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The Linkage of Interest Rates Within the EMU

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Artis/Zhang: *The Linkage of Interest Rates
Within the EMU*



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Introduction¹

The linkage of interest rates between the countries of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) and between the US and the ERM has been the subject of several studies. Successful exchange rate unions are generally regarded as asymmetric (see McKinnon (1993) for a historical review) and the EMS has accordingly been widely interpreted as a *de facto* "DM zone". An implication of this interpretation which has been exploited by researchers is that it should be possible to find evidence of a cointegration relationship between the German interest rate and other EMS rates, as these rates could be expected to move closely together. However, the EMS started with a wide dispersion of inflation rates and interest rates among its members above the level prevailing in Germany and there were substantial sources of flexibility ("escape clauses") built into the provisions and practice of the System. In particular, the options of exchange rate realignment, the adoption of a wider band of fluctuation and controls over capital flows all existed and were exploited to varying degrees by member countries. To the extent that countries gradually reduced their reliance upon these escape clauses, the issues of the existence and timing of cointegration between interest rates in Germany and elsewhere in the system require empirical verification.

Karfakis and Moschos (1990) examined cointegration between interest rates and found that no cointegration relationship existed between any of the bilateral pairings of other EMS rates with the German rate. More surprisingly, Katsimbris and Miller (1993) provided evidence suggesting that whilst there was cointegration between US and EMS interest rates, there was no cointegration between interest rates in Germany and in other EMS countries (except for the case of Germany and the Netherlands).

The purpose of this paper is to reexamine relationships of cointegration of interest rates in the EMS and between the US and the EMS and to attempt to clarify some of the results mentioned above. Two things distinguish this contribution from earlier research. First, the data period covered by this paper extends to 1995 and thus includes the period since German unification and the ERM crises of 1992 and 1993. Because unification set Germany on a distinct

¹ We are grateful to Robin Bladen-Hovell and Ronald MacDonald for constructive comments on the paper. This paper is produced as part of a research project on "*Asset Market, Structural Convergence and European Monetary Policy*" administered by the CEPR and supported by the Leverhulme Trust (no. F/558/C). Financial support from the Foreign and Commonwealth Office is also acknowledged.

policy path from that prevailing in the US, the inclusion of data for this later period affords an opportunity to test the hypothesis that interest rates within the EMS respond to the German rate rather than the US rate. Second, by using rolling window estimation for cointegration analysis, we find that the cointegration relationship within the EMS rates and between the US rate and the EMS rates has a time-varying character, which may provide some explanation of the evidence cited above. The rest of this paper is organized as follows. The next section provides basic statistics about cross-correlations of interest rates across different periods. In section 2, rolling window cointegration estimation is proposed to examine how the cointegration relationship has been changed over time. The paper is completed by a summary of the main results and conclusions.

1. Data and basic statistics

The data used in this analysis are monthly observations of money market interest rates drawn from *International Financial Statistics*: the federal funds rate for the US, treasury bill rate for the UK, call money rate for Germany, France, Italy², the Netherlands, Belgium, Denmark and Ireland. The period covered spans from April 1979 (1979:4) to May 1995 (1995:5); the movement of these interest rates in this period is graphed in Figure 1.

In order to examine whether the relationship between interest rates has changed over time, we report, in Table 1, the contemporaneous cross-correlations of logarithms of interest rates, using the US and German rates as alternative bench-marks for four sub-periods: 79:4-83:12, 84:1-87:12, 88:1-92:7 and 92:8-95:5. Weber (1991), who uses three similar sub-periods in his monthly data study, notes that "during the early EMS period (1979-83) highly volatile movements at relatively high average levels of interest rates ... corresponded to speculative attacks which resulted in frequent unilateral realignments Disinflation, capital controls and policy adjustments in the following period (1983-87) reduced this volatility drastically.... The late ERM period (post-1987) was characterized by relatively parallel movements of interest rates...." Our study has extended the period used in previous research by another sub-period - the period since the latest ERM crisis which forced the British pound and Italian lira out of the ERM³.

² The series for Italy is terminated in January 1994 and treasury bill rate is used for the period from February 1994 to May 1995 in this study.

³ The Italian lira subsequently rejoined the ERM on 25 November 1996.

