an alternative credibility measure which captures the importance of possible realignments in overall expectations of exchange rate changes.

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I. INTRODUCTION

The exchange rate mechanism of the European Monetary System (EMS) began in 1979 as an arrangement among eight European countries to limit fluctuations among their currencies. Intra-European exchange rates would be allowed to fluctuate only within official limits, to be defended by exchange market intervention. Such an arrangement is called an exchange rate target zone.

Much research has modelled the target zone, beginning, in the case of the theoretical research, with Krugman [1991]. Yet empirical research has been unable to fit the European data to the standard target zone model. Flood, Rose and Mathieson [1990] examine many implications of the basic target zone model and find little evidence in its favor. Perhaps the most telling finding is the simple test of target zone credibility proposed by Svensson [1990b]: expected future exchange rates -- constructed using the uncovered interest parity assumption -- were found to lie nearly always outside current EMS target zones for the period 1979 through early 1990. This result suggests that the market during this period usually perceived a strong probability of realignment of the official exchange rate bands.

In this paper we update the tests of EMS credibility, focussing on the period 1987-1991. Our main methodological innovation is our use of survey data, supplementing interest differentials as a measure of market expectations. The potentially important advantage of using survey data is immunity to errors introduced by exchange risk premiums.[1]

We investigate the hypothesis, suggested by the apparent stabilization of the EMS and by institutional developments within the European Community, that the EMS target zones have recently experienced a significant gain in credibility. Our findings, based both on survey data and interest differentials, tend to support this view for most EMS currencies' relationship against the German mark (DM). We do not reject the hypothesis that the Dutch guilder has been credible all along; for the other currencies we generally find evidence of increasing credibility, especially since January 1990. Evidence from the first half of 1991 suggests that the credibility of the EMS, while still imperfect, is the highest in the system's 12-year history.

With regard to policy implications, we note that the interesting effects of exchange rate target zones -- such as the "honeymoon effect" demonstrated in theory by Krugman [1991] -- are dependent on the credibility of the regime. It may be that the EMS is at last in a position to enjoy such a honeymoon.

In addition to testing target zone credibility, we also consider whether the empirical failure of the standard target zone model --

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[1] Much has been written on the question of whether the exchange risk premium is large and variable enough to render the forward discount rate or interest differential a deficient measure of the expected future spot rate. Studies such as Fama [1984], Hodrick and Srivastava [1986], Cumby and Obstfeld [1984], and Giovannini and Jorion [1988] find what they consider to be evidence of a large and variable risk premium. Studies such as Frankel [1982], Froot and Frankel [1989], and Svensson [1990a], on the other hand, argue that the risk premium may be small in magnitude or variability. For a recent discussion of risk premia within the EMS, see Giovannini [1990].

first documented by Flood, Rose and Mathieson [1990] -- might reflect only an erroneous assumption of uncovered interest parity. However, our findings using survey data lead us to dismiss this possibility.

We are instead attracted to a new explanation, based on time-varying credibility, recently advanced by Bertola and Svensson [1990]. Indeed, our analysis suggests that time-varying credibility would be particularly relevant during the period we study. Returning to the credibility question, we use the Bertola-Svensson framework to estimate the expected rate of revaluation.[3] Although based on the overall expected rate of change of the exchange rate, this construct may be a superior indicator of credibility because expected mean-reversion within the target zone has been filtered out. We find ample evidence of changing credibility.

The organization of the paper is as follows. The next section briefly describes the sample and data. Section III provides background on EMS operation, recapitulating the evidence against the credibility of the target zones during the period 1979-1986. In Section IV we use survey data to assess the credibility of the current target zone regime, established in January 1987. We address the empirical failure of target zone models in Section V. After reviewing the elements of the standard model, we use both survey data and interest rate data to test its most fundamental

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[3] Rose and Svensson [1991] have also implemented the Bertola-Svensson framework for the French franc/DM target zone.

implication. In Section VI we use the time-varying credibility framework of Bertola and Svensson to estimate the expected rate of revaluation. Section VII summarizes and concludes.

II. SAMPLE AND DATA

The currencies we study are those of all current participants of the Exchange Rate Mechanism (ERM) of the European Monetary System.[3] These include the seven original participants (Belgium,[4] Denmark, France, Germany, Ireland, Italy, and the Netherlands) as well as Spain and Britain (which joined in June 1989 and October 1990, respectively).

In practice the EMS operates as a bilateral parity grid. With nine currencies now participating, a total of 36 bilateral currency relationships is implied. Official "central" rates are established for each relationship. Around these central rates fluctuations are limited to ±2.25% (±6% for newcomers Spain and Britain, and formerly for Italy). We focus on the eight exchange rates with respect to the German mark (DM).

In addition to readily available data for spot exchange rates and Eurocurrency interest rates, we use exchange rate expectations survey data reported in the monthly Currency Forecasters' Digest

[3] Membership in the European Monetary System (EMS) does not require participation in its ERM. However we follow popular terminology and refer to the exchange rate mechanism as "the EMS."

[4] Belgium and Luxembourg, both EMS members, are joined in a currency union. For brevity we refer only to Belgium and the Belgian Franc throughout.

(hereafter, "CFD").[5] The data set includes forecasts of future exchange rates at horizons of 1, 3, and 12 months. We also examine 5-year forecasts, although these are available only at a quarterly frequency.

The available survey data span the period February 1988 through July 1991, about 40 monthly observations.[6] Note that no realignments have occurred during this period.[7]

III. THE BACKGROUND: EMS OPERATION, 1979-1986

The inception of the EMS in 1979 was greeted skeptically by many. The break-up of the prior "Snake" regime did not inspire confidence in governments' willingness or ability to keep major European currencies together, and there was considerable divergence in the policies and performance of the participants. Yet the EMS did not break apart: in contrast to the record under the Snake, no currency has ever left the system. The EMS survived its turbulent first years through a sequence of realignments (devaluations against the DM). Thus commitments to maintain exchange rates

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[5] These data are proprietary with Currency Forecasters' Digest of White Plains, New York. The survey has apparently been conducted for some years, but the subscription of the Institute for International Economics only extends back to 1988.

[6] Our data set has three missing observations: November 1989, February 1990, and April 1990.

[7] The last EMS realignment occurred in January 1987. In January 1990 the bands for the Italian Lira were narrowed from ±6% to the norm of ±2.25%. The transition was accomplished by lowering the upper band limit and leaving the lower limit unchanged.

within announced bands were "fulfilled" by periodically shifting those bands.

Indeed, the original EMS parity grid lasted only six months. Until recently realignments of central rates have been a basic fact of EMS operation. The history of these realignments is summarized in Figure 1, which presents time series plots of (log) central rates against the DM for each of the six other original EMS members.[6] The chart illustrates the following points. EMS realignments have been relatively frequent and large, at least cumulatively. No fewer than 11 realignments occurred during the first eight years. These realignments have always taken the form of devaluations, in varying degrees, against the DM; no currency has been revalued against the DM. Only the Dutch guilder has maintained a nearly fixed rate against the DM, undergoing only two small devaluations (and none since 1983).

More recent years have seen more stability within the EMS. On January 12, 1987, the last EMS realignment occurred. The current regime, in its fifth year as of 1991, is by far the longest.

Low Credibility: Evidence from Interest Rates

Prior research suggests that the announced exchange rate target zones had little credibility during much of EMS history. Here we review the evidence on this point based on interest rate differentials.

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[6] In each case, the March 1979 DM rate has been standardized to unity so that its natural logarithm equals zero.

If uncovered interest parity holds, interest differentials can be combined with contemporaneously observed spot exchange rates to calculate expected future exchange rates. We construct 1-year expected exchange rates by using interest differentials on 1-year assets. Our purpose is to determine whether these expectations lie within the current bands.* In Figure 2, expected future exchange rates are plotted as deviations from then-current central rates. Vertical lines indicate dates of realignment against the DM, while the horizontal lines indicate the target zone limits. The sample period is March 1979 through the last general EMS realignment in January 1987.

Figure 2 provides striking evidence on the historical credibility of the EMS. At a one-year horizon, the Dutch guilder is nearly always expected to remain inside its current band. However, the other five currencies are nearly always expected to be outside their current limits. This evidence supports the view that the EMS had low credibility during its first eight years. The many devaluations against the DM during this period apparently did not come as a surprise.

IV. THE CURRENT EMS REGIME: CREDIBILITY AT LAST?

The period since the 1987 EMS realignment has produced a sequence of institutional developments which may have enhanced the

* This basic test of target zone credibility was instituted by Svensson [1990b] for the Swedish krone. Here we replicate the findings of Flood, Rose and Mathieson [1990] for the EMS. We thank these authors for access to their data. Giovannini [1990] conducts an equivalent test for the French franc and Italian lira.

credibility of the current target zones. We provide an extensive chronology in Appendix A. Most notably, a process toward some form of more rigid monetary union has begun. There has also been progress on convergence; e.g., differences in inflation rates have narrowed.[10]

We consider whether these developments and the apparent stabilization of the EMS -- the four-year absence of realignments -- have been accompanied by a change in expectations. Has the EMS finally achieved credibility? To what degree, and when? Survey data on exchange rate expectations help us answer these questions. We also consider evidence based on interest rate differentials in the manner of Svensson [1990b]. The sample is extended to include the currencies of newcomers Spain and Britain.

On the Definition and Testing of Target Zone Credibility

A target zone is *perfectly credible* if the probability distribution of the future exchange rate perceived at time t lies within the target zone boundaries:

(4.1) $$\text{Prob}\,[\,s^L \leq s_{t+k} \leq s^U\,] = 1 \qquad \text{(for all } k>0)$$

where s is the exchange rate and s^L and s^U are the lower and upper target zone boundaries.

Since it is not possible to observe the entire probability distribution of s, we examine the weaker conditions:

(4.2a) $$s^L \leq E_t(s_{t+k})_{uip} \leq s^U$$

(4.2b) $$s^L \leq FCST_t(s_{t+k}) \leq s^U$$

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[10] For an argument that 1987 marked the beginning of a "New EMS" see Giavazzi and Spaventa [1990].

where $E(s)_{uip}$ is the expected value of s implied by uncovered interest parity, and FCST(s) is the forecast computed from the <u>CFD</u> survey.

One may fail to find evidence to reject (4.1), but one cannot "find" perfect credibility. Even if (4.2a) and (4.2b) are satisfied, part of the probability distribution of the future exchange rate could lie outside the target zone. Furthermore, a forecast placing future s exactly on s^L or s^U would be inconsistent with perfect credibility: unless the forecast variance were zero, such a forecast must reflect some non-zero probability attached to values outside the band.

The power of the test defined by conditions (4.2a) and (4.2b) is influenced by several factors. First, the greater is k, the forecast horizon, the greater the power. Second, for a given forecast horizon, the power will be greater the further is s_t from the center of the band. (As it happens, low power seems not to be a problem during the period we study. It will be seen that s_t is often close to the band limits. Also, except for small k, conditions (4.2a) and (4.2b) are often rejected.)

