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Publication date:
1992

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Discussion paper

[redacted]

TILBURG UNIVERSITY

No. 9254

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December 1992

ISSN 0924-7815

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IN THE EUROPEAN MONETARY SYSTEM

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Abstract

This article deals with the estimation of models for the expected rate of depreciation within the currency bands of the French franc and the Italian lira against the Deutsche Mark, both unconditional and conditional upon no realignment, as well as the estimation of models for risk premia. Using these estimates, estimates are constructed for the expected rate of depreciation, the expected rate of realignment and the expected rate of devaluation of these exchange rates during their EMS period by appropriate adjustment of interest differentials. It is found that these adjustments are of non-trivial magnitude.

This version: 14 December 1992

The author thanks Andrew Rose and Axel Weber for providing the data. He also thanks, without implicating, Frank de Jong, Theo Nijman and the seminar participants at the University of Limburg for their helpful comments.

1. Introduction

Despite growing consensus among economists in recent years that the European Monetary System (EMS) has become increasingly successful in stabilizing exchange rates between participants, the developments in September and November 1992 have demonstrated that the currency bands are still far from credible. For the British pound participation in the system of bilateral exchange rate bands has been abandoned, while for the Italian lira it has been suspended shortly after a realignment. Moreover, the Spanish peseta has undergone two realignments, and the French franc and the Irish punt have been under heavy speculative pressure. In view of these events it seems important to be able to make an appropriate assessment of the expected rate of depreciation of exchange rates in the system, and, related to this, their devaluation risk and their realignment risk (below, the differences between these terms will be made precise). Estimates of these variables provide us with information about the credibility of the exchange rate bands as perceived by the market and how this credibility of the bands changes over time. Therefore, in this paper we try to construct estimates for these variables of interest. In our definition, the expected depreciation rate is the expected rate of change of the exchange rate. The difference between a realignment and a devaluation is that a devaluation measures the actual jump of the exchange rate at a realignment, which is the sum of the jump in the central parity (the realignment itself) and the jump in the deviation of the exchange rate from its central parity.

One of the papers, which originates from the literature on exchange rate target zones and which addresses the problem of inferring realignment risk, is Bertola and Svensson (1991). In their model, realignment risk is an exogenous stochastic process, and, under some specific assumptions about this process, they simulate patterns of exchange rate time series which resemble the movements of the French franc/Deutsche Mark (Ffr/DM) over time. They indicate how empirical estimates of realignment risk may be constructed by subtracting estimates of expected changes of the exchange rate within its band from interest differentials. Rose and Svensson (1991) use this method to estimate realignment risk for EMS exchange rates, and with a similar procedure Svensson (1991c) obtains estimates of their devaluation risk. Indeed, the adjustments of the interest differentials to construct estimates of these variables of interest are of non-trivial magnitude, so that it is important to obtain appropriate estimates of the movements of the exchange rate within its band. Lindberg, Svensson and Söderlind (1991) use the approach just outlined to estimate realignment expectations for the target zone of the Swedish krona against a weighted average of the currencies of its main trading partners. They apply a variety of estimation methods and use a number of specifications to estimate the expected change of the exchange rate within its band. For the papers mentioned, specification of models for this variable are based on the predictions of the target zone literature, in particular that there should be a nearly linear relationship between the expected rate of depreciation within the band and the deviation of the exchange rate from its central parity.

In this paper, we try to extend the analysis of the papers just mentioned in a number of ways. First, these papers make the assumption of uncovered interest parity (UIP), while, elsewhere in the empirical literature, there is strong evidence of (time-varying) risk premia, especially in forward markets for dollar exchange rates [e.g., see Hodrick (1987) and the references therein]. This does not necessarily imply however, that there is a risk-premium in EMS exchange rates as well. In fact, Svensson (1990) uses a target zone model, in which there is some exogenous and constant probability of a realignment irrespective of the exchange rate position in its band. He derives an expression for the risk premium, which consists of two components: one due to exchange rate movements in the band, and the other due to devaluation risk. The first one is proportional to the variance of the exchange rate in its band and is shown to be negligible. The second one is shown to be small relative to the expected rate of change in the central parity for reasonable values of the model parameters. However, since tests of target zone models on EMS exchange rates have not been very successful [e.g., see Meese and Rose (1990) and Flood, Rose and Mathieson (1991)] and Svensson's (1990) assumptions about the realignment process are rather restrictive, it is not clear to what extent his argument is applicable to EMS exchange rates. Therefore, it seems safer to relax the UIP assumption and let the data decide about the presence of a risk premium.

Because the expected rate of realignment, the expected rate of depreciation within the band and the risk premium are linked by an identity, we model them jointly, using the same regression specification for each variable and applying adding up restrictions, which are automatically fulfilled in our special case. As explanatory variables we include variables suggested by the target zone literature, like the position of the exchange rate in the band and nonlinear terms, and the forward discount, because of the identity just mentioned. To construct estimates for the expected rate of devaluation, one needs to have estimates of the expected rate of depreciation within the band conditional on the absence of a realignment. Specification of models for this variable is along the same lines as for the other variables.

Our empirical analysis is restricted to the Ffr/DM and the lira/Deutsche Mark (lira/DM), because these are the exchange rates between the largest economies in the EMS, which have participated in the Exchange Rate Mechanism from its start onwards. Moreover, as already noticed, they have been under heavy pressure recently, which makes them interesting to study.

The estimates suggest that important determinants of the unconditional expected rate of depreciation within the band are the current position in the band, and, in particular for the Ffr/DM, the forward discount. The position of the exchange rate in the band is also an important determinant of the conditional (upon no realignment) expected rate of depreciation within the band. For the Ffr/DM there are slight indications of the presence of nonlinearities, but this is not the case for the lira/DM. The results suggest the presence of a risk premium which is small and fairly constant for the Ffr/DM, but highly time-varying for the lira/DM, where the forward discount is an important explanatory variable of the risk premium. It becomes sizable from time to time and it is often of the same magnitude as the expected rate of depreciation within the band. Contrary to what one might have expected, the position of the exchange rate in the band does not seem to have any explanatory power for the risk premium. Adjusting interest differentials with Germany for our estimates (unconditional and conditional upon no realignment) of the expected rate of depreciation within the band, it is possible to construct estimates for the expected rates of realignment and devaluation under UIP. When UIP is relaxed, for all variables of interest - the expected rates of depreciation, realignment and devaluation - an additional adjustment has to be made for the estimated risk premium. Note that risk premium estimates are interesting in their own right also, because they give an indication about the costs of not formally ruling out any further realignments in the EMS. For example, real interest payments on government debt of countries with a weak currency are higher if there is an exchange rate risk premium.

The outline of the remainder of the paper is as follows. In section 2 we show how our variables of interest relate to each other. Section 3 motivates the empirical specifications for the regression analysis. Section 4 presents estimates of expected rates of depreciation within the band, unconditional and conditional upon no realignment, while section 5 presents estimates of the risk premium. In section 6, we assess and compare (under UIP and when UIP is relaxed) the adjustments of interest differentials which are needed to construct estimates of our variables of interest. Section 7 concludes the paper.