Figure 1. The movement of interest rates

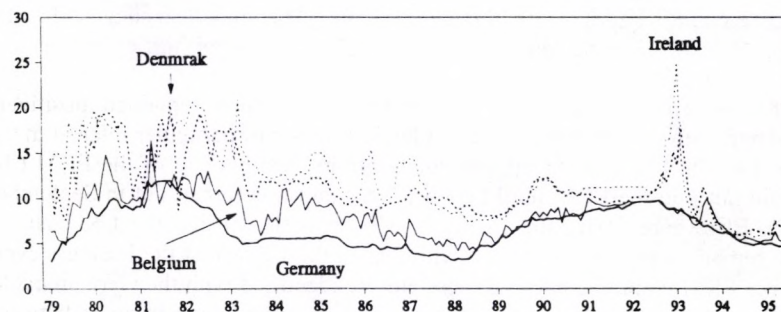
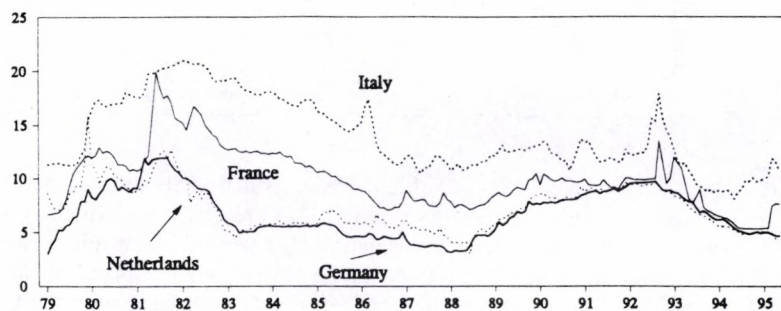
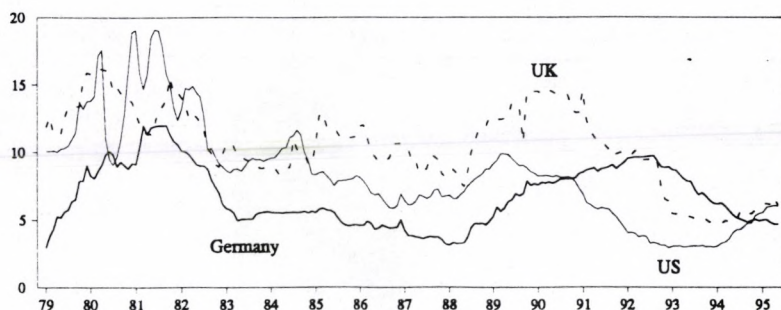


Table 1. Contemporaneous cross-correlations in interest rates

	Period			
	79:4-83:12	84:1-87:12	88:1-92:7	92:8-95:5
Germany-US	.762	.722	-.380	-.848
UK-US	.552	.024	.586	.165
UK-Germany	.617	.369	.374	.331
France-US	.366	.901	-.316	-.579
France-Germany	.544	.768	.899	.854
Italy-US	.198	.854	-.111	-.134
Italy-Germany	.407	.852	.562	.587
Netherlands-US	.706	.312	-.421	-.762
Netherlands-Germany	.840	.730	.969	.982
Belgium-US	.480	.769	-.490	-.805
Belgium-Germany	.729	.822	.929	.898
Denmark-US	.228	.634	-.176	-.623
Denmark-Germany	.488	.503	.594	.869
Ireland-US	.272	.272	-.404	-.507
Ireland-Germany	.382	.572	.845	.791

It is clear from Table 1 that very high cross-correlations both with the US and German rates in the early period (before 1987) are observed, which is an indication that interest rate cycles were synchronized worldwide in this period. However, the correlations of ERM rates with the US rate changed dramatically after 1988 - all the ERM rates then become negatively correlated with the US rate while still remaining highly positively correlated with the German rate - which suggests that a phase shift in the interest rate cycle between the US and the EMS countries took place in the later period. This may also suggest that the relationship of cointegration of interest rates has a time-varying character.