Indeed, the concept of perfect credibility may be too strict to be of interest. More interesting may be the degree of credibility. An informal (and inverse) indicator of credibility is $E_t(s_{t+k})_{uip}$ - c, or $FCST_t(s_{t+k})$ - c, where c is the official central rate.[11] Of course, the degree of credibility may vary with time. We next

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[11] In Section VI we consider a related but possibly superior measure. For an alternative approach to the meaning and measurement of EMS credibility, see Weber [1991].

investigate whether the EMS target zones have recently experienced an increase in their credibility.

Analysis of the Current EMS Target Zones

We begin by presenting actual spot exchange rates over the period February 1988 through July 1991. Again, all rates are natural logs of the DM price of the currency in question.[12] The eight spot rates are shown in Figure 3, together with lines indicating the official DM limits. (Note the wider bands used by Spain and Britain, and by Italy before 1990.) While the Dutch guilder has remained close to its central rate,[13] the other currencies have shown more variation, and several have come close to their lower DM limits. The strength of the Spanish peseta within its DM target zone is atypical.

To assess the credibility of the current EMS target zones, we first consider Svensson's test, computing the 12-month exchange rate expectations implied by uncovered interest parity. Figure 4 presents plots of such 12-month expectations for 1988-1991 and may be compared to the earlier Figure 2 for the 1979-1986 period. All currencies show smaller expected deviations from current central rates than during the pre-1987 regimes. Table 1 compares sample means from the two periods; t-statistics indicate a statistically significant increase in credibility for the currencies of Belgium,

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[12] The data are normalized so that c, the natural log of the central DM rate, equals zero. We follow this practice for the remainder of this paper.

[13] The Dutch seem to use a DM target zone much narrower than the standard EMS bands of ±2.25%. The data since 1983 suggest bands of only about ±0.5%.

Denmark, France and, from January 1990, Italy. The change in the guilder's credibility is less clear, perhaps reflecting that there existed less room for improvement.

Within the recent period, we note an upward trend in the 12-month expectations for most currencies. From early 1990 to the end of our sample, most values were within the target zones, a finding remarkable by historical standards of the EMS. Throughout the period, the guilder forecasts are close to the center of the target zone.

The CFD Forecasts

We now examine the credibility of the current regime by considering evidence from the CFD survey of exchange rate forecasts.[14] For the period February 1988 - April 1991, Figures 5, 6, and 7 present plots of the exchange rates forecasted for horizons of 1, 3, and 12 months, respectively. Figure 8 does the same for a horizon of five years.[15]

The 1-month forecasts typically lie within the official limits; by the second quarter of 1988, the same may be said of the 3-month forecasts. At both horizons, forecasts for the Dutch guilder are

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[14] More precisely, we use the "combined consensus" forecasts reported in CFD. These are the harmonic means of the forecasts of approximately 45 contributors. The CFD forecasts are given in terms of currency units per U.S. dollar. We form an estimate of the implied forecast of intra-EMS exchange rates using the ratio of the relevant forecasts against the dollar.

[15] Since the data in Figures 5 through 8 are computed from ratios of forecasts, the original CFD forecasts cannot be measured from these graphs. To further protect the confidentiality of the original data, we have applied a data-smoothing technique to the series plotted in these figures. The qualitative conclusions are unaffected by this procedure.

relatively stable and tend toward the center of the band. Forecasts for other currencies have often been close to their lower limits, a symptom of imperfect credibility.

A more stringent test of target zone credibility comes with consideration of longer forecast horizons. Indeed, Figure 7 shows that 12-month forecasts were often outside the target zone: prior to 1990, the forecasts for the currencies of France, Denmark, Belgium, and Italy were typically 1 to 3 percentage points below their lower DM limits. However, in January 1990 forecasts for these four currencies began to strengthen, crossing inside the band limits by the second quarter of that year. In the last year of the sample, these 12-month forecasts were typically inside the target zone.

The survey data-based forecasts of Figure 7 are not unlike the interest differential-based forecasts of Figure 4 for the same period and 12-month horizon.[16] However, with the the CFD data, even the Irish Punt seems much more credible: since mid-1988, most of the 12-month forecasts are inside the DM target zone.

Figure 8 presents (quarterly) forecasts for a horizon of approximately five years. Most of the 5-year forecasts have been several percentage points below their lower limits; however, some show an upward trend. Several have recently approached (and at

[16] The (unsmoothed) survey data forecasts are more volatile, and tend to be somewhat more supportive of target zone credibility.

times crossed) the lower DM limit.[17] Nevertheless, even the most recent data indicate some doubt that the EMS has experienced its final realignment.

The exceptional case is the Dutch guilder. Even at the longer forecast horizons, no evidence is found against the perfect credibility of the guilder/DM target zone: forecasts have always been inside the band limits, usually near the center.

Summary

Recent evidence from a survey of exchange rate forecasts suggests that the Dutch guilder-DM target zone is clearly the most credible. For most EMS currencies, the survey data confirm earlier findings that their DM target zones were less than perfectly credible; e.g., 1-year forecasts have often been below the lower DM limits. On the other hand, the evidence suggests that degree of credibility has been increasing over the 1988-1991 period, especially since early 1990. Consideration of interest differential-based exchange rate expectations corroborates these findings and also allows a comparison with earlier regimes: the current EMS regime appears significantly more credible.

With credibility apparently greater than ever before, today's EMS might seem more likely to conform to the basic target zone model developed by Krugman and others. We next re-examine this question using the recent data.

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[17] We also note that some observations suggest an expected revaluation of the Spanish peseta against the DM. This fact is remarkable in that the DM has never been devalued against any currency during the EMS period.

V. REASESSING THE EMPIRICAL PERFORMANCE OF TARGET ZONE MODELS

Previous attempts to apply models of exchange rate target zones to European data have yielded disappointing results. An unexamined possibility is that mismeasurement of exchange rate expectations is to blame: previous studies have all assumed uncovered interest parity. In this section we use data from the CFD survey of exchange rate forecasts to re-examine the most fundamental implication of the basic target zone model.

We find no evidence that mismeasurement of exchange rate expectations is to blame for the empirical failure of target zone models. If anything, the survey-based results are even less supportive than the interest rate-based results we also provide. We thus confirm the empirical failure of the standard target zone model for the EMS (first demonstrated by Flood, Rose and Mathieson [1990]), despite our use of two different expectations measures, and despite our use of more recent data from the EMS' apparently most credible period. Dismissing mismeasurement of expectations as a likely explanation of this failure, we are lead to consider, in Section VI, the variable-credibility framework proposed by Bertola and Svensson [1991].

Empirical Testing of Target Zone Models

We begin by briefly reviewing the essentials of target zone modelling.[18] The theoretical literature on target zones begins with the asset-pricing relationship:

(5.1) $$s_t = f_t + \alpha E_t(ds/dt)$$

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[18] For more detail, see for example Krugman [1991].

where f_t is an indicator summarizing current exchange rate "fundamentals." For example, in the flexible-price monetary model (assumed implicitly in most of the literature) these fundamentals would be relative national money supplies and incomes; the constant α would be the interest semi-elasticity of money demand.

Key to obtaining a solution is the assumption that f_t evolves exogenously.[19] The distribution of s_t, and thus also of $E_t(ds/dt)$, is driven by this single state variable. Typically f_t is assumed to follow the continuous-time version of a random walk, possibly with drift:

$$(5.2) \qquad df_t = \eta\, dt + \sigma\, dz_t$$

Here η and σ are constants, and dz_t is a standard Wiener process. This f_t process is subject to occasional regulation, i.e., exchange market intervention (which alters relative money supplies) is used to keep f_t within upper and lower limits. As a result, the exchange rate is also kept within a target zone.

In this framework, the general solution for the exchange rate in terms of current fundamentals is as follows:

$$(5.3) \quad s_t = h(f_t) = \alpha\eta + f_t + B_1 \exp(\lambda_1 f_t) + B_2 \exp(\lambda_2 f_t)$$

where λ_1 and λ_2 depend on the parameters α, η, and σ.

The solution (5.3) differs from the usual free-float solution in the presence of the final two terms, which reflect the influence of expected intervention on the relationship between s and its fundamental determinants. In a perfectly credible target zone, the

[19] It is for this reason that sticky-price models are not usually considered in the target zone literature.

signs of the constants of integration B_1 and B_2 are such that the s=h(f) function has a flattened S-shape. The interesting policy implication is the "honeymoon effect" emphasized by Krugman: stabilizing expectations mean that given fundamentals bands can support narrower exchange rate bands. Imperfect credibility may lessen the effect, but the solution (5.3) remains valid.[20]

Empirical Failure of the Model: Interpretations

The first rigorous and comprehensive empirical evaluation of the target zone solution is that conducted by Flood, Rose and Mathieson [1990]. In studying the EMS target zones through May 1990, these authors find neglible evidence in favor of the specification (5.3) over the simpler linear ("free float") specification. Their results apparently cannot be attributed to the low credibility of the EMS during most of its history: in extending this methodology to an apparently more credible regime, the Mini-Snake of the 1970s, Phillips [1990] finds similar results.[21]

These negative results might reflect a number of problems. The target zone solution requires several assumptions about the f_t process and its regulation: e.g., that f_t have a constant innovation variance, that the magnitude of expected intervention is constant, that intervention occurs at known points. Furthermore, the characterization of the f_t process as a random walk is only one

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[20] See for example Bertola and Caballero [1990].

[21] However, Phillips [1990] has some success in examining several distributional implications which can be tested using only exchange rate data. This difference might suggest that mismeasurement of expectations is to blame and thus provide a motivation for the use of survey data.

possibility; a mean-reverting process might be more plausible. In addition, estimation of the solution equation faces several problems. For example, the Flood, Rose and Mathieson methodology requires knowledge of the parameter α; however, it does not yield precise estimates of this parameter. One must also hope that actual intervention does not seriously bias estimation of the parameters of the f_t process.[22]

In light of these problems we will not estimate the target zone solution equation.[23] Instead, we focus on the most basic prediction of target zone theory: a negative relationship between the exchange rate's position within the band and its expected rate of change. This relationship is the basis for the honeymoon effect.

In the model described above, the implicit relationship between s_t and $E_t(ds/dt)$ is deterministic and can be simulated using plausible parameter values. The relationship is non-linear and monotonically negative.[24] As discussed however, the deterministic relationships predicted by the standard target zone model reflect

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[22] Flood, Rose and Mathieson conduct a sensitivity analysis and find that their generally negative results are robust to the value of α chosen. They also examine a number of other predictions of the standard target zone model but find little supporting evidence, despite their dependence on fewer auxiliary assumptions.

[23] Another reason that we do not attempt to use the methodology of Flood, Rose and Mathieson is that it probably requires data of greater frequency than the CFD surveys.