2. The expected rates of depreciation, realignment and devaluation.

Define s_t as the logarithm (in the sequel all variables are in logarithms unless otherwise stated) of the nominal exchange rate (measured as the number of units of the home currency needed to buy one Deutsche Mark) and c_t as the central parity of the exchange rate. Furthermore, we refer to $x_t \equiv s_t - c_t$ as the **exchange rate within the band**. Then the **expected rate depreciation of the exchange rate** over some time interval from t to $t+\tau$ is the expected change of the exchange rate in percentages on an annual basis, hence is given by $E_t[\Delta s_{t+\tau}]/\tau \equiv E_t[s_{t+\tau} - s_t]/\tau$. Later on, in our empirical investigation, we shall take τ to be a month (1/12 year).

The **expected rate of realignment** is given by $E_t[c_{t+\tau}]/\tau$, where a **realignment** refers to the jump in the central parity, which occurs when the band on the exchange rate is changed. By a **devaluation**, we mean the actual jump in the exchange rate at a realignment. Hence, a devaluation is the sum of the jump in the central parity and the jump of the exchange rate within the band at a realignment. It is important to distinguish between realignments and devaluations, because often the jump of the exchange rate within the band is of the same order of magnitude as the jump of the central parity, as we shall see.

The expected rate of depreciation can be linked to the expected rate of realignment, using the definition of the expected rate of depreciation within the band

$$E_t[\Delta s_{t+\tau}] = E_t[\Delta c_{t+\tau}] + E_t[\Delta x_{t+\tau}] \ . \qquad (1)$$

The expected rate of depreciation is the sum of the expected rate of realignment and the expected rate of depreciation within the band, or, alternatively, the expected rate of realignment is obtained by subtracting the expected rate of depreciation within the band from the expected rate of depreciation of the exchange rate.

Denote by $f_{t,\tau}$ the forward rate at time t for a contract due at time $t+\tau$, and by $\delta_{t,\tau} \equiv i_{t,\tau} - i^*_{t,\tau}$ the interest differential on an annual basis at time t for deposits of the same default risk and the same time to maturity $\tau>0$. Thus, $i_{t,\tau}$ is the nominal interest rate on deposits denoted in the home currency and $i^*_{t,\tau}$ the nominal interest rate on deposits denoted in Deutsche Marks.

Assuming covered interest parity (CIP), one has

$$\delta_{t,\tau} = (f_{t,\tau} - s_t)/\tau \ , \qquad (2)$$

Furthermore, one has the identity

$$E_t[\Delta s_{t+\tau}] + [f_{t,\tau} - E_t s_{t+\tau}] = (f_{t,\tau} - s_t) \ , \tag{3}$$

where $[f_{t,\tau} - E_t s_{t+\tau}]$ will be referred to as the **risk premium**. It is the difference between the forward rate and the expected future spot rate at the maturity of the forward contract. Under uncovered interest parity, the risk premium should be zero, and the expected rate of depreciation of the exchange rate equals the interest differential.

Upon substitution of (1) into (3), one obtains

$$E_t[\Delta c_{t+\tau}] + E_t[\Delta x_{t+\tau}] + [f_{t,\tau} - E_t s_{t+\tau}] = (f_{t,\tau} - s_t) \ , \tag{4}$$

which states that the forward discount equals the sum of the expected rate of realignment, the expected rate of depreciation within the band and the risk premium. If market participants are risk neutral, then (4) reduces to

$$E_t[\Delta c_{t+\tau}] + E_t[\Delta x_{t+\tau}] = (f_{t,\tau} - s_t) \ , \tag{5}$$

which, together with the assumption of CIP, implies UIP.

One way to test for UIP, is to specify a regression model for the expected rate of realignment and the expected rate of depreciation within the band, including the same regressors (the forward discount should be one of the regressors) in both equations, and test for the implied adding-up restrictions by (5).

A complication with regressions based on (4) and (5) is that x_t (and other variables as well) usually jumps at realignments, as Svensson (1991c) notes. This might introduce a small sample bias in the estimates, because the total number of jumps of x_t could be too small to obtain reliable results. Figures 1a and 1b plot the Ffr/DM and the lira/DM exchange rates respectively, together with the boundaries of their fluctuation margins. The data are daily from 13 March 1979 (the start of the EMS) till 16 May 1990. Details about the data are given in the appendix. During the sample period, the central parity of the Ffr/DM has undergone six realignments and the central parity of the lira/DM nine realignments. Note that for the Ffr/DM at every realignment the jump in the exchange rate is less in magnitude than the jump in the central parity, while for the lira/DM this is the case for the majority of the realignments. This implies that the exchange rate within the band usually jumps at a realignment. Svensson (1991c) proposes to rewrite the expected rate of depreciation within the band as follows

$$
\begin{aligned}
E_t[\Delta x_{t+\tau}] &= (1-p_t^\tau)\, E_t[\Delta x_{t+\tau}|NR] + p_t^\tau\, E_t[\Delta x_{t+\tau}|R] \\
&= E_t[\Delta x_{t+\tau}|NR] - p_t^\tau\, \{E_t[x_{t+\tau}|NR] - E_t[x_{t+\tau}|R]\}\ , \qquad (6)
\end{aligned}
$$

where p_t^τ is defined as the probability that a realignment will occur between time t and time $t+\tau$ and where R and NR denote the events of a realignment, respectively no realignment between t and $t+\tau$. Substituting (6) into (4), and rearranging, one obtains

$$
\begin{aligned}
&E_t[\Delta c_{t+\tau}]/\tau + p_t^\tau\{E_t[x_{t+\tau}|NR] - E_t[x_{t+\tau}|R]\}/\tau \\
&\qquad = (f_{t,\tau} - s_t)/\tau - E_t[\Delta x_{t+\tau}|NR]/\tau - [f_{t,\tau} - E_t s_{t+\tau}]/\tau \\
&\qquad = \delta_{t,\tau} - E_t[\Delta x_{t+\tau}|NR]/\tau - [f_{t,\tau} - E_t s_{t+\tau}]/\tau\ . \qquad (7)
\end{aligned}
$$

In Svensson (1991c), the term $-[f_{t,\tau} - E_t s_{t+\tau}]/\tau$ on the right hand side of (7) drops out, because he assumes UIP. Following Svensson, we refer to the left-hand side of (7) as the operational definition of the **expected rate of devaluation**, or, as we will do in the following, simply the 'expected rate of devaluation'. One can construct estimates for the expected rate of devaluation by estimating models for the conditional expected rate of depreciation within the band and the risk premium and subtract these estimates from the interest differential.

3. Specification of the regression models

In this section we shall motivate the regression specifications which we use for the estimation of the conditional and unconditional expected rates of depreciation within the band, as well as the risk premium, for the case where we relax UIP. As already explained, these estimates can be used to obtain estimates of our variables of interest.

The regression models in Rose and Svensson (1991) and Svensson (1991c) are motivated by the predictions of the target zone literature. One of their explanatory variables for the expected rate of change of the exchange rate within the band is the current exchange rate within the band, x_t, in order to pick up a potential mean-reversion of the exchange rate within the band. In fact, in the standard target zone model [see Krugman (1991)] and some of its generalizations [see Svensson (1991a,b)], where there is an exogenous and constant probability of a realignment, the exchange rate within the band is mean-reverting and it is the only determinant of the expected future exchange rate position in the band. The relationship between these two variables is almost linear as Svensson (1991b) shows. To check for the presence of non-linearities that might be induced by the presence of the boundaries on the exchange rate, Rose and Svensson (1991) also include x_t^2 and x_t^3 as regressors. Furthermore, they introduce a dummy for each exchange rate regime, where a regime is defined as the period between two realignments. In this way one might allow for the effects of potential changes in monetary policies after realignments (e.g., changes in relative growth rates of money supplies).

