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Documento de Trabajo nº 9419

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(*) We are grateful to Santiago Fernández de Lis and José Viñals for helpful comments. We should also like to thank Francisco Alonso and Juan J. Pacheco for outstanding research assistance. The views expressed in this paper are the authors' and they do not necessarily correspond to those of the Banco de España.

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ISBN: 84-7793-326-X
Depósito legal: M-25630-1994
Imprenta del Banco de España

Abstract

This paper proposes an indicator of exchange rate risk for currencies subject to exchange rate regimes which are not perfectly credible. This indicator is applied to several EMS currencies for periods before and after the widening of the fluctuation bands. We find that, contrary to what standard (GARCH-type) estimates suggest, exchange rate risk within the ERM is generally lower after the band widening than before. However, exchange rate risk for currencies that left the ERM is currently higher than for ERM currencies and also higher than in the period when they belonged to the mechanism.

1 Introduction

Between 1987 and the summer of 1992, the exchange rates of the currencies in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) showed a high degree of stability. After that, however, the system was hit by the worst crisis it had ever faced. This crisis gave rise to a reform of the ERM that entailed the temporary widening of the maximum fluctuation limits for bilateral rates to $\pm 15\%$.

During the crisis, the volatility of the exchange rates vis-á-vis the Deutsche mark, measured by the sample variance of their rate of change, increased nearly fourfold. At present, even though exchange rates have tended to be less volatile since the widening of the bands, volatility is still approximately two times higher than in the period of greatest stability in the System.

From the vantage of the founding objectives of the EMS, this rise in exchange rate volatility has been viewed as a negative development. Thus, one of the main concerns prompted by the widening of ERM bands refers to the possibility that the wider margin of fluctuation available may jeopardise the goal of exchange rate stability and, by heightening the exchange rate risk perceived by agents, may undermine the benefits and even the feasibility of the process of economic integration in Europe.

However, all too frequently, this concern arises from the reading of measures of exchange rate volatility which, in general, provide poor estimates of the concept of exchange rate risk that is relevant to the decisions of market agents. Following the study of Ungerer et al. (1986) on the effects of EMS membership on exchange rate and interest rate volatility, numerous papers have underscored the importance of using statistics that measure the conditional variance of the series rather than the unconditional variance. To this end, by estimating processes that model the predictable component of volatility, efforts have focused on obtaining an indicator of the volatility perceived or anticipated by agents. Thus, Artis and Taylor (1988) and Fratianni and Von Hagen (1990), for example, model the conditional variance of the exchange rates using the ARCH methodology introduced by Engle (1982).

Nonetheless, even measures of the conditional variance of exchange rates can prove inadequate for measuring the perceived exchange rate risk, if they focus solely on historical data, as in the ARCH models. Those measures fail to take into account the possibility that agents may consider that the exchange rate regime is likely to change, even though this might not be later confirmed. If, for instance, agents expect a devaluation of the currency, the subjective distribution of the exchange rate incorporates this event in its first and second order moment. If the devaluation does not occur, the volatility estimated on the basis of observed data will tend to underestimate the risk perceived by agents when they carry out transactions in a foreign currency. The effect of those unobservable events on the conditional mean is known in the literature as the "peso problem" (see e.g. Krasker, 1980) and has been the subject of frequent analysis in different contexts. This contrasts with the dearth of studies that extend the analysis to second order conditional moments, as the study of exchange risk requires.

The importance of using exchange risk indicators which incorporate the degree of credibility of the fluctuation regime is even greater if we consider that, in general, those who have expressed concern over the increase of exchange rate variances have also acknowledged that the widening of fluctuation bands has made the ERM more sustainable. Naturally, this gain in the System's credibility -which is evident by simple inspection of the usual indicators (see e.g. Svensson, 1993)-, was also favoured by the corrections made on exchange rates during the crisis and by the observed easing of economic policy dilemmas. Therefore, an analysis of exchange rate risk in the ERM requires proposing indicators that are capable of reflecting both the observed volatility and the perceived sustainability of the exchange rate regime.

This task is partially udertaken in this paper. Thus, the paper proposes an exchange risk indicator which allows the absence of perfect credibility of fluctuation regimes. This indicator is used to evaluate the exchange rate risk associated to the peseta and other ERM currencies between June 1989 and February 1994, paying special attention to the changes observed after the widening of the hands.

The rest of the paper is structured as follows: Section 2 obtains the conditional variance of the exchange rate when it is subject to a system with imperfect credibility and proposes a method for its estimation. Section 3 uses this indicator to study the risk associated to the peseta/D-mark exchange rate. Section 4 extends the analysis to other ERM currencies.

Section 5 presents the main conclusions of the analysis.

2 Exchange Rate Risk Under Imperfect Credibility

In line with the financial literature, this paper measures the risk associated to the exchange rate variation at moment t at term τ as the variance of the exchange rate at $t+\tau$, conditioned to all information available at t. This conditional variance is defined as

$$V_t s_{t+\tau} \equiv E_t(s_{t+\tau} - E_t s_{t+\tau})^2,$$

where E_t is the conditional expectation operator at t, and s_t is the (log) market exchange rate. Thus, the exchange risk at t is defined as the expected value of the volatility of the unanticipated component of the exchange rate at $t+\tau$.

This definition is justified on two fronts. First, even though it is true that greater fluctuations generally imply greater risk, not all the volatility of a series can be considered risk, since part of these fluctuations can be anticipated by the market, and the risk indicator should evaluate the degree of unpredictability in the exchange rates. Second, the measure of relevant exchange risk should be based on the expected or anticipated component of volatility in the series, because this is the component that determines agents' decisions.

2.1 Conditional Variance under Regimes which are not Perfectly Credible

Assume that the (log) exchange rate s , follows at period t a process (R1) characterized by a conditional mean μ_t^1 and a conditional variance h_t^1. However, agents assign at that period, a probability p_t to the next period exchange rate being a realization of a different stochastic process (R2) with conditional mean μ_t^2 and conditional variance h_t^2.

Therefore, the conditional mean at period t of the (log) exchange rate is

$$E_t s_{t+1} = (1-p_t)E_t[s_{t+1}|\mathrm{R1}] + p_t E_t[s_{t+1}|\mathrm{R2}]. \tag{1}$$

Likewise, the conditional variance is

$$V_t s_{t+1} = E_t(s_{t+1} - E_t s_{t+1})^2 = (1-p_t)E_t[(s_{t+1} - E_t s_{t+1})^2|\mathrm{R1}] + p_t E_t[(s_{t+1} - E_t s_{t+1})^2|\mathrm{R2}]. \quad (2)$$

Substituing equation (1) into equation (2) yields

$$\begin{aligned} V_t s_{t+1} &= (1-p_t)E_t\left[(s_{t+1} - \mu_t^1) - p_t(\mu_t^2 - \mu_t^1)|\mathrm{R1}\right]^2 \\ &+ p_t E_t\left[(s_{t+1} - \mu_t^2) + (1-p_t)(\mu_t^2 - \mu_t^1)|\mathrm{R2}\right]^2 = \\ &= \left[(1-p_t)h_t^1 + p_t h_t^2\right] + p_t(1-p_t)(\mu_t^2 - \mu_t^1)^2. \end{aligned} \quad (3)$$

Thus, the conditional variance of the exchange rate has two components. The first one is the mean of the *within the regime* conditional variances of both regimes. The second component measures the effect on the conditional variance of the expected change in the conditional mean of the process.

In order to illustrate the meaning of equation (3), consider a currency subject to a regime characterised by a zero-width band. Assume also that the probability of devaluation is not zero. In this case, the *within the regime* conditional variance would be zero under both regimes. However, since there exists a risk of devaluation ($0 < p_t < 1$), the conditional variance will be positive. Thus, even though the observed market rate does not fluctuate, the foreign exchange risk measured by the conditional variance can be high if the observed parity is not sufficiently credible.