[24] Svensson [1990d] analyzes how the relationship depends on the forecast horizon being considered. The longer the horizon, the more linear is the relationship and the smaller is its slope (in absolute value).

a number of quite specific assumptions. More generally one might expect a negative correlation between s_t and $E_t(ds/dt)$. We therefore examine this most basic implication of a target zone, using both CFD surveys and interest differentials to measure expectations.

Table 2 presents our findings for two sample periods. We see little evidence in favor of a negative correlation (let alone the deterministic relationship implied by most models) between the exchange rate and its own expected rate of change. Indeed, positive correlations are often found. Only for the Dutch guilder do we find statistically convincing evidence of a negative correlation.

Thus the empirical failure of the standard target zone model continues even in the very recent data from the EMS' most credible period. More importantly, it appears that this failure cannot be attributed to mismeasurement of expectations: results using survey data are no more supportive than those using interest differentials. We therefore turn our attention to another possible explanation of the data, based on the recent model of Bertola and Svensson [1990].

The Bertola-Svensson Model: Time-Varying Credibility

While a good "fit" of a target zone model does not require perfect credibility, it does require that the degree of credibility be fairly stable over the sample period. In the Bertola-Svensson framework, credibility is imperfect *and* time-varying; there is then no general implication for the relationship between the exchange rate's position within the zone and its expected rate of change. For example, if the probability of realignment is non-zero but fairly stable, their analysis yields the standard prediction of a negative correlation between s_t and $E_t(ds/st)$. However, if the realignment probability is highly variable, a positive correlation may emerge. The intuition is clear. A change in the perceived probability of a realignment is of course reflected in the overall expected rate of change of s_t, but it also moves the current level of s_t in the same direction. Thus the pattern of covariation between these variables depends on the relative variability of the probability of realignment.

We find the Bertola-Svensson framework appealing for several reasons. First, it avoids the usual (implicit, and implausible) assumption of constant credibility. Indeed, our analysis in Section IV suggested that credibility of the EMS target zones has generally been improving in recent years. Second, the Bertola-Svensson model is consistent with the failure to find a deterministic negative relationship between s_t and $E_t(ds/dt)$ and the occasional findings of a positive correlation (as in Table 2). We find it particularly encouraging that the best evidence of a negative correlation is found for the Dutch guilder. In light of our earlier analysis, a plausible explanation is that the guilder's target zone is nearly perfectly credible and has remained so over our sample period. On the other hand, the positive correlation found for the French franc suggests that credibility has been changing (presumably improving) over the period.

Since unobserved variation in credibility allows the Bertola-Svensson model to be consistent with any pattern of data for s_t and $E_t(ds/dt)$, we will not be testing the model. In the next section we instead use the model to measure indirectly the expected rate of revaluation, a potentially superior indicator of target zone credibility.

VI. ESTIMATION OF THE EXPECTED RATE OF REVALUATION

In this section we return to the question of the degree of target zone credibility. We use the Bertola-Svensson framework to estimate expected rates of revaluation during the recent EMS period.[25] This series is based on $E_t(ds/dt)$, the overall expected rate of change of the exchange rate, which may be measured using either survey data or interest differentials. The difference is that expectations of mean-reversion within the target zone have been filtered out, leaving a potentially superior measure of target zone credibility.

Elements of the Bertola-Svensson Model

Let s_t denote the log exchange rate. In our convention, exchange rates are measured as DMs per currency unit in question, so we refer to rates of change of s as rates of appreciation.

Begin with the following decomposition:

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[25] Rose and Svensson [1991] were first to implement the Bertola-Svensson model; see their paper for a more extensive discussion and investigation of the model. These authors study the French franc/DM target zone over the period March 1979 to May 1990, using interest differentials to measure expectations. For the same period, Svensson [1991] extends the procedure to five other EMS currencies.

(6.1) $$s_t = c_t + \bar{s}_t$$

where c_t is the official central rate at time t, and $\bar{s}_t$ is the current deviation of s from that value. Between realignments, all variation in s_t reflects variation in $\bar{s}_t$.

In the Bertola and Svensson model, the process c_t is a jump process: c_t jumps, along with the exchange rate s_t, at realignments but is otherwise constant. The size of the exchange rate jump when a realignment occurs is denoted z_t.[26] Let a revaluation resulting in an exchange rate jump of random size z_t occur with probability $v_t dt$ in a time interval dt, while no devaluation occurs with probability $1-v_t dt$. Then define an *expected rate of revaluation* process g_t as

(6.2) $$g_t = v_t \, E_t[z_t]$$

Bertola and Svensson assume g_t follows a Brownian motion process; g_t thus becomes a second exogenous state variable in their model.

The details and solution of the Bertola-Svensson model need not concern us here. Our interest is in measuring g_t, using a method we discuss shortly. Note that fluctuations in g_t may reflect fluctuations in either the probability of realignment or in the size of the expected change in s at realignment. Although the method cannot distinguish these components, we consider their product to be a natural indicator of target zone credibility.

The key to the technique is that $E_t(ds/dt)$, the overall expected rate of appreciation, is the sum of two components:

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[26] Bertola and Svensson note that it is not necessary to assume that c_t also jumps by this amount at realignment.

$$(6.3) \qquad E_t(ds/dt) = g_t + E_t(d\bar{s}/dt)$$

These components are g_t, the expected rate of revaluation, and the term $E_t(d\bar{s}/dt)$, which we refer to as the expected rate of change of the exchange rate within the target zone. In a perfectly credible target zone, $g_t=0$ and therefore $E_t(d\bar{s}/dt) = E_t(ds/dt)$. However, we expect credibility to be less than perfect; presumably g_t has been chronically negative for most EMS currencies' DM exchange rates. Our hypothesis of increasing EMS credibility would imply that g_t is approaching zero.

The term $E_t(ds/dt)$ may be measured using either interest differential or survey data, together with the contemporaneous spot exchange rate. Less obviously, $E_t(d\bar{s}/dt)$ may be estimated as in Rose and Svensson [1991]. By then simply combining terms, it is therefore possible to form an estimate of g_t, the expected rate of revaluation.

Estimating $E_t(d\bar{s}/dt)$

Obviously the key step in this procedure is the measurement of $E_t(d\bar{s}/dt)$, the term representing beliefs about the expected behavior of s *within* the band. Using the rational expectations methodology, actual changes in s (observed during a period with no realigments) may be substituted for the unobserved expected changes in $\bar{s}$. The issues then are the explanatory variables and functional form to be used to predict these changes.

In the Bertola-Svensson model, both s_t and $E_t(d\bar{s}/dt)$ are driven by the other exogenous state variable, f_t, the indicator summarizing exchange rate fundamentals. An implicit deterministic relationship exists between s_t and $E_t(d\bar{s}/dt)$, each being a sufficient statistic for the other.[27] Therefore the only explanatory variable needed in a regression of $E_t(d\bar{s}/dt)$ is s_t. With regard to functional form, the analytical relationship between these variables is known to be non-linear and monotonically negative. Svensson [1990d] shows that it may be well-approximated by a linear relationship, particularly for longer forecast horizons.[28] We therefore start with the following simple linear relationship:

$$(6.4) \qquad E_t(\bar{s}_{t+k} - \bar{s}_t) = \beta_0 + \beta_1 \bar{s}_t + e_t$$

where e_t arises from the failure of this linear approximation to match the non-linear relationship implied by theory (or from the failure of the theoretical relationship to match the true process). By including an unrestricted intercept term, we allow for the possibility that the actual target zones may differ from official announcements.[29]

Rational expectations then imply:

$$(6.5) \qquad (\bar{s}_{t+k} - \bar{s}_t) = \beta_0 + \beta_1 \bar{s}_t + e_t + u_t$$

where $$u_t = \bar{s}_{t+k} - E_t(\bar{s}_{t+k})$$

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[27] Note this similarity to the standard target zone model discussed in the previous section. The difference here is that the relationship involves $E_t(d\bar{s}/dt)$, not $E_t(ds/dt)$.

[28] Even if an analytical solution for the relationship were available, its estimation would be subject to a number of problems, several of which were discussed in the previous section.

[29] More precisely, s may revert to a mean other than zero, the official central rate. Inspection of the spot rate data suggests that most EMS currencies do not make use of the upper (stonger) part of their DM target zones.

Thus we seek to predict k-month changes in the exchange rate as a function of the exchange rate's own current position within the target zone. Mean-reversion within the band will be reflected in a value of β_1 which is less than zero.

Estimation

We estimate equation (6.5) using OLS for horizons of k=1, 3, 6 and 12 months. These horizons correspond to those of the CFD surveys. Since our data are monthly, the issue of "overlapping observations" arises for k>1 month.[30] Conventional standard errors are therefore inappropriate. Accordingly we use Newey-West covariance estimators which should be robust to the structure of the errors arising from overlapping observations. For example, for the regressions of 6-month differences we use Newey-West covariance estimators allowing for 5 lags.

Note that estimation of (6.5) requires data for spot exchange rates only. We therefore are able to use data for the entire period of interest, beginning when the current EMS target zones were established in January 1987.[31] As is well known, sample span is key to investigating mean-reverting relationships. Thus we do not estimate (6.5) for the currencies of EMS newcomers Spain and Britain. For the Lira, we limit the sample to the period before the narrowing of its target zone in January 1990.

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[30] Intuitively, a single unanticipated shock or event will appear in a number of consecutive forecast errors. The result is that the error term follows an MA process of order (k-1).

[31] Recall that the survey data are available only from February 1988.

Table 3 presents results of OLS estimation of equation (6.5) for horizons of 1, 3, 6 and 12 months. Before discussing these results, we note that rational expectations would imply that u_t, the error in forecasting the exchange rate, should not be correlated its own lagged values. Even with rational expectations, autocorrelation of the regression residuals could still emerge as a result of the e_t errors from our linear approximation. It is therefore of interest to test for such autocorrelation. For the regressions based on 1-month horizons, Q-tests find significant evidence of autocorrelation only in the case of the Belgian franc.[32]

The β_1 estimates in Table 3 are satisfactory in a number of respects. All are negative, as expected. With the exception of Belgium, the estimates are large in relation to their standard errors.[33] Also as expected, the β_1 estimates for each currency are larger in absolute value the longer is the forecast horizon considered (the single exception is the 12-month Irish punt forecast).

We next consider the magnitudes of the changes in s predicted by the fitted equations. Table 4 presents the changes predicted when

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[32] For horizons longer than one month, Q-tests strongly reject the null of no autocorrelation, as one would expect when overlapping observations are used.