We follow Rose and Svensson (1991) and Svensson (1991c) in our choice of the regression specifications, but, in addition, we include the forward discount as a regressor, for reasons outlied in the previous section, but also because many of the empirical studies [e.g., see Hodrick (1987) and the references therein], find that the forward discount has significant explanatory power for the risk premium:

$$E_t[\Delta c_{t+\tau}]/\tau = \sum_{i=1}^{r} \alpha_{0i} d_i + \sum_{k=1}^{3} \alpha_{1k} x_t^k + \alpha_2 (f_{t,\tau} - s_t) , \tag{8a}$$

$$E_t[\Delta x_{t+\tau}]/\tau = \sum_{i=1}^{r} \beta_{0i} d_i + \sum_{k=1}^{3} \beta_{1k} x_t^k + \beta_2 (f_{t,\tau} - s_t) , \tag{8b}$$

$$E_t[f_{t,\tau} - s_{t+\tau}]/\tau = \sum_{i=1}^{r} \gamma_{0i} d_i + \sum_{k=1}^{3} \gamma_{1k} x_t^k + \gamma_2 (f_{t,\tau} - s_t) , \tag{8c}$$

where r is the number of regimes and where the dependent variables have been divided by τ in order to obtain coefficient estimates on an annual basis. By including x_t in (8a) and (8c) one might pick up effects of the position of the exchange rate in its band on realignment expectations and on the risk premium, because it is often said that the credibility of the band comes into question when a weak currency approaches the upper boundary of its band with the Deutsche Mark.

Equations (4) and (8a)-(8c) imply:

$$\begin{aligned} &\alpha_{0i} + \beta_{0i} + \gamma_{0i} = 0 , \quad i=1,\dots,r , \\ &\alpha_{1k} + \beta_{1k} + \gamma_{1k} = 0 , \quad k=1,\dots,3 , \\ &\alpha_2 + \beta_2 + \gamma_2 = 1/\tau . \end{aligned} \tag{9}$$

Because all regressors are predetermined at time t, we can use ordinary least squares to obtain consistent estimates of their coefficients. The adding-up restrictions (9) are automatically fulfilled by the estimates and the residuals sum up to zero (over the equations) for all t. In the presence of the well-known overlapping observations problem (the time to maturity τ exceeds the sampling interval) consistent estimates of the standard errors are obtained by using the method proposed in Newey and West (1987). It is also easy to see that in the underlying case, where the set of regressors is the same for all equations, simultaneous estimation of two out of three equations yields exactly the same results as separate estimation, both for the coefficient estimates and for the estimated standard errors.

Imposing $\beta_2 = 0$ in (8b) gives one of the specifications that Rose and Svensson (1991) use for the (unconditional) expected rate of depreciation within the band. UIP is tested by testing the hypothesis that all coefficients in (8c) are jointly equal to zero [$\gamma_{0i}(\forall i) = \gamma_{1k}(\forall k) = \gamma_2 = 0$], which says that, given the information in the right hand side variables of (8c), the forward rate is an unbiased predictor of the future spot rate. Rejection of this hypothesis suggests the presence of a, possibly time-varying, risk-premium. The hypothesis of a **constant risk premium** is formulated as the joint hypothesis that the dummy coefficients are all equal to each other but different from zero, and that all other coefficients in (8c) are zero [$\gamma_{0i} = \gamma_0 \neq 0$, $\gamma_{1k}(\forall k) = \gamma_2 = 0$]. If the dummy coefficients are not equal to each other, and all other coefficients in (8c) are zero, then this suggests the presence of a risk-premium which is constant for a given regime, but which changes at a realignment, because of a jump in the perceived riskiness of the exchange rate.

To analyse the expected rate of devaluation [eq.(7)] we specify for the expected rate of depreciation within the band, conditional on the absence of a realignment:

$$E_t[\Delta x_{t+\tau}|NR]/\tau = \sum_{i=1}^{r} \beta_{0i} d_i + \sum_{k=1}^{3} \beta_{1k} x_t^k + \beta_2 (f_{t,\tau} - s_t) , \tag{10a}$$

The complementary regression equation is:

$$E_t[f_{t,\tau} - s_{t+\tau}|NR]/\tau = \sum_{i=1}^{r} \gamma_{0i} d_i + \sum_{k=1}^{3} \gamma_{1k} x_t^k + \gamma_2 (f_{t,\tau} - s_t) , \tag{10b}$$

so that $\beta_{0i} + \gamma_{0i} = 0\ \forall i$, $\beta_{1k} + \gamma_{1k} = 0\ \forall k$, and $\beta_2 + \gamma_2 = 1/\tau$.

When the nonlinear terms and the forward discount are excluded from (10a) ($\beta_{12} = \beta_{13} = \beta_2 = 0$), Svensson's (1991c) specification is obtained.

4. Estimates of the unconditional and conditional expected rates of depreciation within the band.

In this section estimates are presented for the expected rate of depreciation within the band, both unconditional and conditional upon no realignment. These estimates can be used to construct estimates of our variables of interest under UIP. Then, the expected rate of depreciation is given by the interest differential. The expected rates of realignment [see eq.(5)] and devaluation [see eq.(7)] can be estimated by subtracting an estimate of the unconditional, respectively, conditional expected rate of depreciation within the band from the interest differential. Thus, in this section, the main difference with Rose and Svensson (1991) and Svensson (1991c) is the use of more extensive specifications for the unconditional and conditional expected rate of depreciation within the band. In the next section, we present risk premium estimates, which enable use to construct estimates for our variables of interest when UIP is relaxed.

As already explained, here, and in the sequel, estimation takes place by OLS, using the Newey and West (1987) adjustment for the standard errors. Tables 1a (Ffr/DM) and 1b (lira/DM) present estimates for various restricted specifications of $E_t[\Delta x_{t+\tau}]$, the unconditional expected rate of depreciation within the band. To save space, we only report results for specifications for which the dummy coefficients are restricted to be equal across regimes. Earlier regressions (not reported here) suggest that unrestricted estimation results in dummy coefficient estimates which are very sensitive to the backward jump of the exchange rate within the band, which takes place at the end of each regime. Also, we are not able to compare our results with those obtained by Rose and Svensson (1991), who use an unrestricted specification, because they report estimates that are numerically identical Svensson's (1991c) estimates of the conditional expected rate of depreciation within the band, which must be due to a reporting error. Columns (a) of tables 1a/b show that for both the Ffr/DM and the lira/DM, the current position of the exchange rate in its band enters with a negative coefficient, indicating mean-reversion of the exchange rate within the band. In both cases, the t-ratios are well below -2.86, the critical value (at a 5% level) of the standard Dickey-Fuller [see Fuller (1976)] unit root test. One should be careful however, because the potential presence of conditional heteroskedasticity may invalidate these standard critical values to a certain extent. In columns (b) of tables 1a/b, estimates are reported for a specification in which the nonlinear terms x_t^2 and x_t^3 are added. The results suggest that nonlinearities may play a role, but one has to be careful because the jumps in x_t may cause outliers in the nonlinear terms, which could have influenced the estimates. Columns (c) report results for the case where we add the forward discount as an additional explanatory variable. For the Ffr/DM both the forward discount and the position in the band are significant at a 5% level. The significantly negative coefficient of the forward discount can be explained by the fact that for the Ffr/DM extremely high interest differentials are often followed by a realignment, at which x_t jumps downward. For the lira/DM, only the exchange rate within the band is significant, although the forward discount is close to significance.