Similarly, for regimes characterized by target zones -like the ERM-, equation (3) suggests a method to correct the traditional GARCH-type volatility indicators. Thus, equation (3) can be rewritten as

$$V_t s_{t+1} = h_t^1 + C_t, \quad (4)$$

where

$$C_t = p_t(h_t^2 - h_t^1) + p_t(1-p_t)(\mu_t^2 - \mu_t^1)^2. \tag{5}$$

Since the standard indicators only take into account the history of the series, they only estimate the *within the regime* component (h_t^1) of the conditional variance. Therefore, when estimating risk, the usual indicators ignore the correction term C_t which measures the impact of the imperfect credibility of the official bands (or of the target zone within those bands).

Note first that if $h_t^1 \approx h_t^2$, imperfect credibility $(p_t > 0)$ implies that the standard GARCH approach understimates unambigously the conditional variance of the exchange rate. Second, the higher the *within the regime* volatility of the alternative regime and the higher the absolute variation of the conditional mean, the higher the correction term. Third, the second term of equation (5) is independent of the alternative regime implying a currency depreciation or a currency appreciation. Finally, the correction term is not a monotonic function of the switching probability p_t. In fact, $p_t = .5$ maximizes the second term of equation (5) for given μ_t^1 and μ_t^2.

2.2 Measuring Foreign Exchange Risk

In order to measure foreign exchange risk we must specify two alternative processes for the exchange rate. Using a common practice in the literature, we only consider univariate processes. In particular, we assume that the exchange rate is the realization of one of the following stochastic processes:

$$\text{R1:} \qquad s_{t+1} = c + \phi s_t + \epsilon_{t+1} \tag{6}$$

$$\text{R2:} \qquad s_{t+1} = c + d_t + \phi s_t + \omega_{t+1}, \tag{7}$$

where d_t is the difference between the conditional mean of the two processes (a jump) and ϵ_t and ω_t are innovations with zero mean and common conditional variance[1] (h_t) . We also

[1]This assumption implies that both regimes only differ in their conditional mean. Although this assumption might not be verified ex-post, it avoids making additional arbitrary assumptions on the expected change of the conditional variances. In any case, the ex-post estimates of h_t for the different regimes show that this

assume that agents assign at every period t a probability p_t to the current regime switching from R1 to R2. Thus at every period t, an exchange rate jump of size d_t is expected with probability p_t.

From equations (6) and (7), we can rewrite equation (3) as:

$$V_t s_{t+1} = h_t + p_t d_t (d_t - p_t d_t). \tag{8}$$

Thus, measuring exchange risk requires computing the switching probability p_t, the expected jump size d_t and the conditional variance *within the regime* h_t.

Assuming that Uncovered Interest Rate Parity (UIP) holds, the expected rate of exchange rate jump $(p_t d_t)$ can be easily calculated since

$$i_t - i_t^* = E_t s_{t+1} - s_t = p_t d_t + c - (1 - \phi) s_t, \tag{9}$$

where i_t and i_t^* are the domestic and foreign one-period interest rate respectively [2].

Naturally, splitting the expected rate of the exchange rate jump into probability and size is less straightforward. The approach taken is the usual in the related literature (see Lindberg, Svensson and Söderlind, 1993 and Drazen and Masson, 1992). Thus, we fix exogenously the expected jump size, taking into account real exchange rate appreciations and the jumps observed after devaluations and other regime variations (free floating and band narrowing and widening). Once the expected jump size (d_t) has been determined, the probability p_t is obtained by dividing the interest rate differential over d_t.

The conditional variance within the regime is estimated using the GARCH methodology proposed by Bollerslev (1986). Thus, we assume

$$\epsilon_{t+1|t} \sim D_\epsilon(0, h_t) \quad \text{and} \quad \omega_{t+1|t} \sim D_\omega(0, h_t) \quad \text{where}$$

assumption is, at best, biasing downwards the correction term in equation (5).

[2] Svensson (1992) and Ayuso and Restoy (1992) provide theoretical and empirical arguments in favour of using UIP as an approximate measure of expected exchange rates within the ERM. Notice also that under UIP, $i_t - i_t^* - c + (1 - \phi) s_t$ is the expected rate of devaluation defined in Svensson (1993).

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \epsilon_{t+1-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}$$

In the empirical work we use daily data. However, since we are interested in estimating the foreign exchange risk associated to horizons longer than one day, we must deal with interest rates which correspond to maturities longer than the frequency of the data. In order to handle this problem, we assume that there is only one possible jump within the considered horizon τ and rewrite equations (6) and (7) in the following way:

$$\text{R1'}: \qquad s_{t+\tau} = k + \phi^{\tau} s_t + \nu_{t+\tau} \tag{10}$$

$$\text{R2'}: \qquad s_{t+\tau} = k + d_t + \phi^{\tau} s_t + \eta_{t+\tau}, \tag{11}$$

where

$$k = \frac{c(1-\phi^{\tau})}{1-\phi}, \qquad \nu_{t+\tau} = \sum_{i=1}^{\tau} \phi^{\tau-i} \epsilon_{t+i}, \qquad \eta_{t+\tau} = \sum_{i=1}^{\tau} \phi^{\tau-i} \omega_{t+i}$$

$$\text{and} \qquad V_t \nu_{t+\tau} = V_t \eta_{t+\tau} = \sum_{i=1}^{\tau} \phi^{\tau-i} V_t \epsilon_{t+i}$$

Therefore, p_t and d_t should be reinterpreted as the probability and the expected size of an exchange rate jump between t and $t+\tau$ respectively. Taking advantage of the linear form of the GARCH model it is straightforward to compute the τ-period conditional variance $V_t \nu_{t+\tau}$. For example, for the standard GARCH(1,1) model, it holds that

$$\begin{aligned} V_t \epsilon_{t+1} &= h_t \\ V_t \epsilon_{t+j} &= \alpha_0 \left[\frac{1-(\alpha_1+\beta_1)^{j-1}}{1-(\alpha_1+\beta_1)} \right] + (\alpha_1+\beta_1)^{j-1} h_t \qquad j = 2, \ldots \tau \end{aligned} \tag{12}$$

3 The Exchange Rate Risk of the Spanish Peseta

In this section, we use the methodology described in section 2 to analyse the risk associated to the peseta/D-mark exchange rate since the entry of the peseta into the ERM.

In order to calculate the conditional variance of the exchange rate we chose a maturity of 1 month, since this is the term habitually used in the descriptive studies of exchange rate volatility in the ERM. Thus, the (daily) interest rates used correspond to 1-month deposits in the Euromarket, denominated in pesetas and D-marks, respectively.

We distinguish four subperiods (see Chart 4.1). The first begins with the peseta's entry into the ERM, ends at the time of the September 1992 devaluation and coincides with the period of greatest stability in the System. The second ends with the devaluation of May 1993, and the third concludes few days before the widening of the bands on August 2, 1993 (concretely, July 22). Hence the second and third subperiods can be taken as the stages of greatest tension in the ERM, while the fourth subperiod can be used to illustrate the behaviour of the exchange rate within the framework of the new ERM following the widening of fluctuation bands.

For all four subperiods the parameters of the equations (6) and (7) were fixed such that $c = 0$ and $\phi = 1$. These values of the parameters imply that the exchange rate follows a random walk process without drift within each regime. Although the empirical evidence is not very favourable to of this hypothesis for ERM currencies[3], we use it as a simplification that facilitates the subsequent analysis and allows isolating the proposed measure of risk from the possible effects caused by the changes in the mean reversion process throughout the four subperiods studied[4].

As regards the estimation of the GARCH processes, Table 4.1 shows the results for the subperiods considered. As can be observed, with the exception of the third subperiod (characterised by a constant variance), the model that best explains the conditional variances is a GARCH(1,1).