The exceptional behaviour of the UK rate, which remained positively correlated with the US rate (albeit at a lower level) is of particular interest in the context of the UK's failed attempt to sustain its membership of the ERM (the UK did not join the ERM until October 1990 and was forced out in September 1992). Elsewhere, Artis and Zhang (1997) have shown that the UK business cycle remained closely associated with that in the US whilst the business cycle in other ERM countries became more closely identified with the German cycle. Corresponding to these business cycles, which were no longer in phase between the US and Germany during the ERM period, the policy cycle in interest rates was also not in phase. It is also shown in Figure 1 that interest rate policy in the UK after 1989 was pulled in contradictory directions - towards the US cycle of

low and falling interest rates and towards the German cycle of high and rising interest rates - at the same time. It was arguably the unsustainability of this "double act" that led to the UK's withdrawal from the ERM⁴.

2. Rolling window cointegration

Using data covering the period 1979:4 - 88:11, Katsimbris and Miller (1993) find no evidence suggesting cointegration between the German interest rate and other EMS rates, whilst finding some evidence suggesting cointegration between interest rates in Germany, France, the Netherlands and Belgium with the US. These findings, as they noted, appear counterintuitive - cointegration seems more probable as a property of interest rates on currencies inside the ERM. It is argued by Perron (1989) and by Rappoport and Reichlin (1989) that the conventional unit-root test will incorrectly fail to reject the unit-root null hypothesis, if there exist structural breaks such as a shift in mean or in trend in a stationary time series. Banerjee *et al* (1992) develop the asymptotic distributions for recursive, rolling and sequential tests for unit roots in changing coefficients in time series regressions. When they apply these methods to data on real postwar output for seven OECD countries, the techniques fail to reject the unit-root hypothesis for five countries.

One distinct feature in Figure 1 is that there are periods which are characterized by extreme volatility and large jumps in interest rates. These may have been caused by speculative attacks and intervention on the currency market. These periods cause problems for the correct recognition of the cointegration relationship among the variables of interest. One way of dealing with this is to divide the whole period into subperiods defined by the breakpoints or to normalise the breaks, but this procedure may in turn give rise to another problem, that of how to define the breaks. In this paper, we adopt a simple means of avoiding the problem of dating the breaks - the rolling window technique - to examine how the relationship of cointegration between two variables changes over time as new observations move into the window and old observations leave it.

⁴It became clear before the crisis that the recession in the UK was longer and much more severe than had been expected and the unemployment rate was high and still rising. As Masson (1995) has noted, when the UK monetary authorities were faced with the necessity to raise interest rates to clearly unreasonable levels from a domestic perspective, they chose instead to let the currency float outside the ERM.

The procedures used in this paper apply the DF/ADF test on the series of interest rate differentials and on the residuals from the first stage Engle-Granger (EG, 1987) cointegrating equation. The form of the EG cointegrating regression here may be expressed as

$$y_{it} = \alpha x_{it} + u_t \quad (1)$$

where x_i ($i=1,2$) is the US or German rate and y_i ($i=1,...,7$) is the interest rate in other countries. When α is fixed as unity, the interest rate differential may be expressed as $u = y - x$. To test whether \hat{u} is $I(1)$ the following regression is estimated.

$$\Delta \hat{u}_t = \beta_0 + \beta_1 t + \gamma \hat{u}_{t-1} + \sum_{i=1}^k \Delta \hat{u}_{t-i} + \epsilon_t \quad (2)$$

It makes sense to incorporate a trend term in the above regression for this may capture the narrowing differential between two rates over time (also see, for example, Engle and Yoo (1991)). The critical values used in this paper are obtained from MacKinnon (1991): given the size of our window, for the DF/ADF test of the interest differentials, the 10%, 5% and 1% significance levels are -3.16, -3.47 and -4.09 respectively; for the cointegrating equation test, the 10%, 5% and 1% significance levels are -3.60, -3.91 and -4.55 respectively.

Two problems emerge in using rolling window estimation. The first one is how to choose the window width. The criterion used in this paper to select the window width is to keep the minimum number of observations required within the window, which is fixed at 6 years for each sub-period as the window width, although we also experimented with window widths from 5 to 9 years and found that the principal results discussed below are broadly robust to the particular window width chosen. The second problem is related to the choice of the lag length in equation 2. To assume that the ϵ_t 's are serially independent, one should add as many lags as necessary in equation 2. However, it is not feasible to fix the lag length throughout the whole period since the window is moving over time. The criterion used in selecting the lag length for each window is to stop adding lagged values when the Durbin-Watson statistic obtained from equation 2 is within the range from 1.9 to 2.1, which ensures that the residuals in equation 2 appear to be white noise⁵.