[33] The hypothesis $\beta_1=0$ corresponds to the case in which $\bar{s}_t$ is a random walk. As we are concerned with the behavior of s_t within band limits we dismiss the random walk hypothesis *a priori*. (Even if that hypothesis were of interest, it might also be rejected empirically: indeed, many of the estimates would reject $\beta_1=0$ using the usual Dickey-Fuller test.)

s is at its minimum possible value within its DM bands. Note that these forecasts of appreciation within the band are reasonable in an important sense: none place the expected future value of s outside its target zone. First, all are positive -- an exchange rate at its lower DM limit is forecasted to appreciate. Second, the forecasted appreciation is never so large as to place the future exchange rate beyond its upper DM limit.

It appears that within the recent EMS target zones, the current level of s gives a reasonable linear predictor of its own future change. (The possible exception is the case of Belgium.) As a further check, we also estimate the following alternative specification:

(6.6) $(\bar{s}_{t+k} - \bar{s}_t) = \beta_0 + \beta_1 \bar{s}_t + \beta_2 \bar{s}^2_t + \beta_3 \bar{s}^3_t + v_t$

The inclusion of the square and cube of the exchange rate (suggested by Rose and Svensson [1991]) is intended to capture non-linearities in the relationship between $E_t(\bar{s}_{t+k} - \bar{s}_t)$ and $\bar{s}_t$. This functional form may permit a better approximation to this relationship than equation (6.5).

Our interest is to determine whether the two new terms are statistically different from zero. Table 5 reports marginal significance levels of chi-square tests of the joint hypothesis $B_2=B_3=0$. A number of the test statistics are significant at the 5% level. However, except for Belgium we do not find overwhelming evidence against the restriction $B_2=B_3=0$. We therefore proceed using the results from the simpler linear regression (6.5).

Estimates of the Expected Rate of Revaluation

The changes predicted by the fitted values of (6.5) provide us with estimates of $E_t(\Delta\bar{s}/\Delta t)$. The final step is simply to subtract this series from a series measuring $E_t(\Delta s/\Delta t)$, the overall expected rate of change of s. The result is an estimated series for g_t, the expected rate of revaluation.

Figure 9 presents the results of applying this procedure to data from the current EMS regime, based on 12-month forecast horizons and using CFD survey data to measure $E_t(\Delta s/\Delta t)$. (In Appendix B we explain why we favor a 12-month horizon, and also provide results based on a 1-month horizon.) As might be expected, the g_t estimates for the guilder tend to be close to zero, suggesting a low probability of realignment (or a very small realignment). For the other currencies, the g_t estimates are most often negative, indicating expected devaluation against the DM. Except for the Irish punt, g_t estimates of -5 to -2% per year were typical prior to 1990; since early 1990, values greater than -2% are typical. Indeed the estimates have at times indicated revaluation against the DM. For the Irish currency, g_t estimates of -2 to 0% have been the rule throughout the period.[34] Overall, there seems ample evidence of time-varying credibility.[35]

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[34] On the basis of evidence at other horizons we believe that the May 1991 g_t for Ireland reflects a probable data error.

[35] For insight into the interpretation of these estimates, suppose that the expected size of a revaluation against the DM (conditional upon a realignment occurring) is -4%. A g_t estimate of -.02 (i.e., -2% per year) would then imply that the probability intensity of a realignment is 50% a year (or that the expected time to realignment is two years).

Figure 10 is analogous to Figure 9, the difference being that we use interest differentials instead of CFD surveys to measure $E_t(\Delta s/\Delta t)$. We are thus able to estimate g_t beginning just after the January 1987 EMS realignment. As in Figure 9, we note an improvement after early 1990 in the credibility of those currencies for which g_t estimates are available. However, the results in Figure 10 differ from those of Figure 9 in several respects. For example, the Irish punt seems less credible over 1988-1989 than Figure 9 suggests. Also, the availability of earlier g_t estimates allows us to see that the Irish punt and even the Dutch guilder experienced proportionately large increases in credibility during 1987. Finally, the g_t estimates based on interest differentials are noticeably less volatile.

Because expected mean-reversion within the band has been filtered out of the overall expected change, the estimated g_t series may be superior to $E_t(\Delta s/\Delta t)$ as an indicator of credibility. The importance of this distinction depends on the relative magnitude of the expected rate of appreciation within the band.[36] Table 6 provides summary statistics for the estimated $E_t(\Delta\bar{s}/\Delta t)$ series, for both 1 and 12 month horizons. (To aid comparison, the $E_t(\Delta\bar{s}/\Delta t)$ series were first expressed as annualized percentage rates of change before computing these statistics. The figures in Table 6 are thus directly comparable to interest differentials based on annualized percentage interest rates.) Not surprisingly, the sample means of the $E_t(\Delta\bar{s}/\Delta t)$ series are close to zero. Mean

[36] Svensson [1991] also draws attention to this issue.

absolute values for the currencies using ±2.25% bands range from 0.5 to 1.6% per year for the 1 month horizon; for the 12 month horizon the range is 0.2 to 0.9% per year.

Compared to historic levels of EMS interest differentials, for example, such values seem relatively small.[37] The implication would be that interest differentials reflect mostly expected revaluation and imperfect credibility. On the other hand, consider the minimum and maximum values also presented in Table 6. Furthermore, the very recent evidence (e.g., from the first half of 1991) indicates that the expected rate of revaluation for several EMS currencies is becoming small in absolute value, often not far from zero. If so, expected mean-reversion within the band may now represent the larger portion of overall expected exchange rate changes in a newly credible EMS.

VII. SUMMARY AND CONCLUSIONS

In this paper we have used very recent evidence from a survey of exchange rate forecasts to examine a number of aspects of the EMS target zones. In light of recent institutional developments within the European Community, we have been particularly interested in the hypothesis that the EMS target zones have experienced an important increase in credibility.

The analysis in Section IV suggests the following conclusions. The Dutch guilder-DM target zone is clearly the most credible. For

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[37] During the 1979-1986 period, mean interest differentials for the currencies using ±2.25% bands ranged from about -4% for Belgium to about -7% for Ireland.

most other EMS currencies, the survey data confirm earlier findings that their DM target zones have been less than perfectly credible. On the other hand, the survey evidence suggests that credibility has been increasing over the 1988-1991 period, especially since early 1990. Consideration of exchange rate expectations constructed from interest differentials corroborates these findings and also allows a comparison with earlier regimes: the current EMS regime is significantly more credible. However, we still find some evidence against perfect credibility of most EMS target zones, even in 1991.

Turning our attention to the previously documented failure of the standard target zone model to conform to EMS data, we consider whether mismeasurement of expectations is to blame. However, we find that results based on survey data are no more supportive than those based on uncovered interest parity.

In our view, the most plausible explanation of the failure of the standard model is not mismeasurement of expectations but rather the implicit assumption of constant (if not perfect) credibility. We are therefore attracted to the Bertola-Svensson framework in which an expected rate of *revaluation* is permitted to vary over time. We attempt to measure this expected rate of revaluation. Although based on the overall expected rate of appreciation, this series differs in that expected mean-reversion within the target zone has been filtered out. We therefore consider this series as a potentially superior indicator of target zone credibility. We find ample evidence of shifting credibility over the sample period.

The results suggest conclusions about EMS credibility which are qualitatively similar to those based on direct examination of expected future exchange rates. During most of the sample period, expected revaluation has often been a large component of overall expected rates of change of EMS exchange rates. However, the truth of this generalization seems to be fading: results from the first half of 1991 indicate that expected rates of revaluation of several EMS currencies are often near zero.

Table 1. Mean 12-Month Expectations (from interest rates) as Deviations from DM Central Rates

currency	Mar. 1979-Dec. 1986	Feb. 1988-July 1991	difference of means	t-test of inequality
France	-5.57%	-3.00%	+2.57	+5.40
Belgium	-4.95	-2.16	+2.79	+10.53
Denmark	-5.17	-3.28	+1.89	+5.57
Nether-lands	-0.531	-0.186	+0.345	+1.98
Italy	-8.40	-7.42 -2.02**	+0.98 +6.38	+1.49 +13.19
Ireland	-6.50*	NA	NA	NA

Percentages approximated as log deviations times 100.

* Irish interest rate data available for 1982-1986 only.

** The central rate of the Italian Lira shifted with the narrowing of the target zone in January 1990. The February 1988 - December 1989 mean was -7.42%, while the mean for January 1990 - July 1991 was -2.02%.

Table 2. Correlation Coefficients:
Spot Position in Band and Expected Change over 12-month Horizon

Full Sample: February 1988 - July 1991

	from survey data	from interest differential
Belgium	+.654 (.000)	+.801 (.000)
Denmark	+.248 (.139)	-.089 (.575)
France	+.321 (.053)	+.201 (.202)
Ireland	+.129 (.447)	NA
Netherlands	-.309 (.063)	-.294 (.059)
Italy Feb.88-Dec.89	-.059 (.794)	+.491 (.017)

Marginal significance levels given in parentheses.

January 1990 - July 1991 only:

	from survey data	from interest differential
Belgium	+.579 (.024)	+.805 (.000)
Denmark	+.232 (.406)	-.059 (.810)
France	+.063 (.822)	-.322 (.179)
Ireland	+.180 (.521)	NA
Netherlands	-.499 (.059)	-.326 (.174)
Italy	-.182 (.516)	-.249 (.305)

Marginal significance levels given in parentheses.

Table 3. **Expected Mean Reversion Within the Band: Estimates of β_1**

currency of		k=1 mo. (54 obs)	k=3mo. (52 obs)	k=6mo. (49 obs)	k=12 mo. (43 obs)
Belgium	β_1	-.0704	-.168	-.343	-.799
	std. err.	(.0623)	(.126)	(.273)	(.248)
	Rbar2	.01	.04	.09	.21
Denmark	β_1	-.139	-.407	-.846	-1.05
	std. err.	(.0643)	(.192)	(.179)	(.194)
	Rbar2	.06	.24	.57	.67
France	β_1	-.165	-.472	-.814	-0.959
	std. err.	(.0767)	(.172)	(.197)	(NA)
	Rbar2	.07	.26	.48	.65
Ireland	β_1	-.420	-.933	-1.34	-0.724
	std. err.	(.115)	(.135)	(.0665)	(.153)
	Rbar2	.21	.47	.67	.35
Nether-lands	β_1	-.381	-.748	-1.11	-1.16
	std. err.	(.139)	(.207)	(.112)	(.208)
	Rbar2	.18	.38	.57	.60
Italy	β_1	-.154	-.523	-.727	-1.37
	std. err.	(.0775)	(.146)	(.187)	(.122)
	Rbar2	.06	.33	.47	.85

Based on monthly observations, January 1987 through July 1991 (January 1987 through December 1989 for Italy).
Standard errors based on Newey-West covariance estimators.

Marginal significance of Q statistics for regressions based on 1-month horizons: Belgium, .016; Denmark, .374; France, .750; Ireland, .461; Netherlands, .968; Italy, .902.