In the breakdown of the expected rate of exchange rate jump by the probability of the jump and its expected size, the size corresponding to each of the four subperiods was obtained under the criteria described forthwith. If the average value in the year 1988 is fixed as a reference, at the time of the peseta's entry into the ERM the Spanish economy had accumulated losses

[3]See Frankel and Phillips (1991), Holden and Vikoren (1992), Ayuso, Pérez Jurado and Restoy (1993), Svensson (1993) and Alberola, Humberto and Orts (1994).

[4]In any case, all qualitative results proved to be robust to an alternative specification where the exchange rates were allowed to follow unrestricted stationary AR(1) processes (see chart 4.4.).

in competitiveness ranging between 3% (production prices) and 10% (unit labour costs in the manufacturing sector). In addition, one month after the devaluation of September 1992, the peseta/D-mark exchange rate was depreciated by approximately 13%. Taking these data as a reference, we imposed linearly increasing size from 5% to 13% for the first subperiod. As for the second and third subperiods, we used constant sizes of 7% and 5% respectively. Those sizes correspond approximately to the observed market depreciations one month after the third devaluation and the band widening respectively. Lastly, for the fourth subperiod we used the minimum constant size compatible with the observed interest rate differentials[5]. This assumption is justified by the absence of devaluations in the period and by the elimination of the currency real overvaluation as a consequence of the three devaluations experienced by the peseta.

Chart 4.2 shows the expected rate of jump of the exchange rate and its breakdown on the expected size and the probability of the jump. As can be observed, the product $(p_t d_t)$ tended to move downwards from the peseta's entry into the ERM until approximately the Danish referendum of June 1992. It then headed on a generally upward course, albeit with significant falls after each devaluation. Following the upturn in July 1993 and the widening of the bands on August 2 of that year, the rate slipped again and, by the end of February 1994, reached values close to those of June 1992.

With respect to the probability and expected size of the jump, the pronounced difference observed between the periods prior and subsequent to the widening of the bands is congruent with the interpretation occasionally made of the difference between a system of pegged exchange rates and a system of more flexible rates (Edison and Melvin, 1990): characteristically, in a pegged exchange rate system, the probability is small (less than 15% in this case) that a large jump will occur (up to 13%) whereas, in a system of more flexible rates, there is a large probability (nearly 50%) of a small jump (less than 1%).

Lastly, the ***within the regime*** conditional variance $(V_t \nu_{t+\tau}) = (V_t \eta_{t+\tau})$ can be obtained by using expression (12) and the GARCH estimates of Table 4.1.

[5]Note that, since probability is bounded by 0 and 1, the maximum (positive) value for the observed interest differential is the lower limit for a (constant) size of the expected jump.

After obtaining the probability of a change of regime (p_t), the expected jump in the peseta/D-mark exchange rate (d_t) and the *within the regime* conditional variance ($V_t v_{t+\tau}$), the exchange rate risk associated to the peseta/D-mark exchange rate is estimated by computing equation (8).

Chart 4.3 compares the *within the regime* (uncorrected) conditional variance together with the (corrected) conditional variance of the exchange rate.

The key finding derived from the analysis of Chart 4.3 is the enormous quantitative importance of the correction arising from the possibility of a jump in the market exchange rate. In fact, it can be observed that, due to this correction, the exchange rate risk that characterised the period between June 1989 and August 1992 is approximately four times greater than what would be deduced from the simple estimation of the *within the regime* volatility. During the crisis period (September 1992-July 1993), the exchange rate risk is still substantially higher than what would be reflected in the standard analysis of observed exchange rate volatility. However, after the widening of fluctuation bands, the narrowing of the interest rate differential with Germany makes the discrepancy between the proposed measure of risk and the standard volatility estimates much less relevant[6].

The importance of the correction of the conventional volatility indicator is also evident if we compare the levels of the peseta's exchange rate risk before and after fluctuation bands were widened (August 2, 1993). In this sense, the performance of the standard volatility (uncorrected conditional variance) suggests that the volatility of exchange rates following the widening of the bands is practically three times greater than the level observed in the period prior to September 1992 and only 25% lower than in the crisis period. However, the analysis of the corrected conditional variance shows that, after an initial bout of high volatility, the risk characterising the wide-band period is 60% lower than in the crisis period and 25% lower than during the three-year period that preceded the first devaluation of the peseta in the ERM.

These findings signal that, as expected, the larger margin of fluctuation available has translated into more volatile exchange rates. However, the observed gain in credibility of the

[6]This result does not decisively depend on imposing a relatively small jump in the last subperiod. It holds also for reasonably higher sizes (e.g. 3%).

fluctuation regime has a greater impact on the conditional variance of the exchange rate than the rise in observed volatility. Thus, contrary to what conventional estimators suggest, the proposed indicator shows that the exchange rate risk of the peseta has subsided since the widening of the bands.

Since other currencies' interest rate differentials with the D-mark have also narrowed considerably, it makes sense to analyse whether the observed effect of greater credibility gives rise to conclusions on exchange rate risk similar to those obtained for the peseta.

4 Application to other currencies

his section examines the patterns of risk associated to exchange rates vis-á-vis the D-mark for the rest of the currencies that belong, or have belonged to, the Exchange Rate Mechanism, with the usual exception of the Dutch guilder.

The period analysed is the same as for the peseta except for those currencies whose incorporation in the ERM took place later. As a result, the samples for the Portuguese escudo and the British pound begin on April 9, 1992 and October 8, 1990, respectively. The assumptions used in obtaining the proposed measure of exchange risk are also similar to those applied in the Spanish case. Thus, we impose a random walk process for all exchange rates and the sample is divided into several subperiods. In each case, the break points chosen are those corresponding to devaluations, to changes in the width of the fluctuation band or to the switch to free floating. For the French franc, the Danish krone, the Belgian franc and the Irish pound, periods of exchange rate instability are also slightly different: between September 1992 and August 1993 in the case of the first three currencies, and between September 1992 and January 1993 for the Irish pound.

Chart 5.1 shows the expected size of the exchange rate jump assumed for each of the currencies and the subperiods considered. In general, for the periods prior to a currency's devaluation or to a switch to free floating, the expected jumps imposed are equal to the variations in the average exchange rates that arose after these events occurred. These variables either remain constant or grow linearly from lower values when they are very high and coincide with periods of a progressive accumulation of losses of competitiveness. For the free floating or wide band periods, the expected jumps correspond to the maximum value registered by the interest rate differentials (i.e., the minimum constant value which is compatible with the implied probability being not higher than one). Since the Danish krone, the French franc and the Belgian franc have suffered neither a devaluation nor significant real exchange rate appreciations, the expected jumps for the narrow-band period were set equal the size of their last devaluation. This same criterion was applied to the Irish pound in the period prior to the British pound's withdrawal from the system.

Thus, by following the steps detailed in the previous sections, the measures of exchange rate risk presented in Charts 5.1 to 5.7 were obtained from the results of the estimation of GARCH(1,1) models for the conditional variances of the exchange rates which figure in Table 5.2 and the 1-month interest rate differentials with the D-mark.

As can be observed, the exchange rate risk perceived by agents is, in all cases, substantially higher in most of the sample when measured by the corrected conditional variance than when the standard measure of conditional volatility is used. Logically, this difference is less striking in the periods when the interest rate differential with Germany is small. This occurs for the former narrow-band currencies and the British pound for several months before the crisis. Both measures are also similar during the stages of free floating and of $\pm 15\%$ bands, as expected for regimes of greater exchange rate flexibility and narrower interest rate differentials.