⁵Roughly speaking, for around 20% of the windows no lag is needed; in approximately 70% of windows, one lag is added to ensure that the DW statistics are in the range from 1.9 to 2.1 and more lags are added for the remaining windows.

Using the US and the German rates as benchmark rates, Figure 2 shows the sequence of statistics of the DF/ADF test for a unit root in interest rate differentials; Figure 3 plots the sequences of statistics of the EG test for cointegration between the US /German rate and the rates in the other countries with observations plotted at the end-point of the window in both figures. The horizontal line in each figure indicates the 5% significance level; thus observations falling below the line suggest that the two series are cointegrated over the previous six years⁶.

Although the degree of cointegration in Figure 2 is slightly more significant than that in Figure 3, both figures provide broadly similar pictures. It is convenient to concentrate on the results provided in Figure 2. It is immediately clear that the long-run relationship of the two rates under consideration has indeed a time-varying character as the DF/ADF statistics are changing over time. Despite the time-varying character, there are still a number of interesting regularities which may clearly be observed.

With respect to the US rate: For almost all interest rate differentials, the unit root hypothesis can be rejected for the early part of the period, suggesting that US interest rates could be regarded as having been cointegrated with EMS rates then. However, the relationships of cointegration with the US rate totally disappear for almost all the EMS rates in the late period. These results are quite consistent with the high cross-correlations between the US rate and the EMS rates shown in Table 1 for the early period and are a clear indication that interest rate cycles were synchronized worldwide during this period. However, when the phase in the US interest rate cycle shifts dramatically with respect to the phase in the EMS rates, the cointegration relationships no longer exist. Thus our results, on the one hand, confirm the findings by Katsimbris and Miller (1993) to the effect that there is evidence of cointegration between the interest rates in Germany, Belgium, France and the Netherlands with those in the US for the period from 79:4 to 88:11 they use in their study. On the other hand, when testing cointegration with respect to the German rate, our results are contrary to the findings of these two authors, who report no evidence of cointegration between the German rate and other EMS interest rates for the same period, although they note that these findings may appear counterintuitive.

⁶ The rolling window technique was also used to test the unit-root hypothesis for each series in levels before running the cointegration equation and it was confirmed that the individual interest rate series are $I(1)$.

Figure 2. The DF/ADF statistic for interest rate differentials
Rolling window estimation