Table 4. Forecasted Appreciation at s = Lower DM Limit

currency	k=1 mo.	k=3 mo.	k=6 mo.	k=12 mo.
$s^L = -.0225$:				
Belgium	.00105	.00259	.00524	.0112
Denmark	.00180	.00537	.0110	.0139
France	.00224	.00630	.0107	.0117
Ireland	.00827	.0183	.0261	.0140
$s^L = -.005$:				
Netherlands	.00186	.00374	.00553	.00572
$s_L = -.06$:				
Italy	.00571	.0209	.0291	.0560

Based on OLS estimation of equation (6.5) for the period January 1987 through July 1991 (for Italy, January 1987 through December 1989).

Table 5. Test of $B_2=B_3=0$: Marginal Significance

currency	k=1 mo.	k=3 mo.	k=6 mo.	k=12 mo.
Belgium	.000**	.000**	.000**	.050**
Denmark	.344	.528	.211	.000**
France	.357	.123	NA	.252
Ireland	.526	.152	.307	NA
Netherlands	.000**	.002**	.351	.687
Italy	.954	.919	NA	NA

Marginal significance of chi-square(2) test of $B_2=B_3=0$.
** denotes significance at the 5% level.
Based on Newey-West covariance estimators.
NA denotes computational problems.

Table 6. Magnitude of Expected Rates of Mean-Reversion

1-Month Horizon: Expected Rate of Appreciation (as annualized percentages)

currency	mean	mean absolute	min.	max.
Belgium	0.09%	0.59%	-1.49%	1.26%
Denmark	-0.49	1.37	-4.30	2.07
France	-0.32	1.26	-3.41	2.45
Ireland	0.13	1.59	-2.85	6.36
Netherlands	0.02	0.70	-2.78	3.15
Italy (pre-Jan.'90)	-1.56	2.40	-6.65	2.36

12-Month Horizon: Expected Rate of Appreciation (as annualized percentages)

currency	mean	mean absolute	min.	max.
Belgium	-0.02%	0.56%	-1.47%	1.13%
Denmark	-0.27	0.85	-2.66	1.33
France	-0.28	0.62	-1.78	1.06
Ireland	0.001	0.23	-0.43	0.89
Netherlands	0.01	0.18	-0.70	0.81
Italy (pre-Jan.'90)	0.67	1.69	-4.46	2.25

Based on OLS estimation of equation (6.5) for the period January 1987 through July 1991 (for Italy, January 1987 through December 1989).
Approximate percentages based on log differences.

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APPENDIX A. EMS DEVELOPMENTS, 1986-1991

1986

Feb. Single European Act sets Dec. 31, 1992 as date for completion of internal market with free movement of goods, services, labor and capital within the EC.

1987

Jan. 12 EMS Realignment (the eleventh, and possibly final)

Jan. France and Italy announce changes in their exchange rate management.

Sept. Basle-Nyborg Agreement. Committee of Central Bank Governors agrees to strengthen the ERM by providing for intra-marginal intervention and more liberal short-term finance of intervention.

1988

June 13 Agreement to free capital movements in the EC. Germany softens previous opposition to EC central bank; France and Italy persuaded to remove major capital controls over next two years.

June 28 Hanover Summit. Britain rejects proposal for European central bank and single currency; Delors Committee is created.

July 14 Bundesbank's president denies opposition to concept of a European currency.

1989

April 17 Delors Committee Report. Proposes a three-stage transition to economic and monetary union (EMU), without specifying a timetable:

Stage 1: Capital movements liberalized, ERM membership enlarged, more powers to EC Committee of Central Bank Governors.
Exchange rate realignments still permitted.

Stage 2: Exchange rate bands narrowed from ±2.25%, realignments permitted only in exceptional circumstances. Economic policy guidelines, not yet binding, set at the Community level. European System of Central Banks (ESCB) set up, absorbing existing monetary arrangements.

Stage 3: Exchange rates irrevocably locked. ESCB replaces the national central banks. Adoption of single currency completes stage.

June 3 An editorial in The Economist calls for one last general devaluation against the German mark.

June 19 Spain joins the ERM.

June 27 European Council decides to begin Stage 1 of the Delors plan on July 1, 1990. (According to the Delors Report, "a decision to enter upon the first stage should be a decision to embark on the entire process.")

Nov. Berlin Wall falls.

Dec. Strasbourg Summit. Agreement that by December 1990 an intergovernmental conference would convene to prepare changes in Treaty of Rome needed for EMU. Having favored a slower pace, West Germany agrees to this schedule as its EC partners give their stamp of approval to German monetary unification.

1990

Jan. 8 Lira bands narrowed from ±6% to the standard ±2.25%. Lower limit unchanged.

Feb. 6 Apparently sudden decision of Germany's Kohl in favor of rapid movement toward a German currency union.

March France: minister announces French franc will never again be devalued in the EMS.

March European Commission releases its plan for EMU; similar to Delors' report, but drops centrally-set rules for members' budget deficits. Plan to be discussed by EC finance ministers on March 31.

March 31 Ashford Castle meeting of EC finance ministers. Eleven of 12 ministers agree on main features of a new European Central Bank.

April German governments agree on terms of monetary conversion and union, to be enacted July 2, 1990.

April 28	Dublin summit. Declaration that changes in Treaty of Rome relating to EMU must be ratified by end of 1992 (thus possible for Stage 2 to begin in January 1993). Dec. 14, 1990 chosen as date for conference on EMU.
May 18	Treaty to unify the two Germanies signed. FRG agrees to set up DM 115 billion fund to support GDR through end of 1994.
June	Belgian central bank declares DM exchange rate as its main policy target.
July 1	Stage 1 of EMU begins.
July 1	Complete removal of capital controls, as previously scheduled. Exceptions: Ireland, Spain, Portugal, and Greece (deadline 1992).
July 1	German monetary unification.
August	European Commission finalizes its contribution to the upcoming Rome conference on EMU. (See March 1990.) Recommends the ecu replace existing currencies (rather than fixing permanent exchange rates among them). Proposes that Stage 2 should start in January 1993, leading after "a short duration" to full monetary union.
Sept.	Meeting of finance ministers in Rome reveals large differences over timing of EMU. Belgium, France and Italy call for Stage 2 to start January 1993 and Stage 3 soon afterwards. Germany and the Netherlands are against setting any deadlines, argue economic convergence must come first.
Oct. 8	Britain joins the ERM, using bands of ±6%.
Oct. 22	Norway unilaterally links its currency to EMS.
Oct. 27	Rome Summit. Breakthrough in favor of EMU deadlines. Eleven of 12 agree that Stage 2 of EMU should begin January 1994 (subject only to mild conditions). European central bank to be set up at start of Stage 2, to begin conducting monetary policy in Stage 3. Timing of Stage 3 is vague, but apparently before 2000. Countries will be permitted to stay outside Stages 2 and 3 if they choose.
Nov. 13	EC central bankers unveil their draft statutes for a future European central bank: first objective is to be maintenance of price stability.

Nov. 22 U.K. Prime Minister Thatcher resigns.

Dec. 14 Rome Summit. Intergovernmental conference on EMU begins work on a treaty to be signed by October 1991. Draft treaty published by European Commission to be used as its working base.

1991

April Spain removes virtually all capital controls.

April Speculation that Britain and Spain will narrow their exchange rate bands to ±2.25%.

May 13 Financial Times reports that many EMU negotiators have now accepted that a "two-speed" transition to EMU is inevitable.

May 19 The Economist reports that EMU negotiators, after five months of little progress, now appear likely to accept compromises embodied in draft EMU treaty proposed by Luxembourg.

May 13 Reports that Bundesbank's president will resign; resignation officially announced May 16.

May 17 Sweden unilaterally links its currency to EMS, using bands of ±1.5%.

June 7 Finland unilaterally links its currency to EMS.

June 9 U.K. and German leaders agree they will try to slow the pace of EMU negotiations at upcoming summit.

June 30 Luxembourg Summit takes no significant new steps toward EMU; key remaining decisions are apparently postponed until Maastricht Summit in December 1991.

Aug. 1 Financial Times reports that Germany proposed a two-tier approach to EMU at the June 30 Luxembourg Summit.

Sources: The Economist, The Financial Times of London, Giovannini [1990], Haberler [1990], Weber [1991].

APPENDIX B. ESTIMATION OF g_t FOR OTHER HORIZONS

In section VI we use the framework of Bertola and Svensson [1990] to estimate expected rates of revaluation based on 12-month forecast horizons. In this appendix we explain why we favor this horizon length; we also present estimates of the expected rate of revaluation based on 1-month forecast horizons.

Role and Choice of Forecast Horizon

In studying target zone credibility, our interest is in g_t, the expected rate of revaluation. We estimate this series by first measuring the overall expected rate of change of s_t (using either survey data or interest differentials) and then subtracting an estimated expected rate of mean-reversion within the band. This procedure may be thought of as a filter.

In implementing this procedure one must choose a time horizon of some discrete length. For example, the estimates in Section VI are constructed as follows, where $\Delta t = 1$ year:

$$g_t = E_t(\Delta s/\Delta t) - E_t(\Delta \bar{s}/\Delta t) \qquad \text{(B.1)}$$

Of course, these expected rates of change are *average* rates over the horizon being considered.

Whatever horizon is chosen, one must be concerned with error in estimating $E_t(\Delta \bar{s}/\Delta t)$. There are several reasons to believe that the resulting error in estimating g_t will be smaller for a longer time horizon. First, recall that we use a linear approximation to estimate $E_t(\Delta \bar{s}/\Delta t)$. In an earlier paper, Svensson [1990d] shows that the relationship we are approximating comes close to being linear for longer horizons. Second, as the horizon length is extended, the true value of $E_t(\Delta\bar{s}/\Delta t)$ must approach zero, since $E_t\Delta\bar{s}$ is bounded (again, see Svensson [1990d] for a full analysis).[38] Therefore, horizon length itself acts as the needed filter: $E_t(\Delta\bar{s}/\Delta t)$, the component to be removed from $E_t(\Delta s/\Delta t)$, becomes a relatively small component of observed $E_t(\Delta s/\Delta t)$ as longer horizons are considered. If so, the error in measuring $E_t(\Delta\bar{s}/\Delta t)$ (arising from sampling error or specification error) may be relatively unimportant at longer horizons.

Estimates of g_t for a 1-Month Horizon

Both the CFD surveys and Eurocurrency interest rates are available at horizon lengths of 1, 3, 6 and 12 months. In light of the above discussion, we favor analysis based on a 12-month horizon. Here we provide results based on a 1-month horizon.

Figures A1 and A2 are analogous to Figures 9 and 10, presenting estimated g_t values based on CFD surveys and interest differentials, respectively. (Although based on 1-month horizons, the rates of change shown are annualized values.)

The survey data-based results of Figure A1 are surprising in their magnitude and volatility. Furthermore, the estimates often point to expected revaluation against the DM, a result that seems implausible. We are inclined to dismiss these results. The problem appears to lie in computing $E_t(\Delta s/\Delta t)$ from the 1-month survey data, not in the estimated $E_t(\Delta\bar{s}/\Delta t)$ series. Indeed, the interest differential-based results of Figure A2 seem reasonable.