These findings underscore, once again, the importance of considering the possible existence of imperfect credibility in the exchange rate fluctuation regime when estimating the degree of exchange risk perceived by market agents. Thus, depending on how agents value the possibility of a future jump in the the exchange rate, the observed volatility provides incomplete information about the uncertainty associated to the exchange rate. Moreover, not only does the scale of the exchange rate risk differ greatly according to the measure used, but also, in most cases, its variation between one period and another. In this sense, the estimates show that the proposed correction is decisive –to the extent that, for most of the currencies studied, it reverses the conclusions on the conduct of exchange rate risk after the widening of the fluctuation bands.

As can be seen in Charts 5.1. to 5.7, during the ERM crisis between September 1992 and August 1993, there was –not surprisingly– a significant increase in the exchange rate risk of all currencies considered. However, as from August 1993, for the currencies that remained in the ERM, we observe a reduction in the corrected conditional variance (much more pronounced than what the uncorrected conditional variance reflects) that places the level of exchange rate risk below the level registered in the crisis period.

Naturally, the main concern caused by the widening of fluctuation bands does not refer to a possible increase in the volatility of exchange rates in relation to the periods of strongest tension and frequent speculative attacks, but rather to the possible difficulty in recovering the levels of exchange rate stability that characterised the three years prior to the crisis. Nonetheless, as seen in Charts 5.1 to 5.5, a comparison between the exchange rate risk registered after the widening of the bands and the levels prevailing during the pre-crisis period of stability should, at least partially, dispel this concern. Thus, for the French franc and the Danish krone, in the last part of the sample, the corrected conditional variance of the exchange rate shows levels similar to those prevailing during the year prior to the crisis and lower than those estimated for the first two years of the sample; for the escudo, from the very start of the period of ±15% fluctuation bands, exchange rate volatility is significantly lower than during the period between its entry into the ERM and September 1992.

The conclusion is, however, different in the case of the Belgian franc and the Irish pound, whose exchange rate risk is now higher than when narrow bands were in force. This is explained by the high credibility of their exchange regimes in the pre-crisis period and by the increase in the volatility of their exchange rates after the widening of the bands. Note, nonetheless, that, even in these cases, the exchange rate risk observed several months after the widening of the bands is appreciably lower than in the case of the peseta and the escudo in practically the entire period between their respective entries in the ERM and the outbreak of the crisis.

Unlike what occurred for most currencies which widened their fluctuation bands, the currencies which withdrew from the ERM have been subject to a substantial increase in their associated exchange rate risk. As shown in Charts 5.6 and 5.7, the corrected conditional variance of the lira and the British pound moves in the same direction as their uncorrected conditional variance. In the last part of the sample, both currencies register higher exchange rate risk than when they belonged to the System and, moreover, reflect the highest risk among the currencies considered. Thus, the risk associated to the British pound and, especially, the lira, not only exceeds that attached to currencies traditionally characterised by greater risk but which, nonetheless, opted not to leave the ERM (the peseta and the escudo) but is also higher than that in the case of currencies hit by stronger fluctuations after the widening of the bands (the Belgian franc and the Irish pound).

In sum, the analysis of this group of currencies confirms, in all essential aspects, the results obtained for the peseta. Thus, that analysis confirms the great importance of taking into account the possible existence of imperfect credibility in the exchange rate fluctuation regime when measuring exchange rate risk. When this factor is considered, not only does the estimated scale of risk change radically (in the periods prior to the widening of fluctuation bands, it is significantly greater than that reflected in conditional variance) but also, for most currencies, there is a reversal in the direction in which it varies after the widening of the bands to ±15%. As a result, exchange rate risk is now lower than during the period of exchange rate stability under the former fluctuation bands. Nonetheless, the application of a corrected conditional volatility measure does not allow changing the conclusions with respect to the conduct and relative scale of exchange rate risk for the currencies that went from a regime of fluctuation bands to another of free floating. The exchange rate risk estimated for the first few months of 1994 is greater than the one corresponding to the period when they belonged to the ERM.

5 Conclusions

The reform of the Exchange Rate Mechanism arising from the widening of fluctuation bands is often viewed as a lesser evil that facilitates the survival of the ERM at the expense of distorting its essence. Thus, the idea has spread that it was necessary to give up the beneficial effects on exchange rate risk associated to less volatile parities in order to guarantee the sustainability of the EMS in the context of free capital flows and scant convergence among European economies. In other terms, the reform of the System would have allowed achieving a greater degree of sustainability at the price of heightening exchange rate volatility. Even though the standard volatility indicators support this pessimistic view of the impact of the ERM's reform on exchange rate risk, the present paper provides evidence that counters this hypothesis.

As a first step, we questioned the general practice of measuring exchange rate risk by applying the standard models of conditional heteroskedasticity to the observed exchange rate data. This practice fails to take into account much of the risk assumed by agents when they operate with currencies of scant volatility but which fluctuate around parities perceived to be fairly unsustainable. To surmount this problem, we propose an indicator of exchange rate risk that explicitly reflects the possible lack of credibility of the fluctuation regime.

The empirical implementation of the indicator involves assumptions – difficult to test – regarding the expected size of the exchange rate jumps associated to the changes of regime. Since the quantitative results inevitably depend on these assumptions, we used conservative criteria which are, in any event, consistent with those habitually applied in the literature. Hence, the expected sizes never exceed the jumps that effectively occurred and are always lower than the losses of competitiveness accumulated by the different countries. In addition, qualitative conclusions proved to be robust to moderate variations in the assumptions applied.

This indicator was applied to the peseta and other currencies that belong, or belonged, to the ERM in order to evaluate the evolution of exchange rate risk within the EMS in recent years. The following conclusions were drawn:

– The conventional measures of volatility considerably underestimate the exchange rate risk of all the currencies in practically the entire period when narrow bands were in force.

– The proposed indicator signals a pattern of exchange rate risk in the ERM very different from that suggested by conventional volatility yardsticks. Within months from the widening of the bands, for most of the currencies that remained in the ERM, the prevailing exchange rate risk is not only substantially lower than during the crisis period; it is also milder than during the period prior to the signing of the Maastricht Treaty and comparable to the levels observed during the period of greatest stability in the narrow-band ERM. Additionally, in the only two cases where exchange rate risk has risen since August 2, 1993 (the Belgian franc and the Irish pound), its level is lower than that registered by the higher-risk currencies (the peseta and the escudo) during the system's most stable period.

– The exchange rate risk associated to the currencies that remained in the System is, in any event, lower than that attached to the currencies that switched to a free floating regime, whose risk is now substantially higher than when they belonged to the ERM.

The results obtained suggest that, even in the absence of speculative attacks, exchange rate regimes that severely limit the fluctuation of exchange rates can have negative effects on the perceived exchange risk, if those regimes require economic policies that the market considers fairly unsustainable. Under these circumstances, to reduce the risk of foreign currency transactions, it may be preferable to adopt less ambitious exchange rate commitments that are flexible enough to warrant an acceptable degree of credibility, even though they may imply greater exchange rate volatility. Nonetheless, the results for the lira and the British pound suggest that, from the standpoint of minimising exchange rate risk, the optimal degree of flexibility is not close to the one corresponding to a free floating regime.

Lastly, a note of caution. It must be borne in mind that the gain in credibility observed in the ERM, which explains much of the evidence presented, cannot be attributed solely to the System's reform. Thus, the positive effect of the exchange rate adjustments made during the crisis and of the easing of economic policy dilemmas is also at play. Naturally, the reappearance of disequilibria or other destabilising factors could eventually cause a substantial increase in exchange rate risk, even under a regime as flexible as the one now in force in the EMS.

REFERENCES

ALBEROLA, E., HUMBERTO, J. and ORTS, V. (1994): "An Application of the Kalman Filter to the Spanish Experience in a Target Zone (1989-92)", forthcoming in *Revista Española de Economía.*

ARTIS, M.J. and TAYLOR, M.P. (1988): "Exchange Rates, Capital Controls and the European Monetary System: Assessing the Track Record", in Giavazzi, Micossi and Miller (eds.). *The European Monetary System*, Cambridge University Press.