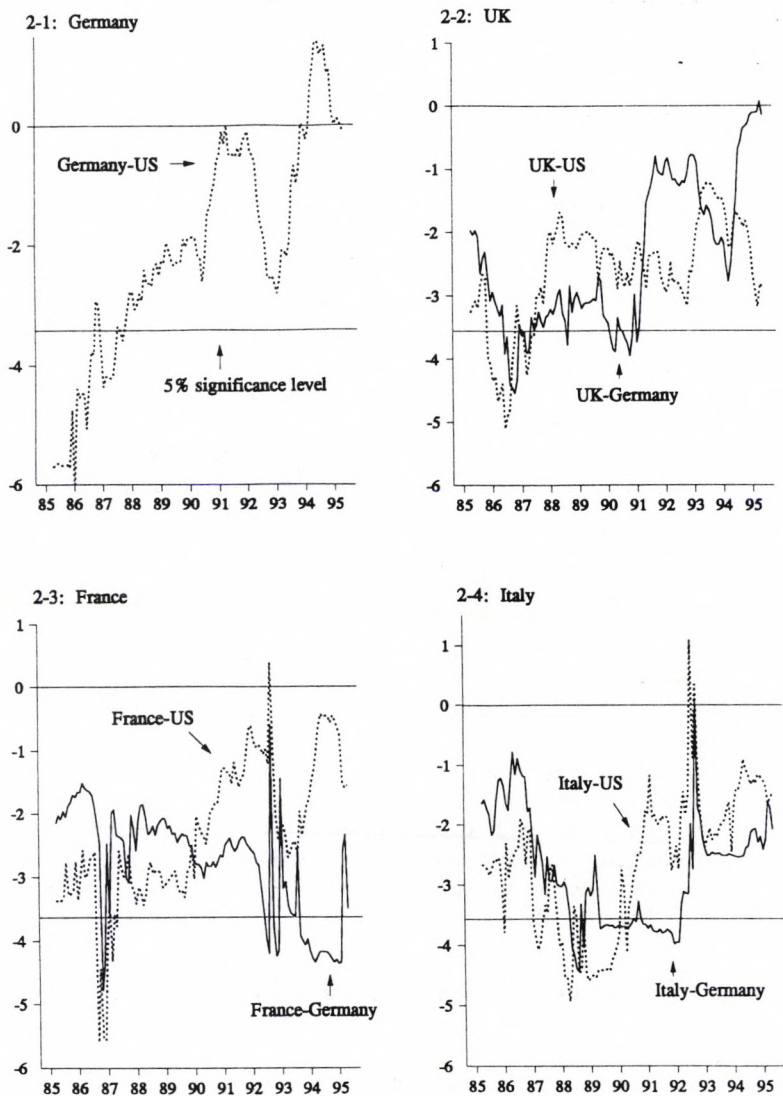


Figure 2 (cont.)

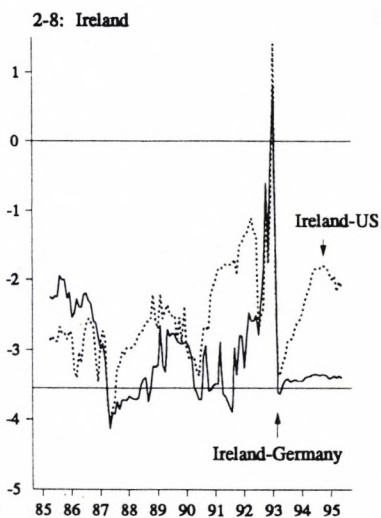
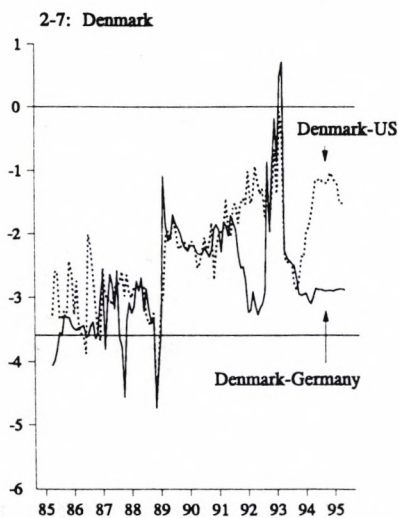
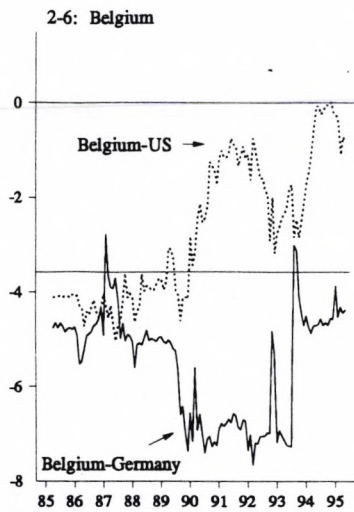
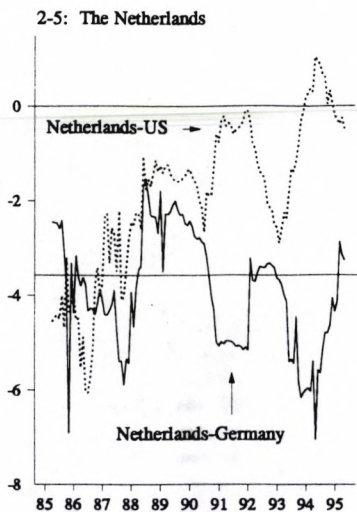