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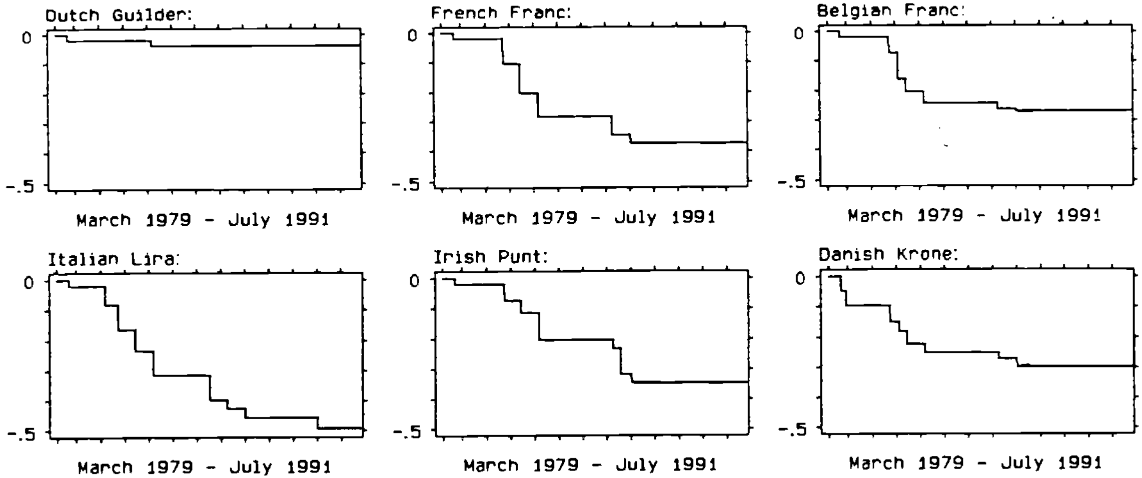
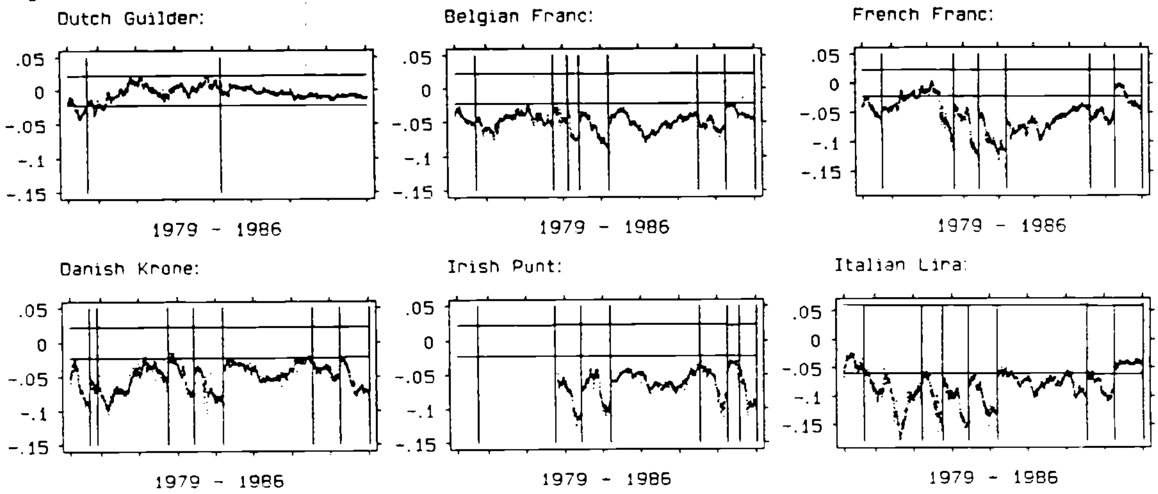
[38] The results shown earlier in Table 6 reflect this result. Note that the (annualized) rates of mean-reversion estimated for 1-month horizons are larger than those for 12-month horizons.

Figure 1



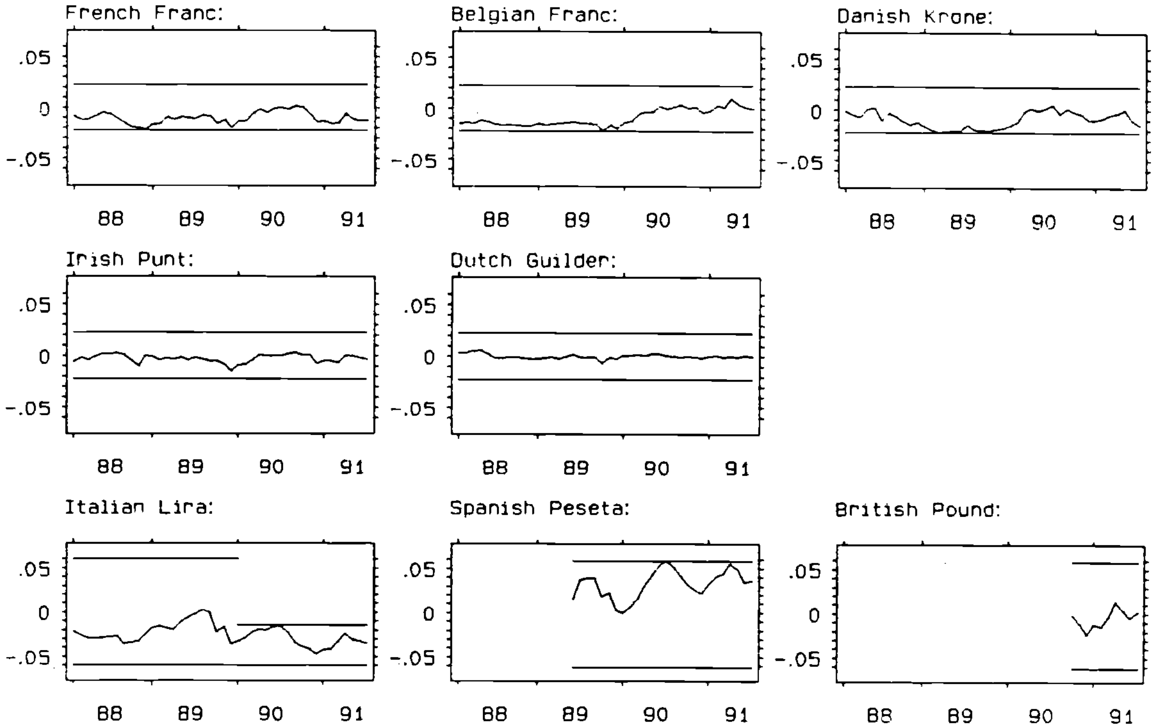
March 1979 - July 1991
EMS Currencies: log of DM Central Rates

Figure 2



March 1979 - Jan. 1987, as deviations from current DM Central Rate
1-Year Expectations, based on interest differentials