In tables 2a (Ffr/DM) and 2b (lira/DM), estimates are given for models of the expected depreciation rate within the band, conditional upon no realignment. The specifications corresponding to columns (a) are the same as the ones estimated by Svensson (1991c), and, indeed, our estimates are numerically the same as Svensson's estimates. For the majority of the realignments, the dummy coefficients enter with positive sign, which is explained by the fact, that usually, at a realignment, the exchange rate jumps from a weak position in its old band to a stronger position in its new band, and starts to depreciate after the realignment. For both currencies, the hypothesis that the dummy coefficients are equal across regimes is rejected for all specifications. Contrary to the case where we did not condition on the absence of realignments, here we do not expect the dummy coefficient estimates to suffer from outliers. There are two main differences with the results for the unconditional expected rate of depreciation within the band. First, the forward discount has lost much of its explanatory power [columns (c)]. The reason is that the realignments and the jumps of the exchange rate within the band coincide and are usually preceded by peaks in the forward discount, in particular for the Ffr/DM. Secondly, for the lira/DM, the estimated coefficient of x_t has also lost much of its explanatory power, which can be explained by the exclusion of the downward jumps in x_t at realignments. These jumps exert a mean-reverting influence. Again, note that for the Ffr/DM there is some indication of nonlinearities [column (b), table 2a].

5. Estimates of the risk premium

Tables 3a (Ffr/DM) and 3b (lira/DM) present estimates for various specifications of the risk premium model. As explained before, we restrict the dummy coefficients to be equal across regimes. For both currencies and all specifications, the hypothesis that the regression coefficients are jointly equal to zero is rejected. This suggests the presence of a risk premium, contrary to what Rose and Svensson (1991) and Svensson (1991c) assume. Columns (a) report the results when only a constant is included as a regressor. For both exchange rates it is significant. The interpretation is interesting. For most of the sample the forward rate lies above the realized spot rate at maturity date. Only in case of a realignment between date t and $t+\tau$, the realized spot rate lies above the forward rate. When market participants are risk neutral these occasional jumps of $s_{t+\tau}$ beyond $f_{t,\tau}$ should on average offset that $f_{t,\tau}$ lies above $s_{t+\tau}$ for most of the time. The position of the exchange rate within the band [columns (b)] is neither significant for the Ffr/DM nor for the lira/DM, which is a remarkable, because it is often suggested that realignment risk increases in the EMS when the exchange rate approaches the weak edge of its band. Including nonlinear terms [columns (c)] does not have a significant effect on the results either, although for the Ffr/DM the cubic term is not far from significance. Columns (d) report results for a specification which includes a constant and the forward discount. The difference between columns (d) and (e) is that for the latter the exchange rate within the band has been included as an additional regressor. Although x_t is far from significance for both currencies, we report the results for this regression, because, in order to construct estimates for our variables of interest, we prefer to use the same regression specification for both the risk premium and the exchange rate within the band [as suggested by eq.(8a)-(8c)]. For the Ffr/DM the forward discount does not enter significantly, but for the lira/DM it does (at a 5% level). This suggests the presence of a time-varying risk-premium for the lira/DM. The significantly positive estimate of the coefficient of the forward discount indicates that if the forward rate is above the current spot rate (which is the case for most of the time), then for being certain about the price at which they can sell liras for Deutsche Marks at maturity date, agents pay a risk premium. The risk premium is quite sizable: if the forward discount is 0.5% (6% on an annual basis), the risk premium is almost 2.5% on an annual basis (taking into account the estimate for the constant).

6. Estimates of expected rates of depreciation, realignment and devaluation

In this section, adjustments of interest differentials used to construct estimates of our variables of interest, both under UIP and when UIP is relaxed, are shown and discussed.

Figures 3a.1 and 3b.1 depict the one-month interest differential between France and Germany, respectively between Italy and Germany. Here, and in the sequel, plotted variables are in **percentages on an annual basis**. Under UIP, the expected rate of depreciation equals the interest differential. For most of the time the French-German interest differential is fairly flat. However, especially the period from the beginning of 1981 until the realignment in March 1983 seems to be one of serious crises in the Ffr/DM. To a lesser extent this is also the case for the period around the realignment in April 1986. For Italy, the interest differential has more peaks, although not such an extreme one as the French/German peak in March 1983. Still it is clear, except for Italian-German differential in the second half of 1981, that the most turbulent periods in both currencies coincide. This coincides with the ex-post observation that the majority of the realignments of the lira/DM and the Ffr/DM were joint ones. The observation that the peaks in the interest differentials for both exchange rates are less pronounced for later years in our sample, is consistent with the fact that at more recent realignments the exchange rate itself did not jump so much.

Unconditional estimates of expected rates of depreciation within the band are shown in figures 3a.2 and 3b.2, while conditional (on the absence of a realignment) estimates are shown in figures 3a.3 and 3b.3. The underlying specifications include a constant [for the unconditional estimates; tables 1a/b, columns (c)] or dummies [for the conditional estimates; tables 2a/b, columns (c)], the exchange rate within the band, and the forward discount. For the unconditional estimates, the latter variable has a strong influence on the estimates, as shown by the large and negative peaks which coincide with the peaks in the interest differential. As already explained, this effect disappears when one conditions on the absence of realignments.

Figures 3a.4 and 3b.4 plot constructed estimates of the risk premium for respectively the Ffr/DM and the lira/DM. Again the underlying specifications [tables 3a/b, columns (e)] include a constant, the exchange rate within the band and the forward discount. For the Ffr/DM the estimated risk premium is small and more or less constant over time. More interesting are the estimates for the risk premium in the lira/DM, which are clearly non-negligible, and have pronounced peaks during periods of crises (second half of 1981 till March 1983; also prior to the realignment in April 1986). Hence, increases in the risk premium indeed coincide with periods of unrest, which have often been followed by a realignment. During later years in our sample the risk premium seems to have decreased on average, although it would be interesting to see how its estimates would behave during the turbulent months September and November 1992.

Under UIP the expected rate of depreciation of the exchange rate equals the interest differential. When UIP is relaxed, estimates of the expected rate of depreciation can be constructed by subtracting risk premium estimates (figures 3a/b.4) from the interest differential (figures 3a/b.1). In particular for the lira/DM this adjustment is non-trivial. Estimates for the expected rate of realignment under UIP are obtained by subtracting unconditional estimates of the expected rate of depreciation within the band (figures 3a/b.2) from the interest differential. The adjustment is important, especially for the Ffr/DM, where peaks in the interest differential get even more pronounced. The reason is that under UIP the interest differential prior to realignments should be of the same order of magnitude as the **jump in the exchange rate**, while the estimated expected rate of realignment should correspond to the **jump in the central parity**, which is usually larger than the jump in the exchange rate (note that the exchange rate within the band jumps back at realignments). Outside periods of crises, adjustment of interest differentials for the estimated expected rate of depreciation within the band is also important. For most of the time during these periods the expected rate of realignment is below the interest differential. When UIP is relaxed, in addition to the estimated expected rate of depreciation within the band, one has to subtract the estimated risk premium (figures 3a/b.4) from the interest differential. Again, the latter adjustment is in particular important for the lira/DM, and it is usually of the same order of magnitude as the adjustment for the estimated expected rate of depreciation within the band only. Construction of estimates for the expected rate of devaluation is along the same lines as for the expected rate of realignment.