AYUSO, J., PEREZ-JURADO, M. and RESTOY, F. (1993): "Indicadores de Credibilidad de un régimen cambiario: el caso de la peseta en el SME", *Cuadernos Económicos de ICE*, 53.

AYUSO, J. and RESTOY, F. (1992): "Efficiency and Risk Premia in Foreign Exchange Markets", Banco de España, Working Paper 9225.

BOLLERSLEV, T. (1986): "Generalised Autoregressive Conditional Heteroskedasticity", *Journal of Econometrics*, 38.

DRAZEN, A. AND MASSON, P. (1992):"Credibility of Policies vs. Credibility of Policy Makers", IMF Research Paper.

EDISON, H. and MELVIN, M. (1990): "The Determinants and Implications of the Choice of an Exchange Rate System" in W. Haraf and T. Willet, eds.,*Monetary Policy for a Volatile Global Economy*, American Enterprise Institute, Washington D.C.

ENGLE, R.F. (1982): "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK Inflation", *Econometrica*, 50.

FRANKEL, J. and PHILLIPS, S. (1991): "The European Monetary System: Credible at Last?", National Bureau of Economic Research, Working Paper 3819.

FRATIANNI, M. and VON HAGEN, J. (1990): "The European Monetary System Ten Years After", in Meltzer and Plosser, *Carnegie Rochester Conference Series*, 32.

HOLDEN, S. and VIKOREN, B. (1992): "Have Interest Rates in the Nordic Countries Been 'Too High? A Test Based on Devaluation Expectations", Norges Bank, Arbeids Notad 1992/6.

KRASKER, W.S. (1980): "The 'Peso Problem' in Testing the Efficiency of Forward Exchange Markets", *Journal of Monetary Economics*, 6.

KRUGMAN, P. (1990): "Target Zones and Exchange Rate Dynamics", *Quarterly Journal of Economics*, 106.

LINDBERG, H., SVENSSON L. and SÖDERLIND, P. (1993): "Devaluation Expectations: The Swedish Krona 1985-1992",*Economic Journal*, 103.

SVENSSON, L. (1992): "The Foreign Exchange Risk Premium in a Target Zone with Devaluation Risk", *Journal of International Economics*, 33.

SVENSSON, L. (1993): "Assessing Target Zone Credibility: Mean Reversion and Devaluation Expectations in the EMS", *European Economic Review*, 37.

UNGERER, H., EVANS, O., MAYER, T. and YOUNG, P. (1986): "The European Monetary System: Recent Developments", International Monetary Fund, Occasional Paper n. 48.

Table 4.1. GARCH ESTIMATES: ESP/DEM

$$s_{t+1} - s_t = \epsilon_{t+1}, \quad \epsilon_{t+1|t} \sim D(0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_t^2 + \beta_1 h_{t-1}$$

Subsample	α_0	α_1	β_1	$\chi^2(5)$	N
22.06.89-15.09.92	.91E-6	.28	.55	2.99	782
	(.22E-6)	(.05)	(.07)		
18.09.92-12.05.93	.66E-5	.33	.35	7.64	155
	(.24E-5)	(.18)	(.19)		
15.05.93-22.07.93	.70E-3	--	--	1.83	47
	(--)				
26.07.93-25.02.94	.11E-5	.14	.80	5.44	146
	(.73E-6)	(.07)	(.08)		

NOTES:

- Standard errors in parenthesis.
- N stands for the number of observations.
- $\chi^2(5)$ stands for the LM test on residual heteroscedasticity up to order 5.

Table 5.1. EXPECTED EXCHANGE RATE JUMP SIZES

PTE	**5%** to **9%** (8.04.92-13.05.93)[a]	**6%** (14.05.93-30.07.93)	**0.5%** (02.08.93-25.02.94)
FRF	**3%** (19.06.89-15.09.92)	**3%** (17.09.92-30.07.93)	**0.3%** (02.08.93-25.02.94)
DKK	**3%** (19.06.89-15.09.92)	**3%** (17.09.92-30.07.93)	**0.9%** (02.08.93-25.02.94)
LIT	**5%** (19.06.89-07.01.90)	**1%** to **14%** (8.01.90-17.09.92)[a]	**1%** (18.09.92-25.02.94)
GBP	**5%** to **13%** (09.10.90-17.09.92)[a]	**0.2%** (18.09.92-25.02.94)	
IEP	**3%** (19.06.89-11.09.92)	**9%** (15.09.92-29.01.93)	**0.7%** (02.02.93-30.07.93)[b]
			0.1% (03.08.93-25.02.94)[c]
BEF	**3%** (19.06.89-18.09.92)	**3%** (21.09.92-29.07.93)	**0.1%** (03.08.93-25.02.94)

(a) Lineal increase along the subsample.
(b) For negative interest rate differentials a **-0.1%** jump size is considered.
(c) For negative interest rate differentials a **-0.05%** jump size is considered.

Table 5.2. GARCH ESTIMATES: OTHER CURRENCIES / DEM

$$s_{t+1} - s_t = \epsilon_{t+1}, \quad \epsilon_{t+1|t} \sim D(0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_t^2 + \beta_1 h_{t-1}$$

Subsample		α_0	α_1	β_1	$\chi^2(5)$	N
	20.06.89-	.15E-6	.20	.64	4.69	785
	15.09.92	(.05E-6)	(.05)	(.08)		
FRF	17.09.92-	.20E-6	.22	.70	4.97	210
	30.07.93	(.08E-6)	(.07)	(.06)		
	03.08.93-	.03E-6	.04	.93	5.88	160
	25.03.94	(.03E-6)	(.03)	(.03)		
	20.06.89-	.12E-6	.26	.65	4.07	791
	15.09.92	(.04E-6)	(.05)	(.06)		
DKK	17.09.92-	.17E-6	.31	.68	3.58	208
	30.07.93	(.08E-6)	(.09)	(.07)		
	03.08.93-	.09E-6	.05	.92	6.02	140
	25.02.94	(.08E-6)	(.03)	(.03)		
	09.04.92-	.05E-4	.28	.47	3.74	263
	12.05.93	(.01E-4)	(.09)	(.09)		
PTE	14.05.93-	.03E-4	.12	.79	2.97	53
	30.07.93	(.03E-4)	(.20)	(.11)		
	02.08.93-	.96E-6	.11	.77	1.79	151
	15.03.94	(.66E-6)	(.06)	(.10)		

Table 5.2. (CONT.)

	Subsample	α_0	α_1	β_1	$\chi^2(5)$	N
	22.06.89- 05.01.90	.20E-6 (.16E-6)	.18 (.10)	.77 (.10)	3.66	134
LIT	09.01.90- 11.09.92	.32E-6 (.09E-6)	.19 (.05)	.62 (.08)	8.39	648
	18.09.92- 25.02.94	.05E-4 (.02E-4)	.09 (.03)	.78 (.07)	6.58	451
GBP	19.06.89- 17.09.92	.86E-6 (.28E-6)	.19 (.06)	.71 (.06)	7.02	468
	17.09.92- 15.03.94	.49E-6 (.46E-6)	.08 (.03)	.90 (.04)	1.93	351
	19.06.89- 11.09.92	.19E-7 (.57E-8)	.16 (.02)	.84 (.02)	9.11	790
	15.09.92- 29.01.93	.09E-4 (--)	--	--	1.24	90
IEP	02.02.93- 30.07.93	.95E-6 (.11E-6)	.24 (.08)	--	2.05	122
	03.08.93- 26.04.94	.10E-4 (.10E-4)	.26 (.08)	--	3.73	176
	20.06.89- 18.09.92	.29E-8 (.10E-8)	.13 (.02)	.88 (.01)	7.75	797
BEF	21.09.92- 29.07.93	.48E-7 (.13E-7)	.40 (.08)	.57 (.05)	3.33	207
	03.08.93- 26.04.94	.15E-6 (.7E-7)	.46 (.18)	.61 (.10)	3.10	178

NOTES:

- Standard errors in parenthesis.
- N stands for the number of observations.
- $\chi^2(5)$ stands for the LM test on residual heteroscedasticity up to order 5.