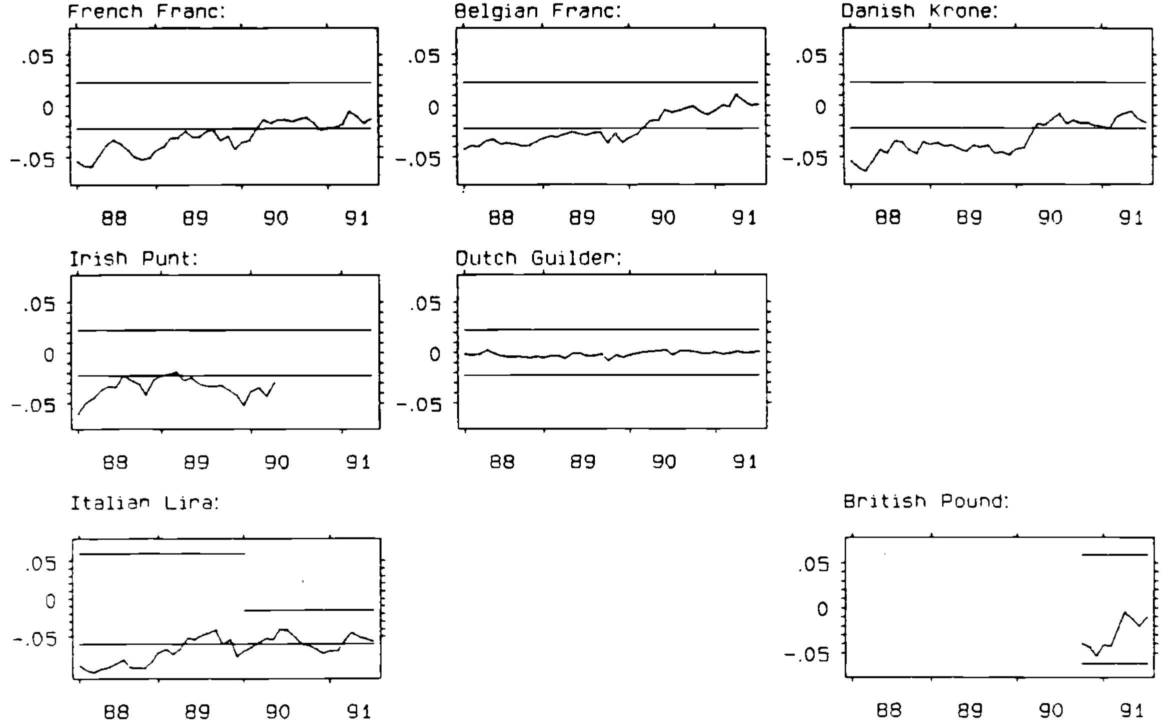
Figure 3



as log deviation from DM central rate

EMS Spot Exchange Rates, Feb. 1988 - July 1991

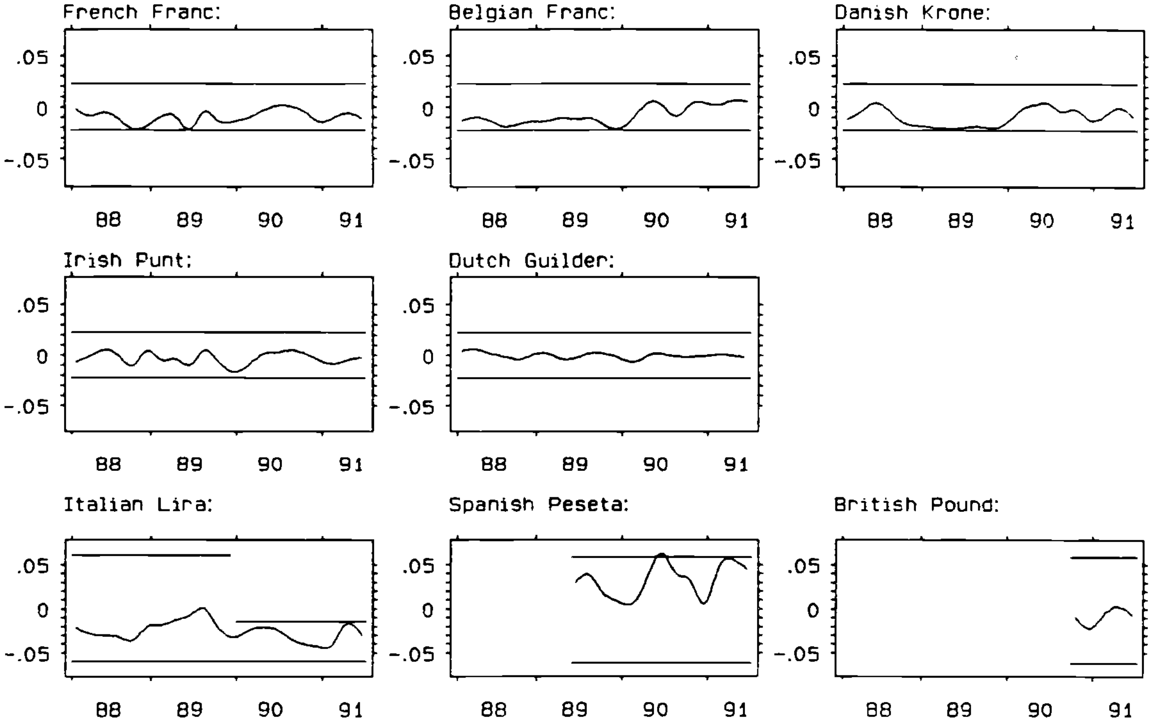
Figure 4



as log deviation from DM central rate, Feb. 1988 - July 1991

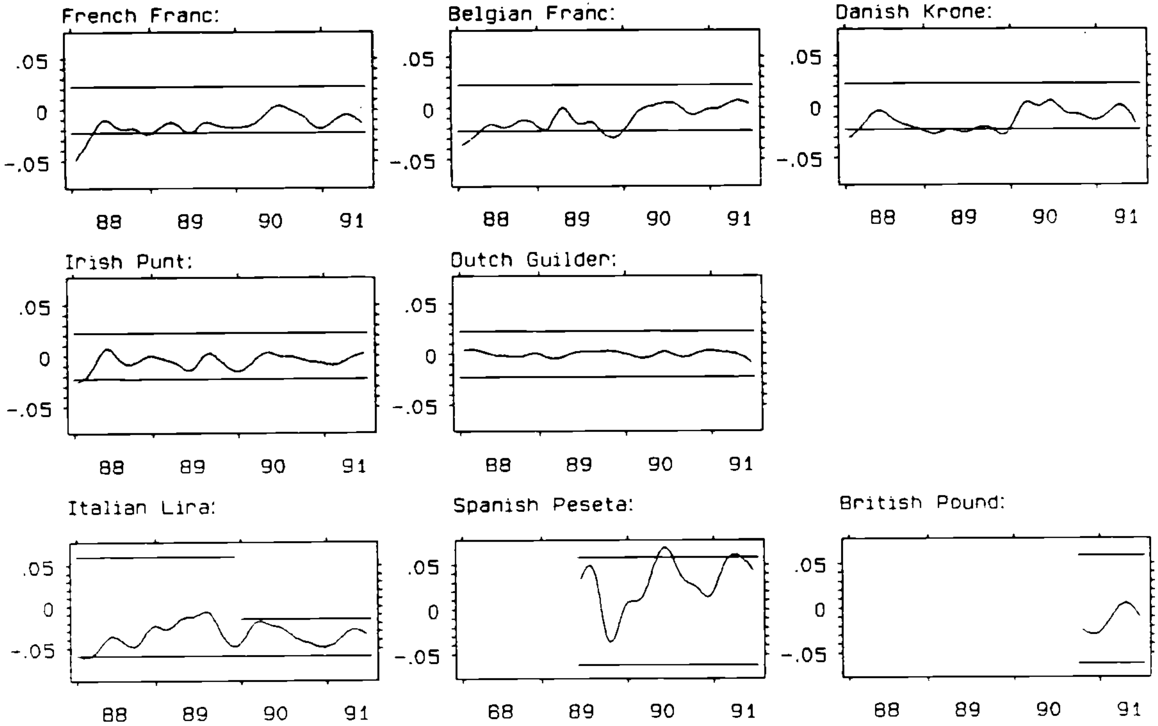
12 Month Expectations, using interest differentials

Figure 5



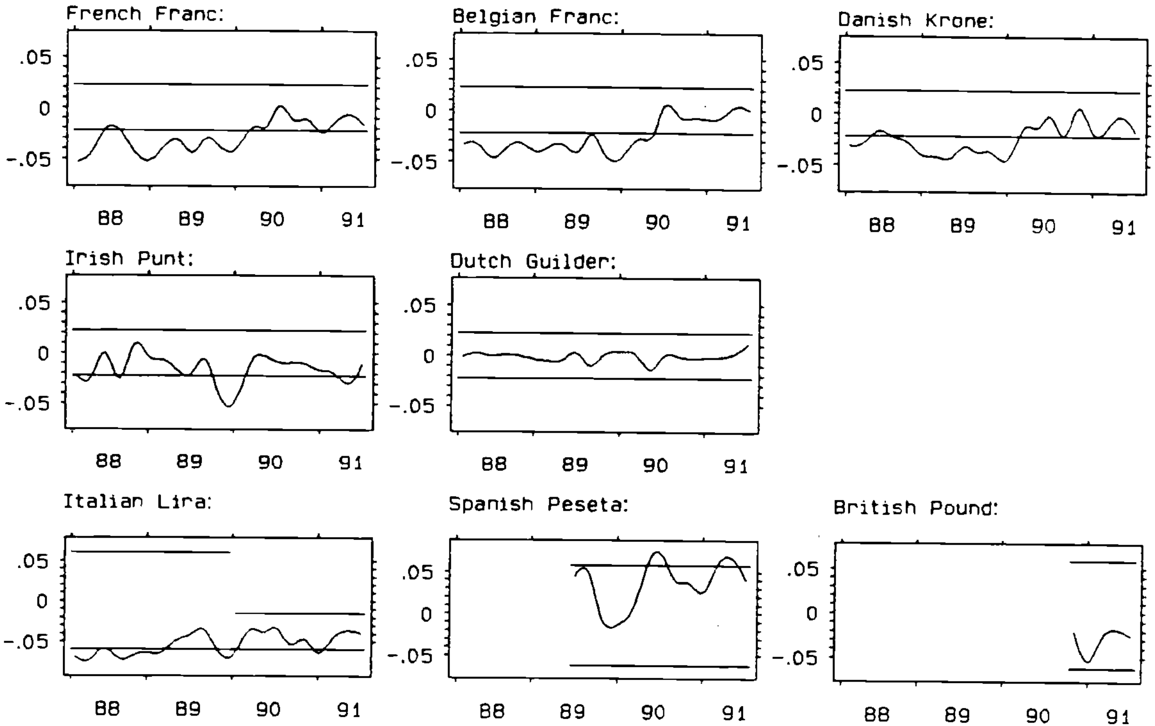
as log deviation from DM central rate, Feb. 1988 - July 1991
1 Month Forecasts, computed from CFD Survey

Figure 6



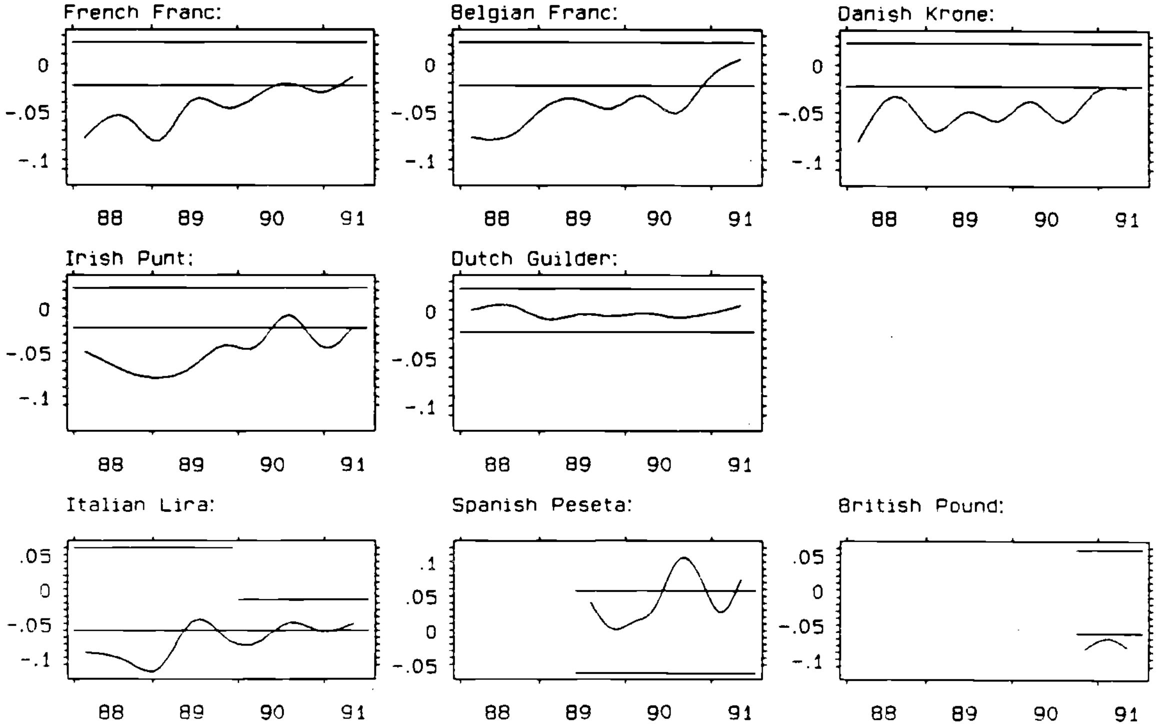
as log deviations from DM central rates, Feb. 1988 - July 1991
3 Month Forecasts, computed from CFD Survey

Figure 7



as log deviation from DM central rate, Feb. 1988 - July 1991
12 Month Forecasts, computed from CFD Survey