7. Summary and conclusions

In this paper we have shown for the Ffr/DM and the lira/DM, how estimates for the expected rates of depreciation, realignment and devaluation can be constructed (under UIP and when UIP is relaxed) by non-trivial adjustments of interest differentials. These estimates give an indication about the development of the credibility of the exchange rate system, which is still a problem of major concern, as the events in September and November 1992 show.

Estimates for our variables of interest are obtained by using estimates of the expected rate of depreciation within the band, both unconditional and conditional upon no realignment, and estimates of the risk premium. It turns out that for both the unconditional and conditional expected rate of depreciation within the band, the current exchange rate position in the band is an important explanatory variable, while for the unconditional expected rate of depreciation within the band, the forward discount plays an important role also, especially for the Ffr/DM. The results suggest the presence of a small and almost constant risk premium for the Ffr/DM and a time-varying, sometimes sizable, risk premium for the lira/DM. Here the forward discount captures a large part of the time-variability. On the other hand, for none of the exchange rates, the position in the band seems to contribute to the explanation of the risk premium, contrary to what one might have expected. Estimates of the risk premium are also interesting in their own right, because they give an indication of the credibility of the exchange rate band, and the costs associated with a lack of credibility.

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Appendix: The data

The data are daily from 13 March 1979 till 16 May 1990. They are taken from a database created by Andrew Rose from BIS data. It is used and described by Flood, Rose and Mathieson (1991). We use spot exchange rate series, which are recorded at daily 'official fixing'. The interest rates are annualized bid rates for 1 month Euro-market bills at around 10am Swiss time. Assuming CIP [eq.(2)], forward rates are constructed from interest rates and exchange rates. This is motivated by the fact that the interest rates are offshore rates and therefore not subject to capital controls.

There are a number of missing observations (in our terminology, any Monday,..., Friday, with no observation recorded, counts for a missing observation). An observation of a variable, which is constructed from other variables, will be missing, if at least one of the source variables is missing in this period. In absence of any missing observations, the total number of observations would be 2917.

Table 1a: Estimates of the unconditional expected rate of depreciation within the band for the Ffr/DM (annualized, in %); eq.(8b).

	(a)	(b)	(c)
constant	-0.17 (0.70)	1.09 (0.66)	3.53 (0.74)
x_t	-3.34 (0.68)	-1.08 (0.96)	-2.86 (0.56)
x_t^2	-	-1.16 (0.54)	-
x_t^3	-	-0.88 (0.32)	-
$f_{t,\tau}-s_t$	-	-	-7.90 (1.57)
N	2542	2542	2542
H_0: $\beta_2=0$	-	-	25.3 (1)
JH	24.0 (1)	27.4 (3)	35.8 (2)

Remarks:
1. *Standard errors are given between brackets.*
2. *N is the number of observations.*
3. *All tests are chi-square distributed under the null hypothesis with the degrees of freedom given between brackets.*
4. *JH stands for the joint hypothesis that all coefficients except for dummy coefficients, or constant, are jointly equal to zero.*

Table 1b: Estimates of the unconditional expected rate of depreciation within the band for the lira/DM (annualized, in %); eq.(8b).

	(a)	(b)	(c)
constant	-0.31 (1.08)	2.94 (1.25)	6.46 (3.82)
x_t	-2.22 (0.54)	-1.55 (0.71)	-2.37 (0.56)
x_t^2	-	-0.87 (0.32)	-
x_t^3	-	-0.12 (.069)	-
$f_{t,\tau}-s_t$	-	-	-9.16 (5.69)
N	2606	2606	2604
H_0: $\beta_2=0$	-	-	2.59 (1)
JH	16.6 (1)	19.1 (3)	17.8 (2)

Remarks:
1. *See remarks 1 to 4 table 1a.*

Table 2a: Estimates of the expected rate of depreciation within the band conditional on no realignment for the Ffr/DM (annualized, in %); eq.(10a).

	(a)	(b)	(c)
d_1	3.72 (0.90)	3.59 (0.93)	4.40 (1.16)
d_2	-0.18 (1.44)	0.71 (1.61)	0.65 (1.85)
d_3	5.55 (2.49)	6.68 (2.76)	6.93 (3.34)
d_4	2.83 (1.36)	3.24 (1.46)	4.73 (2.52)
d_5	-0.06 (0.55)	0.29 (0.59)	1.09 (1.27)
d_6	3.95 (2.04)	3.75 (2.25)	4.56 (2.10)
d_7	1.62 (0.88)	1.92 (1.02)	2.06 (0.97)
x_t	-1.98 (0.49)	-0.34 (1.03)	-1.81 (0.52)
x_t^2	-	-0.46 (0.33)	-
x_t^3	-	-0.60 (0.28)	-
$f_{t,\tau}-s_t$	-	-	-2.04 (2.17)
N	2426	2426	2426
$H_0:\beta_{0i}=\beta_{01}\forall i$	19.5 (6)	15.7 (6)	19.3 (6)
$H_0:\beta_2= 0$	-	-	0.89 (1)
JH	16.4 (1)	34.6 (3)	16.9 (2)

Remarks:
1. See remarks 1 to 4 table 1a.

Table 2b: Estimates of the expected rate of depreciation within the band conditional on no realignment for the lira/DM (annualized, in %); eq.(10a).

	(a)	(b)	(c)
d_1	-2.42 (2.57)	-2.70 (2.95)	-0.41 (3.19)
d_2	4.25 (1.86)	4.88 (1.83)	6.80 (2.94)
d_3	3.69 (2.86)	3.89 (2.87)	6.88 (3.22)
d_4	7.11 (3.01)	7.25 (3.19)	10.2 (4.44)
d_5	4.00 (3.20)	3.98 (3.47)	7.62 (4.83)
d_6	1.22 (1.97)	2.17 (2.41)	3.92 (3.34)
d_7	2.00 (1.44)	1.86 (1.43)	4.68 (2.95)
d_8	0.37 (1.03)	-.021 (1.51)	2.18 (2.04)
d_9	3.32 (1.48)	4.40 (1.84)	4.86 (2.08)
d_{10}	-6.75 (0.88)	-7.10 (1.14)	-5.56 (1.46)
x_t	-1.13 (0.46)	-1.67 (0.71)	-1.08 (0.45)
x_t^2	-	-0.14 (0.20)	-
x_t^3	-	0.023 (.048)	-
$f_{t,\tau}-s_t$	-	-	-3.17 (2.98)
N	2431	2431	2429
$H_0:\beta_{0i}=\beta_{01}\forall i$	99.8 (9)	100.2 (9)	75.0 (9)
$H_0:\beta_2=0$	-	-	1.13 (1)
JH	6.12 (1)	11.8 (3)	8.18 (2)

Remarks:
1. See remarks 1 to 4 table 1a.