Chart 4.1

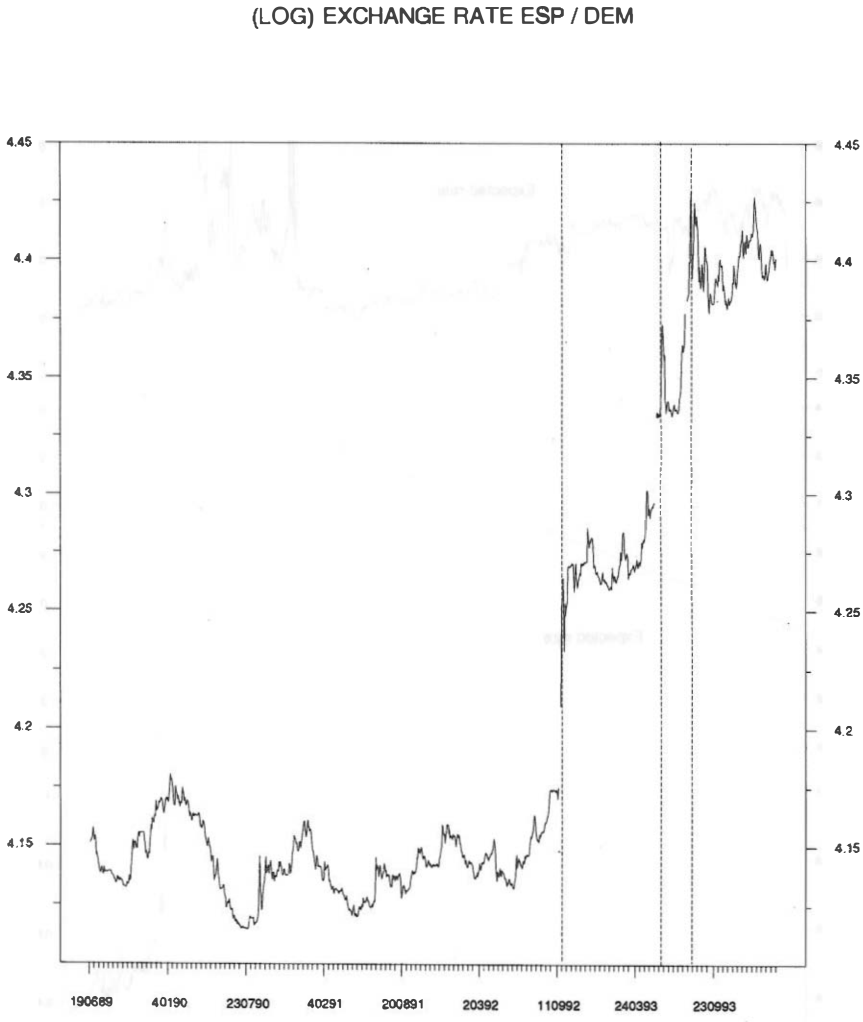

(LOG) EXCHANGE RATE ESP / DEM
4.45
4.4
4.35
4.3
4.25
4.2
4.15
190689
40190
230790
40291
200891
20392
110992
240393
230993

Chart 4.2

EXPECTED RATE OF THE ESP / DEM EXCHANGE RATE JUMP.