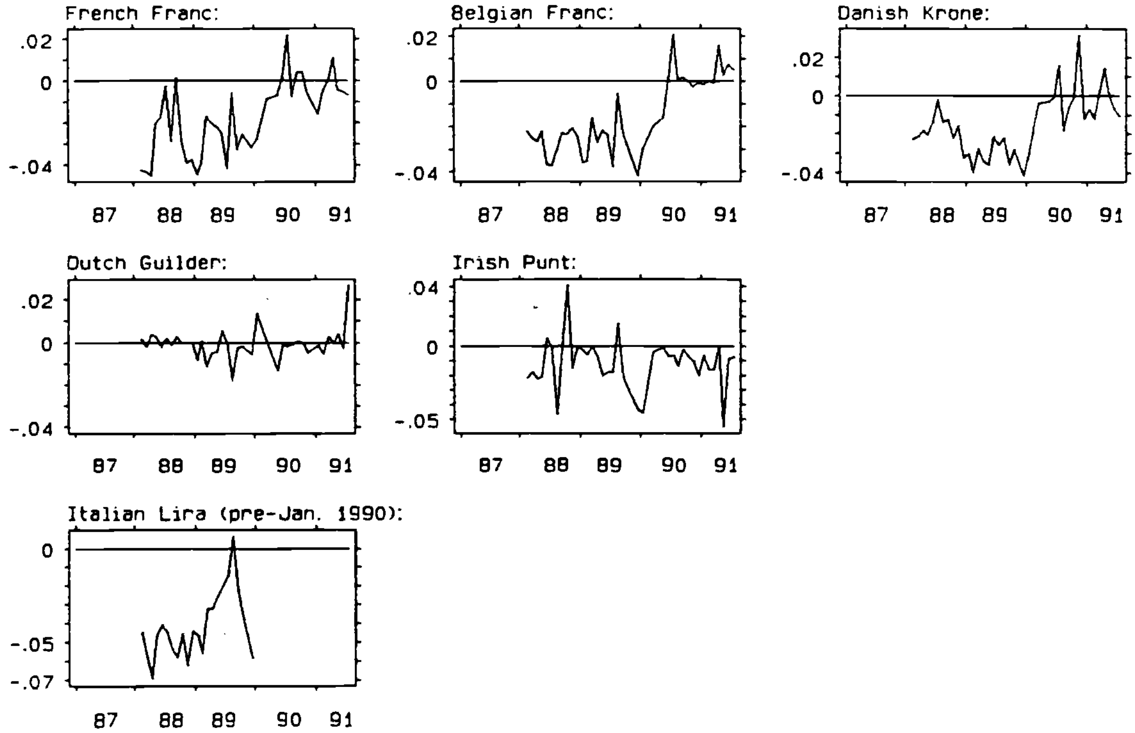
Figure 8



as log deviation from DM central rate

5 Year Forecasts, computed from quarterly CFD Survey

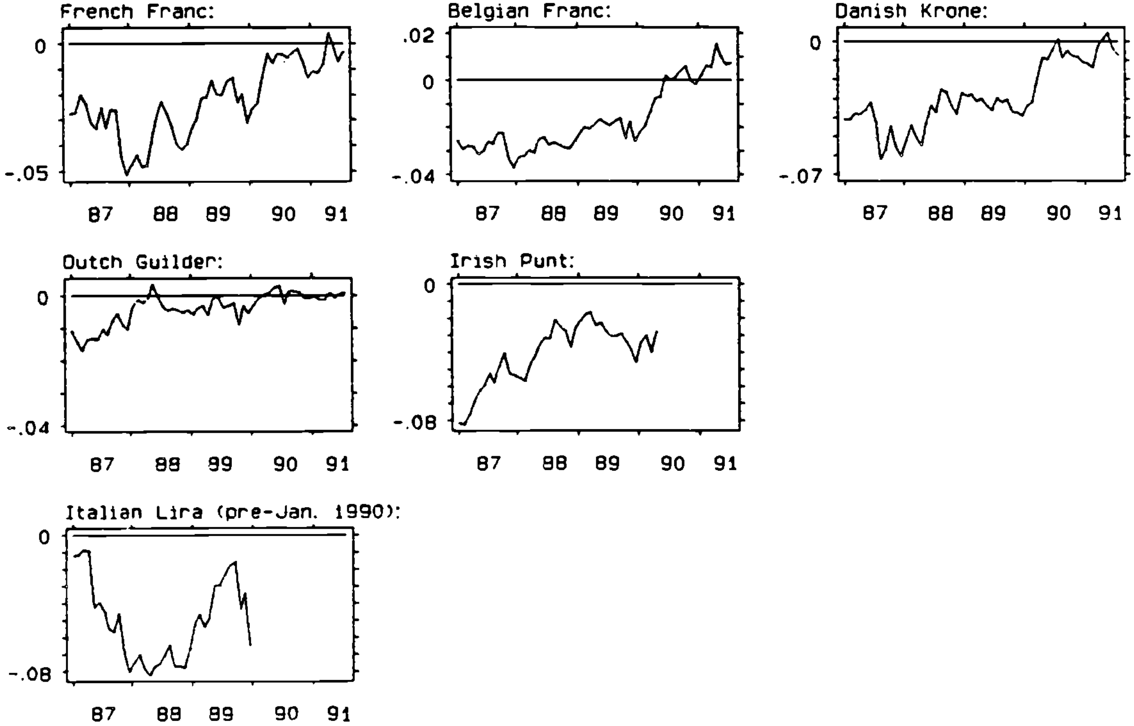
Figure 9



12 Month Horizon, annualized, based on CFD survey

g Estimates: Expected Rate of Revaluation against DM

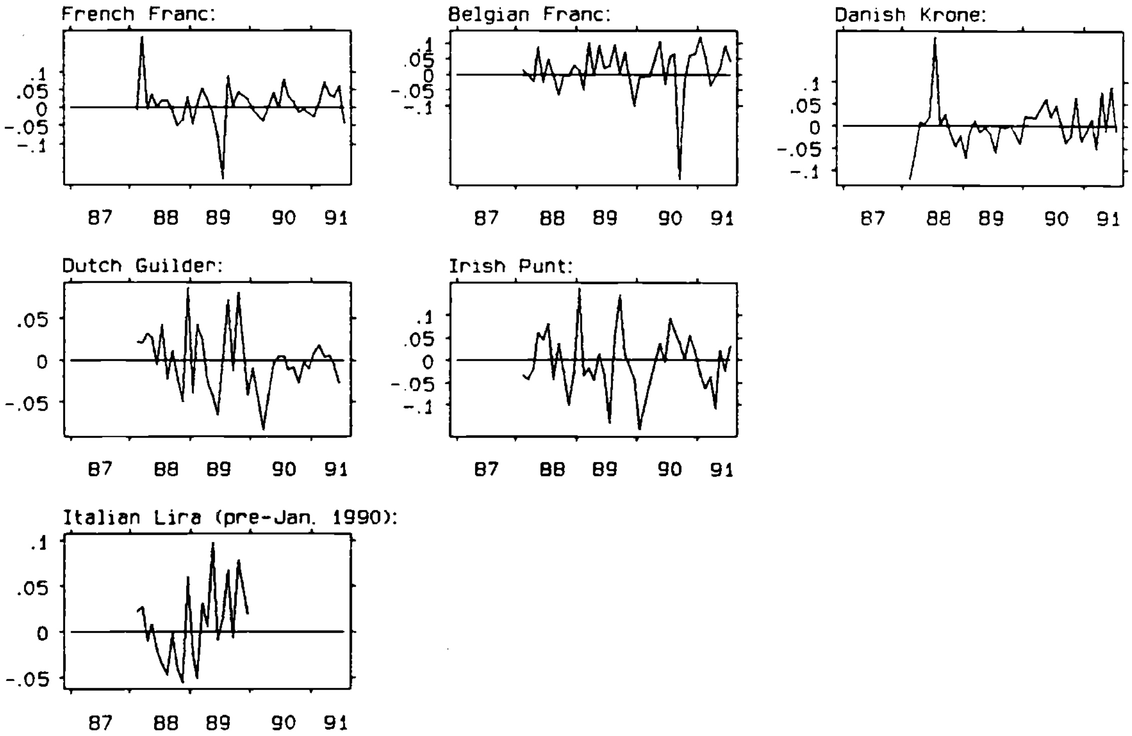
Figure 10



12 Month Horizon, annualized, based on uncovered interest parity

g Estimates: Expected Rate of Revaluation against DM

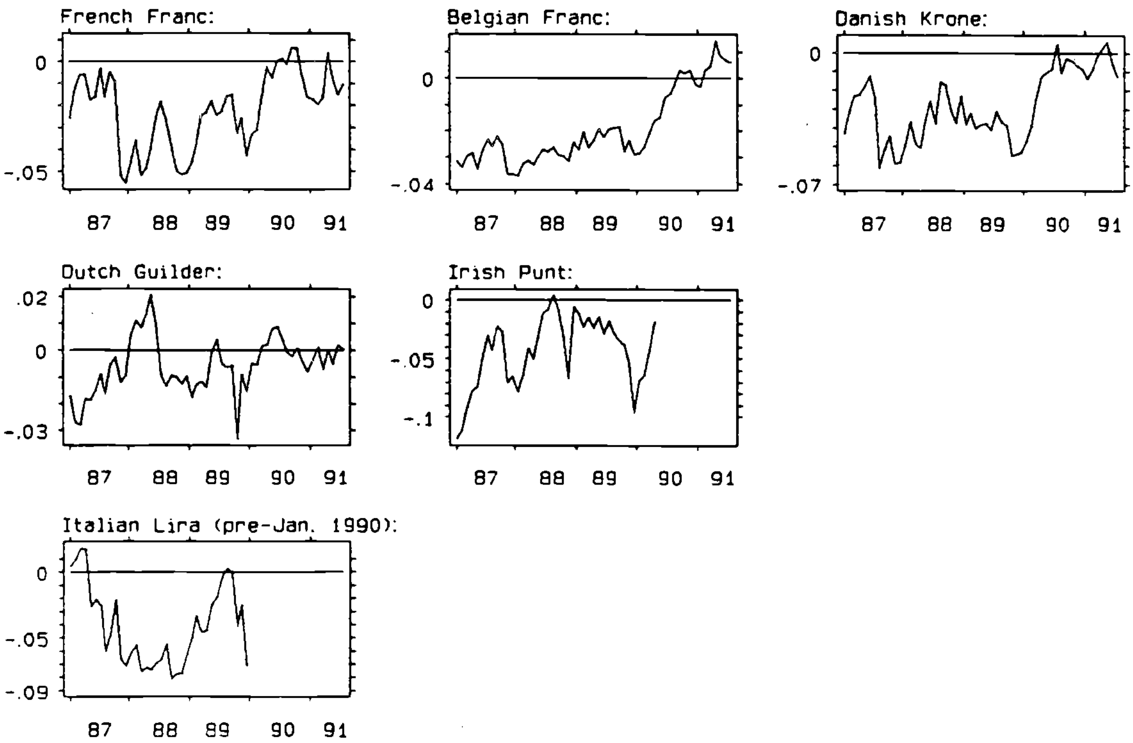
Figure A1



1 Mo. Horizon, annualized, based on CFD survey

g Estimates: Expected Rate of Revaluation against DM

Figure A2



1 Mo. Horizon, annualized, based on uncovered interest parity

g Estimates: Expected Rate of Revaluation against DM