Table 3a: Estimates for the risk premium of the Ffr/DM (annualized, in %); eq.(8c).

	(a)	(b)	(c)	(d)	(e)
const	2.06 (0.75)	2.11 (0.78)	2.56 (0.89)	1.70 (1.14)	1.85 (1.06)
x_t	-	0.64 (0.80)	-1.44 (1.06)	-	0.56 (2.80)
x_t^2	-	-	-0.24 (0.69)	-	-
x_t^3	-	-	0.68 (0.37)	-	-
$f_{t,\tau}-s_t$	-	-	-	0.77 (2.92)	0.61 (0.70)
N	2545	2542	2542	2542	2542
JHIC	7.48 (1)	7.59 (2)	15.7 (4)	9.53 (2)	10.6 (3)
JHEC	-	0.65 (1)	6.39 (3)	0.07 (1)	0.87 (2)

Remarks:
1. *See remarks 1 to 3 table 1a.*
2. *JHIC stands for the hypothesis that all coefficients are jointly equal to zero.*
3. *JHEC stands for the hypothesis that all coefficients, except for the constant, are jointly equal to zero.*

Table 3b: Estimates for the riskpremium of the lira/DM (annualized, in %); eq.(8c).

	(a)	(b)	(c)	(d)	(e)
const	4.25 (0.94)	4.22 (0.97)	4.37 (1.31)	-1.68 (2.61)	-1.68 (2.62)
x_t	-	-0.14 (0.44)	0.38 (0.75)	-	-.0068 (0.45)
x_t^2	-	-	-.067 (0.25)	-	-
x_t^3	-	-	-.046 (.060)	-	-
$f_{t,\tau}-s_t$	-	-	-	7.98 (3.57)	7.98 (3.65)
N	2604	2604	2604	2604	2604
JHIC	20.5 (1)	24.6 (2)	26.9 (4)	22.6 (2)	27.4 (3)
JHEC	-	0.01 (1)	1.50 (3)	4.99 (1)	5.25 (2)

Remarks:
1. *See remarks 1 to 3 table 3a.*

Figure 1a: log(Ffr/DM) with boundaries.

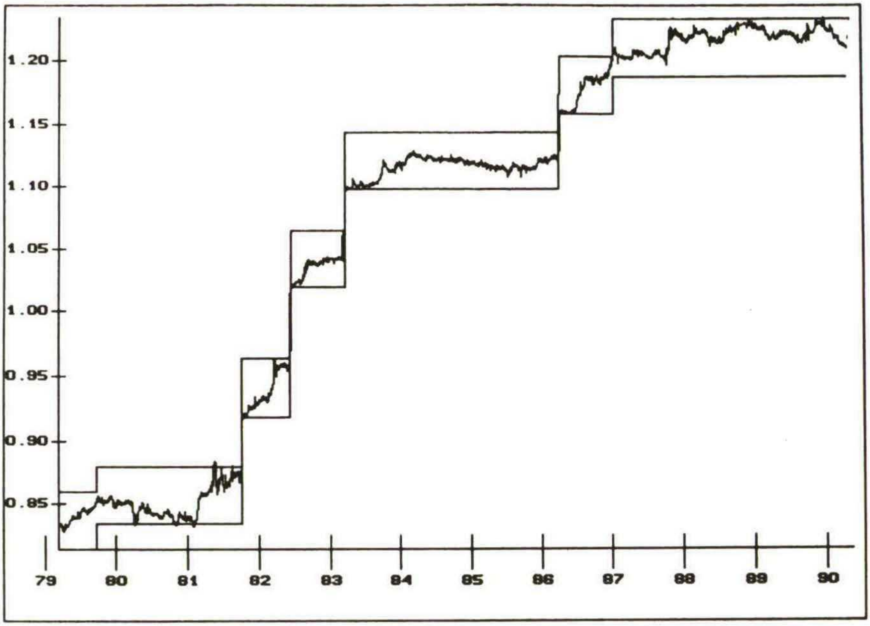


Figure 1b: log(lira/DM) with boundaries.

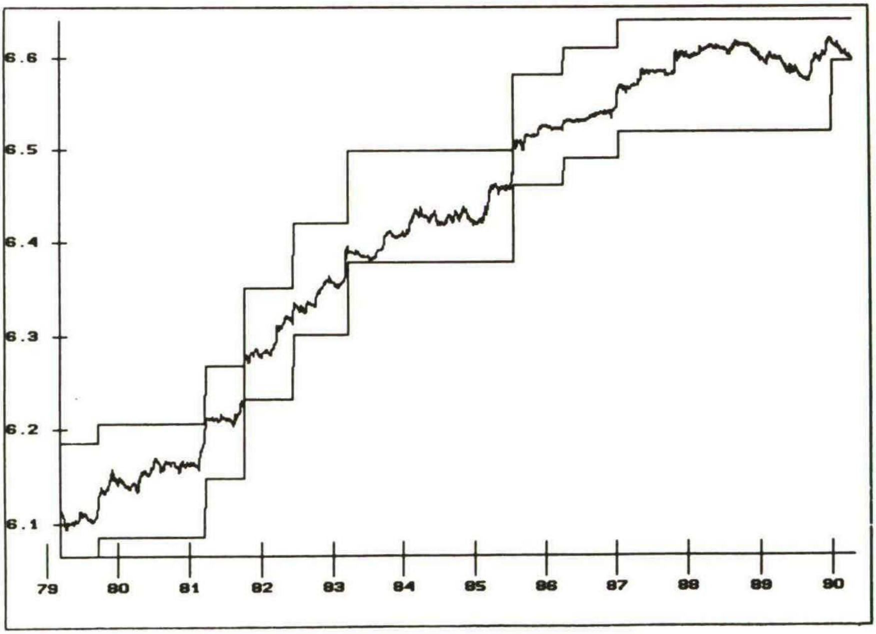


Figure 2a.1: Annualized interest differential Ffr/DM (in %).

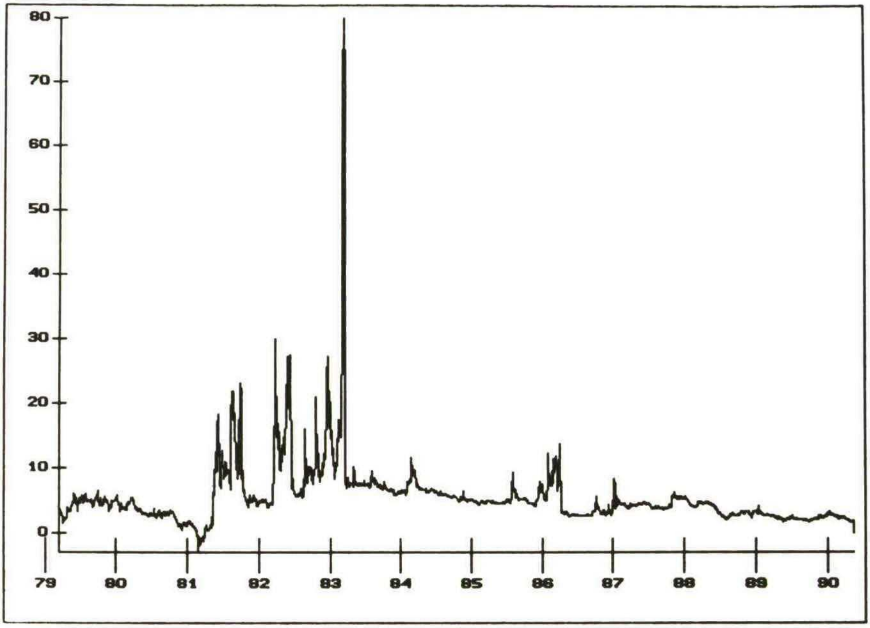


Figure 2a.2: Fit of $E_t[\Delta x_{t+\tau}]/\tau$ [Table 1a; column (c)]; Ffr/DM.