Figure 3. The DF/ADF statistic for cointegration
Rolling window estimation

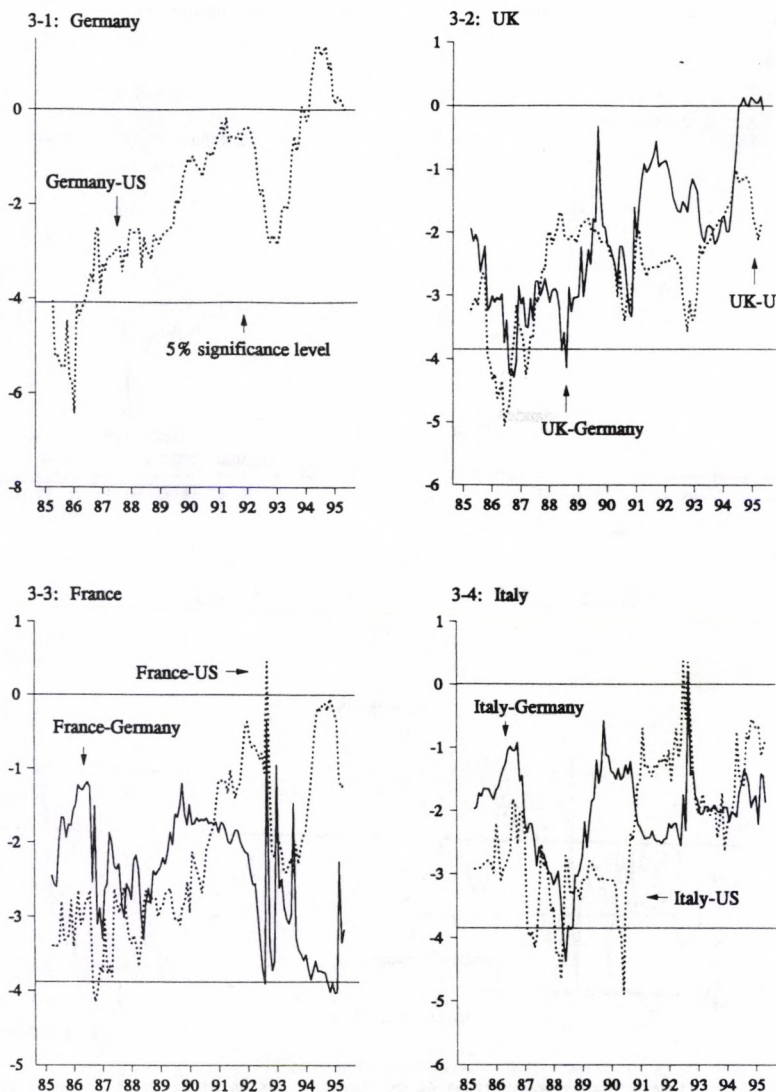
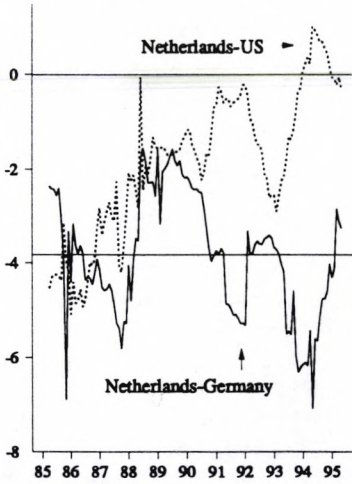
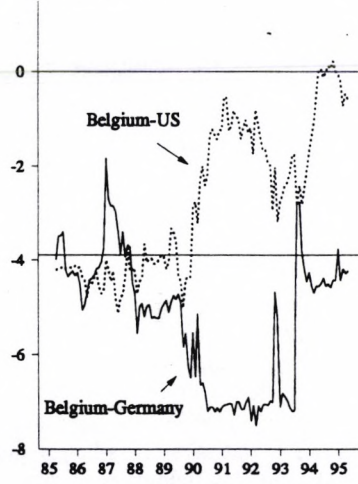


Figure 3. (cont.)