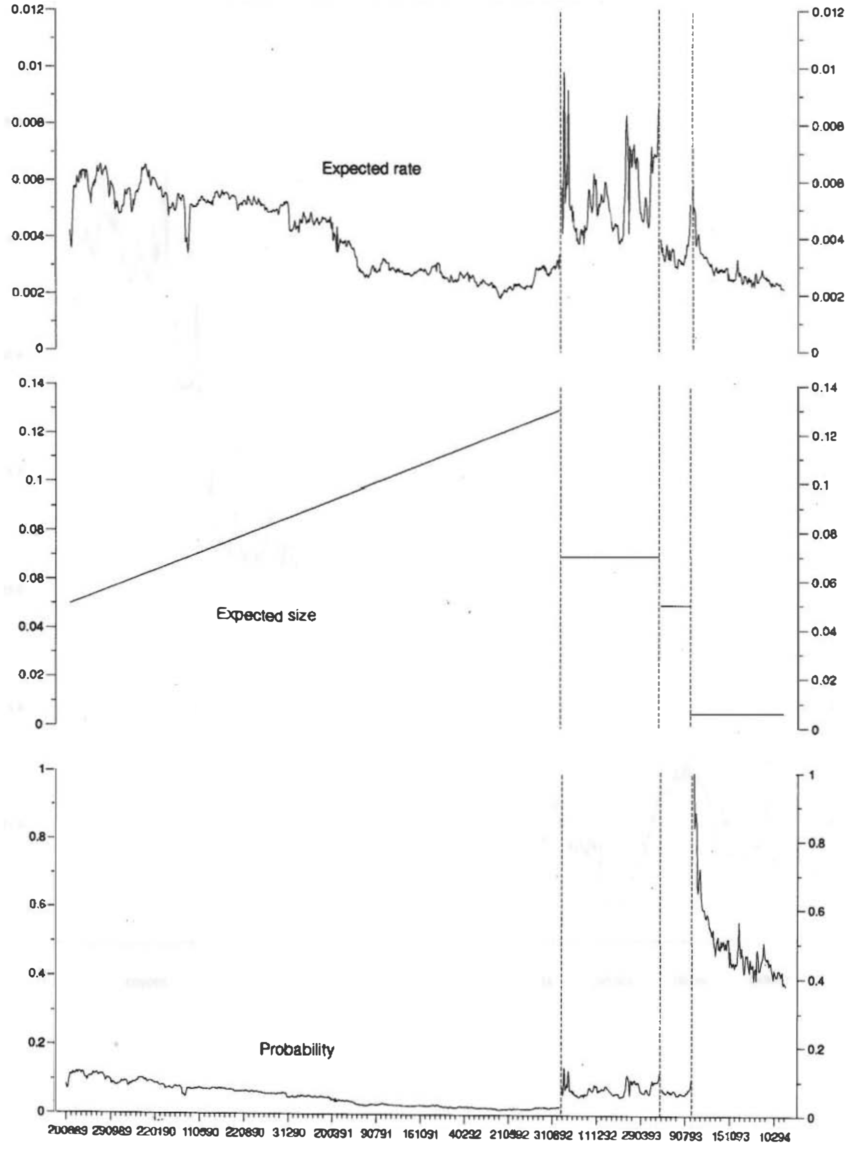


Chart 4.3

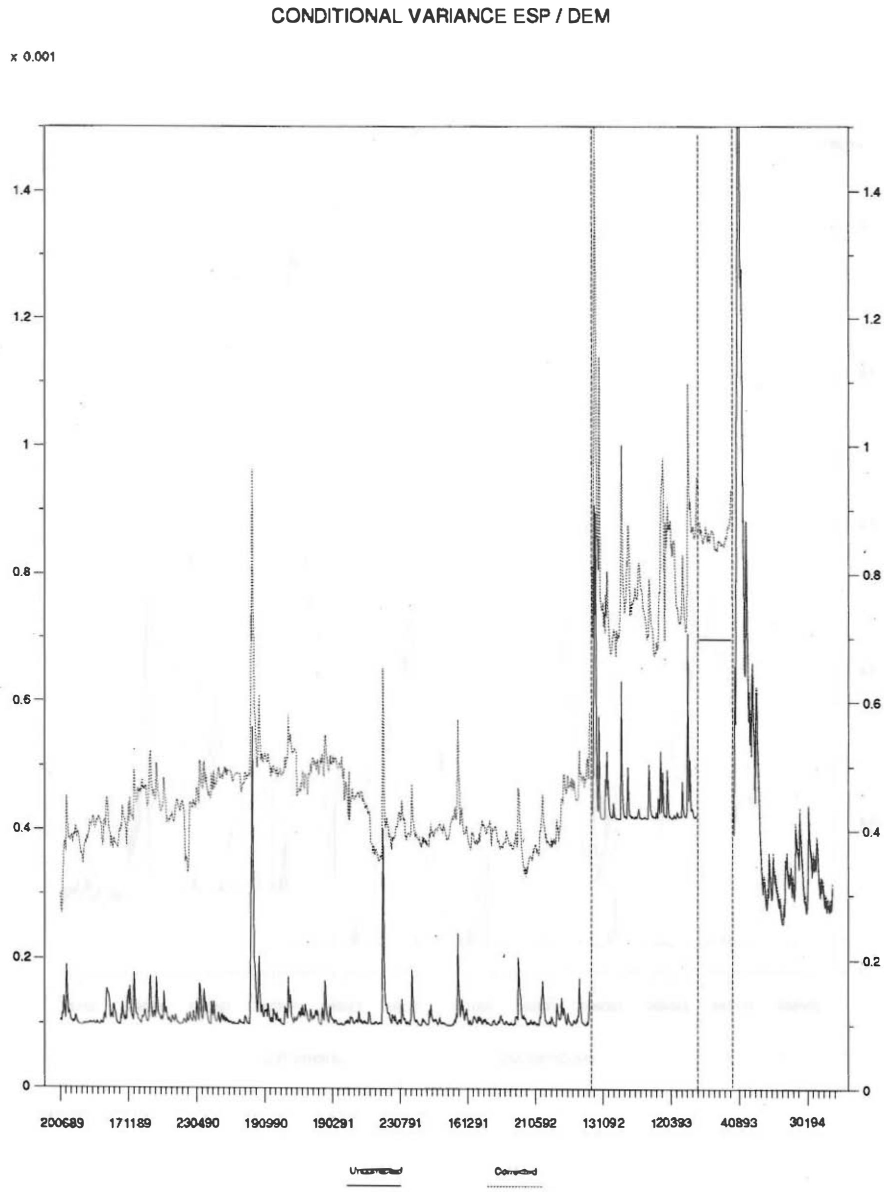

CONDITIONAL VARIANCE ESP / DEM
x 0.001
0
0.2
0.4
0.6
0.8
1
1.2
1.4
200689
171189
230490
190990
190291
230791
161291
210592
131092
120393
40893
30194
Uncorrected
Corrected

Chart 4.4

CONDITIONAL VARIANCE ESP / DEM
($\phi = .97$)