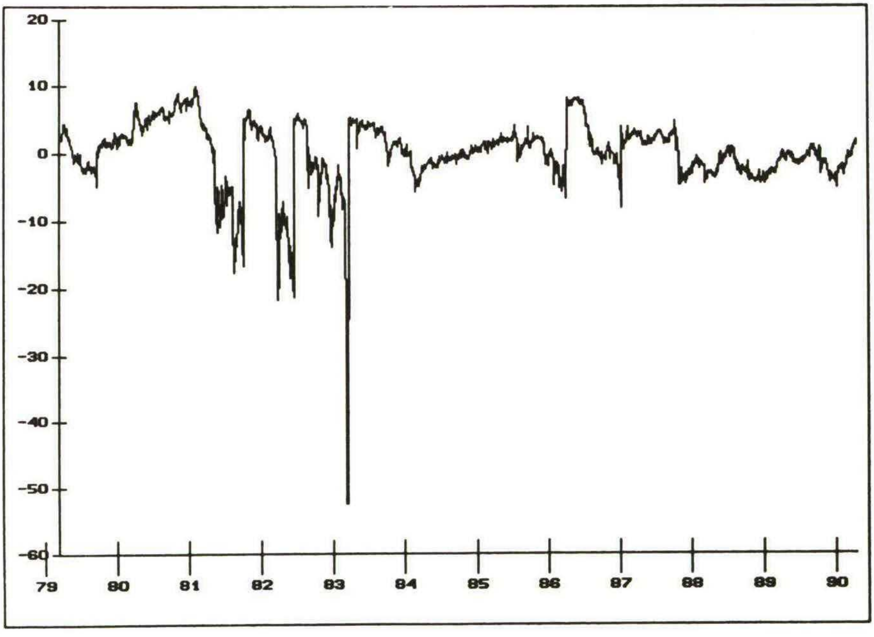


Figure 2a.3: Fit of $E_t[\Delta x_{t+\tau}|NR]/\tau$ [Table 2a; column (c)]; Ffr/DM.

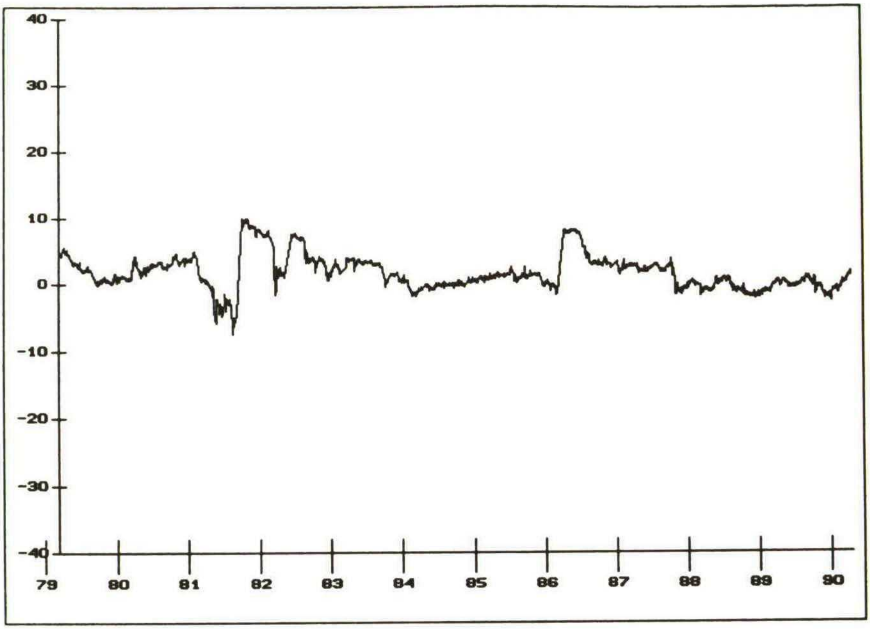


Figure 2a.4: Fit of $E_t[f_{t,\tau} - s_{t+\tau}]/\tau$ [Table 3a; column (e)]; Ffr/DM.

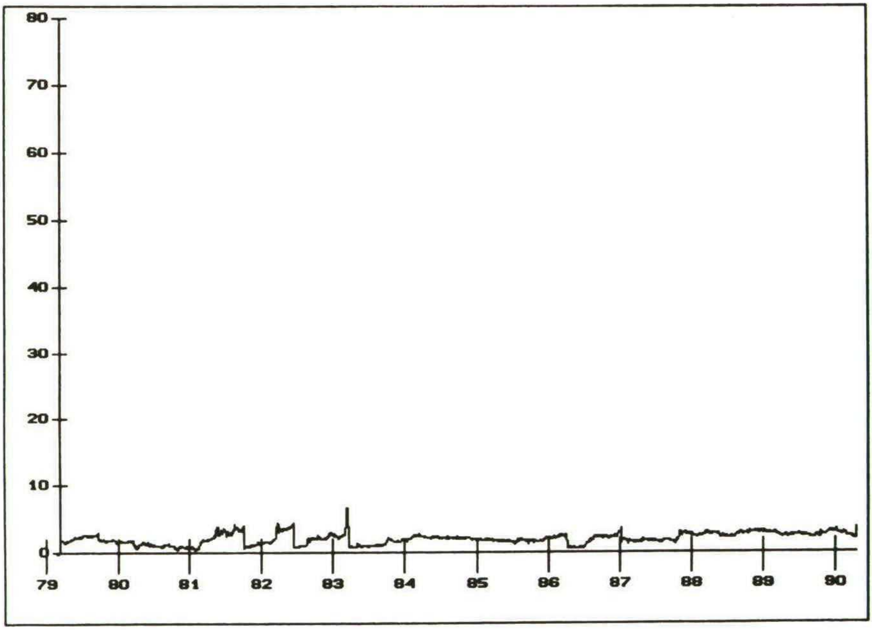


Figure 2b.1: Annualized interest differential lira/DM (in %).