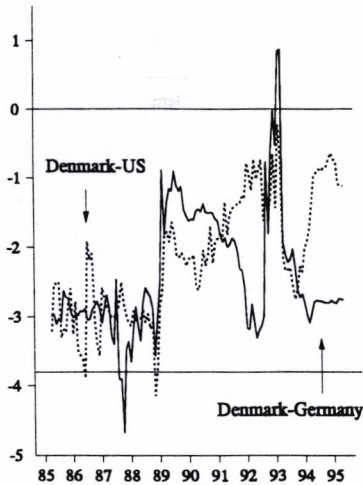
3-5: The Netherlands



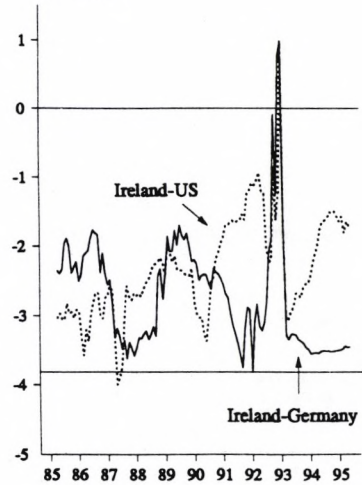
3-6: Belgium



3-7: Denmark



3-8: Ireland



With respect to the German rate: It is not surprising to find that the differentials between the German rate and the rates in other EMS countries are stationary since all the rates under investigation in this paper follow a very similar cycle, which may be driven by common factors such as the oil shock and the experience of high inflation in the early 1980's. It is indeed seen to be the case from Figure 2 that the interest rates in the other countries are cointegrated with the German rate as well as the US rate. However, what may be more important is to investigate which cycle the interest rates in the other countries follow when the interest rate cycles in the US and in Germany depart from each other, as they did in the late period of our sample. There is clear evidence in Figure 2 suggesting that while cointegration between the EMS rates and the US rate totally disappears, cointegration of the EMS rates with the German rate continues to exist.

It appears that the Dutch guilder interest rates, and those on the Belgian and French francs are cointegrated with the rate on the DM most of the time, not only in the late period⁷. For example, the Dutch and Belgium rates are cointegrated with the German rate for much of the ERM period as the DF/ADF statistics stay below the 5% significance level line, while for the French rate, the DF/ADF statistics cross below the line in June 1992 (the DF/ADF statistic is -3.54) and stay below it for most of the time except for the period prior to and after the September crisis of 1992, during which the extremely volatile movements in EMS rates occurred.

It is worth noting that cointegration relationships of the British and Italian interest rates with the German rate also share similar features: the long-run relationship between the British and German rates continues to exist for a while and disappears after early 1991 (1991:2); cointegration between the Italian and German rates does not disappear until early 1992 (1992:2) and no longer exists after that. It is clear from Figure 1 that the rates on British pound and DM had moved in parallel, with the UK rate being significantly higher than the German rate, for quite a while until October 1990 when the UK joined the ERM, but the UK rate was then reduced significantly within a relatively short period towards the German rate after that time. The Italian interest rate, on the other hand, had gradually been reduced towards the German rate, but moved away just before the crisis of 1992. These movements may provide an explanation for the non-cointegration of the two series after the structural breaks and the associated large jumps move into the estimation window.

⁷ This is also suggested by the results in Table 1 that the cross-correlations of the three interest rates with the German rate are among the highest for the period 88:1-92:7.

There is little evidence suggesting cointegration of the rate on Danish kroner with the German rate at the 5% significance level. The DF/ADF statistics for the differential between the Irish and German rates wander around the line showing the 5% significance level, even after the crisis of 1992 suggesting that two series are cointegrated at least at the 10% significance level.

4. Conclusions

It must be noted that the power of the unit root test is low and it is often difficult to reject the null if there are structural breaks in the series. In the EMS, there are such breaks which may be associated with the use of the interest rate to defend a currency against speculative attacks and realignments of exchange rates within the EMS. Given the low power of the DF/ADF test and breakpoints in the interest rate series, it may be difficult to reach a decisive conclusion; in particular, researchers may reach quite different conclusions simply by adding or moving a breakpoint into or out of the period being analyzed, as we show in this study.

Instead of focusing on one specific data period, in this paper we use the rolling window technique to investigate the cointegration relationship. Despite the time-varying character of the cointegration, some common features emerge and some general conclusions may be arrived at. Broadly speaking, our results may be summarised as follows: 1) In the early period of the ERM, there is strong evidence suggesting a cointegration of the EMS rates both with the US and German rates as the interest rate cycles worldwide were synchronized, being driven, it seems reasonable to suppose, by common factors such as oil shocks and the high inflation rate in the early 1980's; 2) For much of the late period, the cointegration of all the EMS interest rates with the US rate totally disappears, while those with the German rate continue to exist; 3) Among the EMS rates, cointegration of the Dutch guilder interest rates, and those on Belgian and French francs with the German rate remain particularly significant for much of late period; while cointegration of the UK and Italian rates with the German rate ceased to exist just before early 1991 and 1992 respectively, which may be due to the breakpoint of the ERM crisis of 1992.

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This draft: January 1997

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