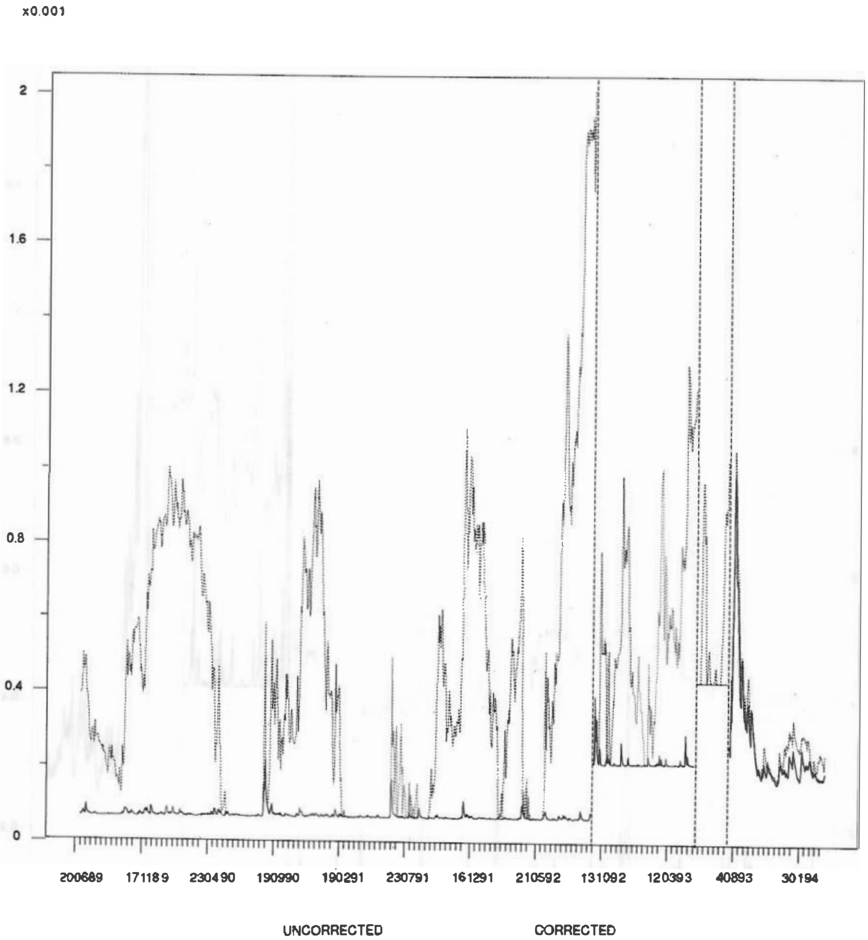


Chart 5.1

CONDITIONAL VARIANCE FRF / DEM

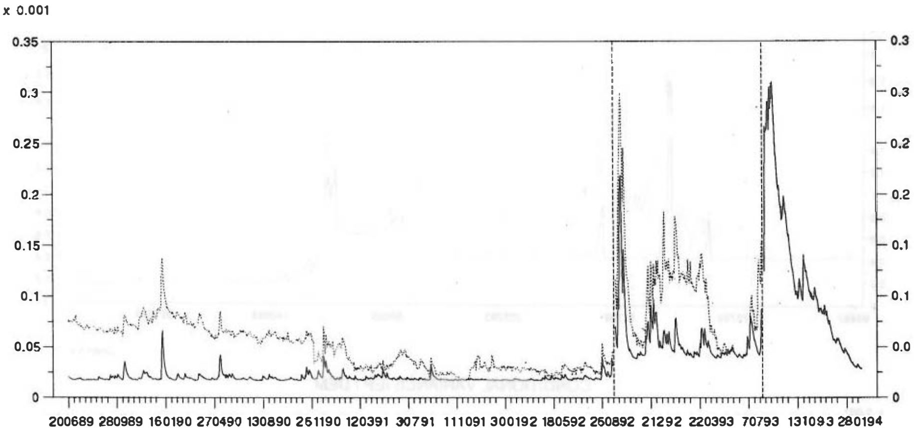


Chart 5.2

CONDITIONAL VARIANCE DKK / DEM

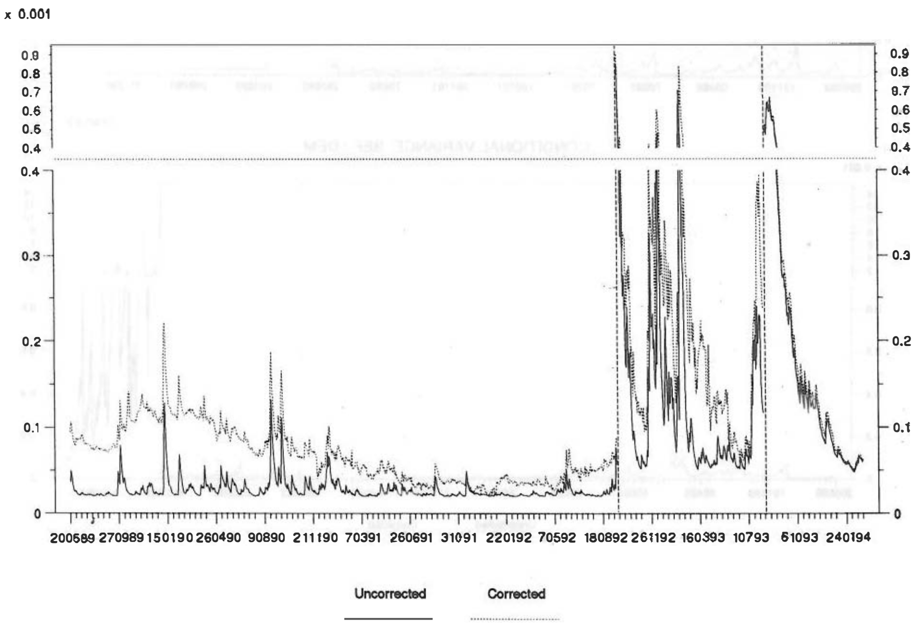


Chart 5.3

CONDITIONAL VARIANCE PTE / DEM

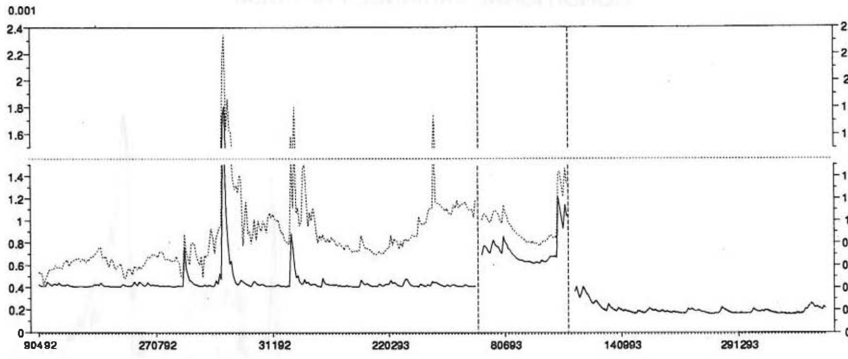


Chart 5.4

CONDITIONAL VARIANCE IEP / DEM

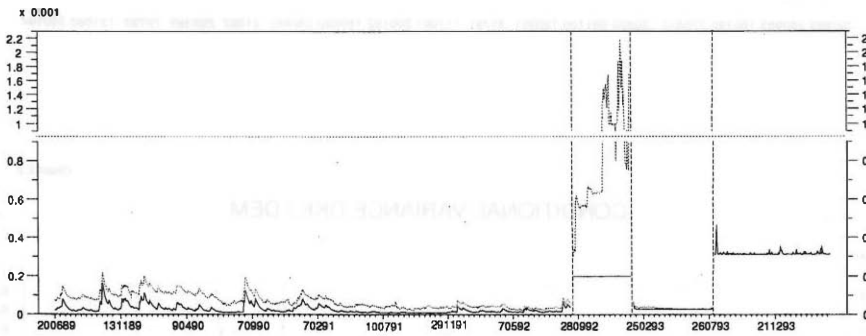


Chart 5.5

CONDITIONAL VARIANCE BEF / DEM

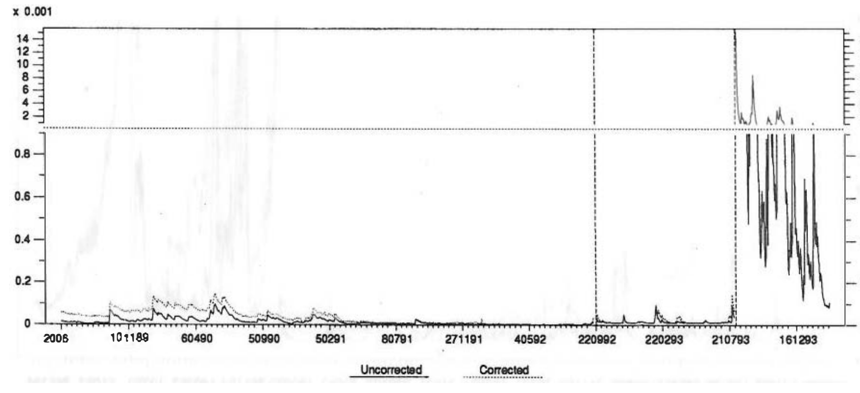


Chart 5.6

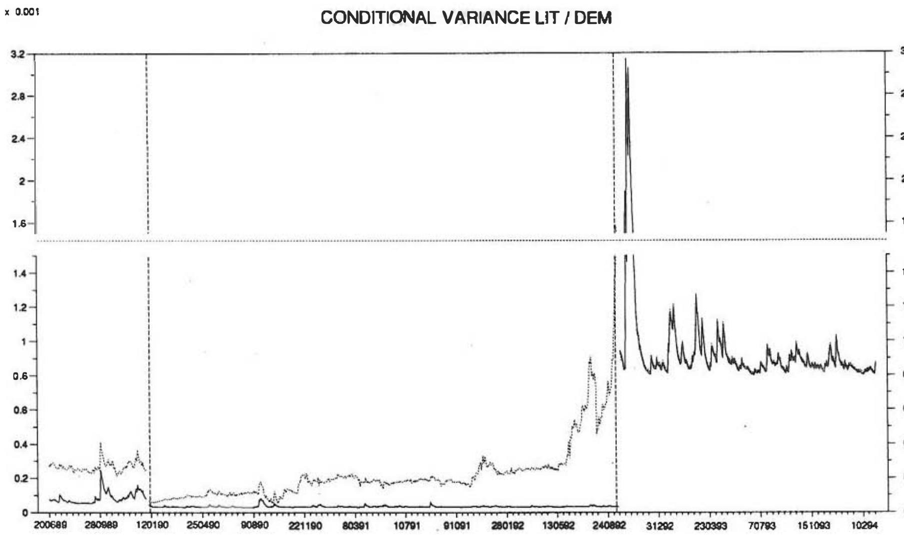
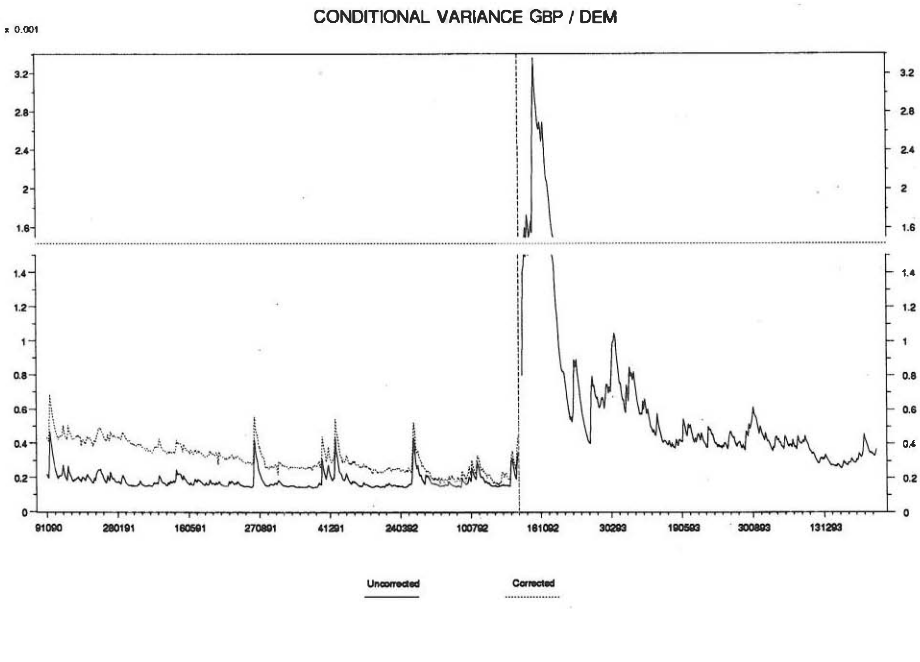


Chart 5.7



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