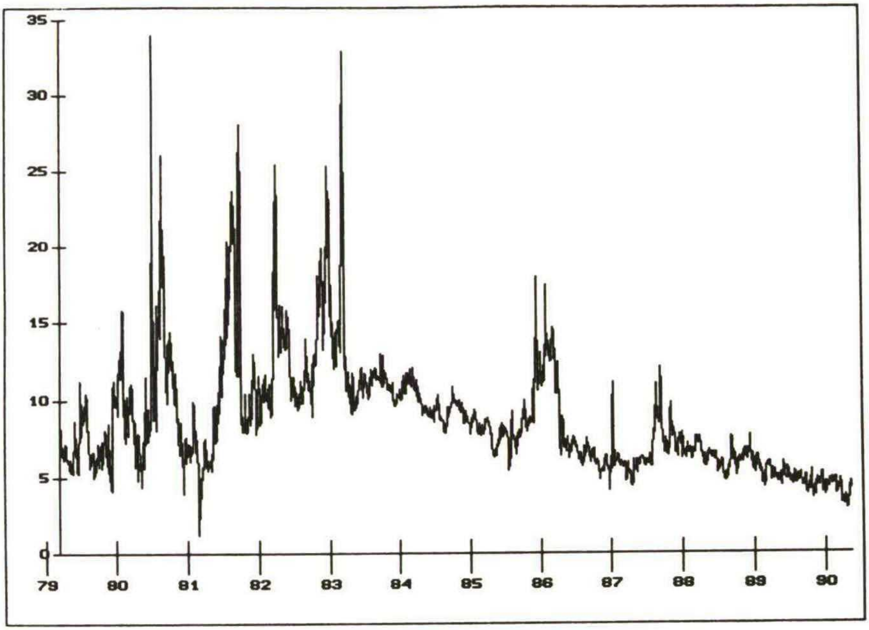


Figure 2b.2: Fit of $E_t[\Delta x_{t+\tau}]/\tau$ [Table 1b; column (c)]; lira/DM.

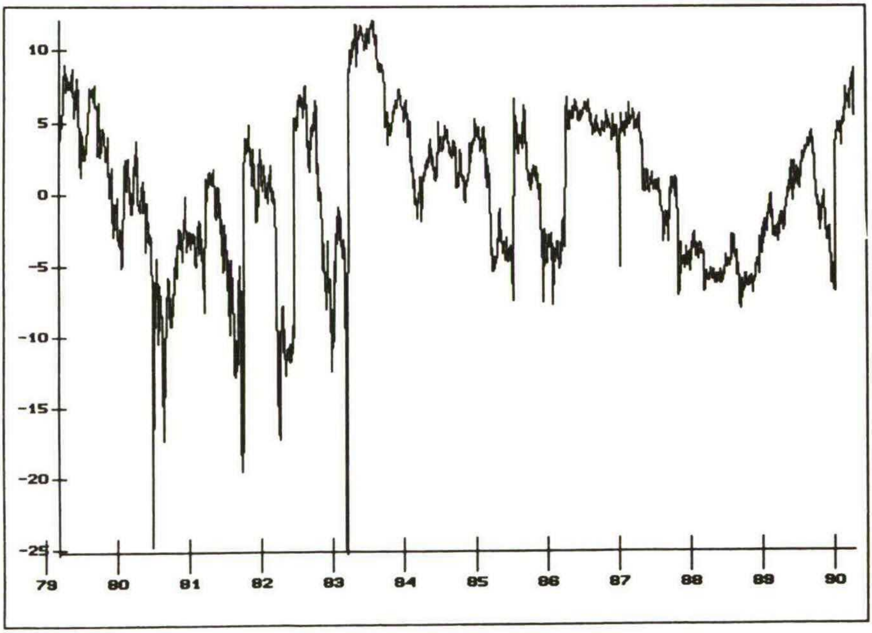


Figure 2b.3: Fit of $E_t[\Delta x_{t+\tau}|NR]/\tau$ [Table 2b; column (c)]; lira/DM.

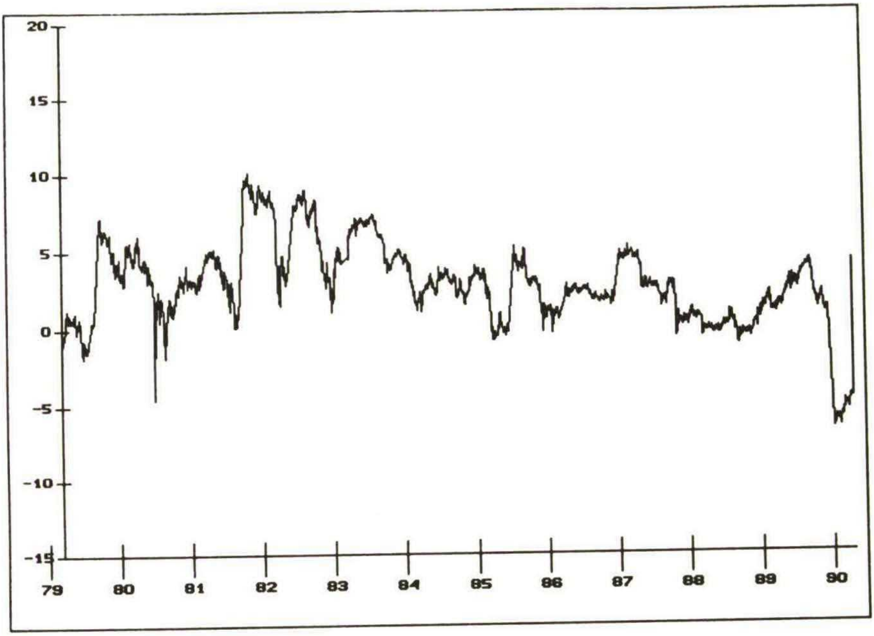
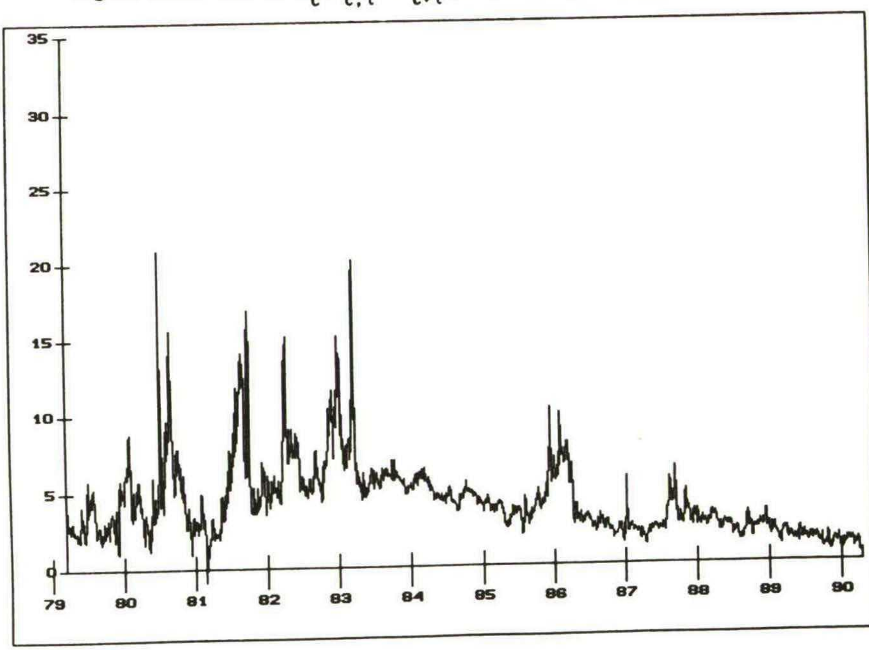


Figure 2b.4: Fit of $E_t[f_{t,\tau} - s_{t+\tau}]/\tau$ [Table 3b; column (e)]; lira/DM.



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