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Business Cycles, Exchange Rate Regimes and the ERM: Is there a European Business Cycle?

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RSC No. 96/55

EUI WORKING PAPERS

EUROPEAN UNIVERSITY INSTITUTE

EUI Working Paper RSC No. 96/55

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EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

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BADIA FIESOLANA, SAN DOMENICO (FI)

Printed in Italy in October 1996
European University Institute
Badia Fiesolana
I – 50016 San Domenico (FI)
Italy

Robert Schuman Centre

Programme in Economic Policy

The Working Papers series

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Abstract
Successful fixed exchange rate regimes impose policy disciplines that are likely to lead to conformity in the business cycles of the participating countries. This conjecture is borne out in the present paper by the evidence in it that the business cycle affiliation of ERM member countries has shifted from the United States to Germany since the formation of the ERM. This effect is bolstered by the growing links in trade between the EU countries. The United Kingdom is conspicuous among the latter in that its business cycle affiliation did not change in the period of study.

Introduction[1]

In Artis and Zhang (1996) we investigated the effects of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) on the international business cycle in terms of the linkage and synchronization of cyclical fluctuation between countries. More specifically, by using the US cycle and the German cycle as two bench-mark cycles and the pre-ERM period and the ERM period as two subperiods, and by dividing the sample of 15 countries into two groups - the ERM-group and non-ERM group - we attempted in that paper to examine whether systematic differences in business cycle behaviour within the two groups of countries across the two periods could be observed. The inclusion of the non-ERM countries enabled us to distinguish ERM-specific phenomena from the general development of the international business cycle and thus allowed us to establish whether there is a "European" business cycle.

This paper extends the previous study in the following three respects: 1) by using the latest data set supplied by the OECD, the sample period covered is extended to run from January 1961 to October 1995, 2) the sample size is extended to 19 countries instead of the 15 countries examined in the previous study and 3) more importantly, the hypothesis that business cycle affiliation is associated with the exchange rate regime is tested by using a non-parametric rank correlation approach. There is clear evidence suggesting that business cycle affiliation is linked to the fixity of in exchange rates between countries.

The investigation of linkage in business cycles and the way in which economic disturbances are transmitted across countries has a long history. Earlier literature includes the paper by Mitchell (1927), who found that the correlation of business cycles across countries was positive and tended to rise over time due to the openness of financial markets. Recent contributions to this literature, particularly those that investigate the question whether the transmission of foreign economic shocks depends on the exchange rate regime, include papers by Gerlach (1988), Baxter and Stockman (1989), and Ahmed *et al* (1993), among others. Dividing exchange rate experience into fixed and floating rate regimes, identified respectively with the Bretton Woods period and after, these

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[1]. We should like to thank the OECD for supplying the latest data set used in this study. We are grateful to the *International Journal of Finance and Economics* for permission to reproduce some parts of our previous paper, "International business cycles and the ERM: Is there a European business cycle?". We should also like to acknowledge financial support from the Leverhulme Foundation under a grant administered by CEPR and also from the CEPR's Mirage programme. Participants in seminars at the Universities of Brescia and Siena and at the European University Institute in Florence, along with our discussant, Peter Bofinger, and other participants in the CEPR Conference on Regional Integration at La Coruña made many helpful comments on the earlier version of this paper. We are grateful to them all, whilst accepting full responsibility for the errors remaining in this version.

studies examine whether the international business cycle has changed between the two periods.[1]

Gerlach (1988) examines the cross-correlations of monthly industrial production series under the two regimes (1963:2-1973:2 and 1973:3-1986:3) and finds that the variances of monthly growth rates are typically higher in the flexible exchange rate period; but output movements have been correlated across countries under both regimes. He also suggests that there is evidence of a world business cycle.

Baxter and Stockman (1989) use the industrial production data of a sample of 49 countries to compare the behaviour of business cycles under the two exchange rate regimes (1960:1-1970:4 and 1973:1-1985:4). They find little evidence of systematic differences in the behaviour of macroeconomic aggregates. They also find that the cross correlations decrease in the flexible rate period and argue that business cycles became more country-specific in the post-1973 period.

Ahmed *et al* (1993) use a structural macroeconometric model to study the source of international economic fluctuations. Among other results, they report that the interactions between output, relative prices, and fiscal and monetary variables in the United States and the rest of the world were much the same in the pre-1973 fixed-exchange-rate period as in the post-1973 flexible-exchange-rate period. Thus they argue that there is no evidence of differences in the transmission properties of economic disturbances across exchange-rate regimes.

In this paper we take the ERM countries as constituting a 'quasi-fixed' exchange rate bloc. The ERM has been characterised as a hegemonic system centred on Germany as the anchor country. In such a case, standard economic theory makes it clear that in choosing to target its exchange rate against the currency of a dominant country with which trade and financial links are probably in any case important, a small open economy will be obliged to import the disturbances hitting the dominant country and will indeed be using its policy instruments to enforce this (for a theoretical characterization, see Canzoneri, 1982). Of course this does not completely rule out that the country may also import shocks from elsewhere or experience its own idiosyncratic disturbances (dependent on the flexibility of the exchange rate arrangements and the availability of policy instruments); but it would appear that this could only be of secondary importance. We can rule out that the loss of monetary independence would lead to more idiosyncratic behaviour on the grounds that this must be incompatible with continued maintenance of the exchange rate peg.

Turning now specifically to the case of ERM membership, it must be noted that whilst Germany is considerably the largest economy in the ERM, the economies of France and Italy (respectively, the fourth and fifth largest in the G-7 ranking) are hardly "small". Moreover, the ERM has contained a number of "escape" clauses. Exchange rates have not been rigidly fixed but have

fluctuated within a band; central parity realignments have occurred; and, until the second half of the 1980s, member countries could buy a degree of freedom by deploying exchange controls on capital flows. Nevertheless, the hypothesis that the formation of the ERM may have bred a "European business cycle" centred on Germany is worth exploring. Indeed, the synchronization of business cycles in the ERM may have become one of the key conditions for the efficient coordination of monetary policy in Europe, as noted for example by Christodoulakis *et al.* (1995) in their recent study of this matter[2]. However, where these authors analyze and compare the cyclical behaviour of a large number of aggregate variables for the EC countries over the period 1960-1990, the focus of our own study is on the change over time in the business cycle affiliation of the set of ERM countries. The papers by Karras (1994) and by Fiorito and Kollintzas (1994) are also complementary to the concerns of the present study. The former paper is concerned with the sources of business cycle fluctuations in the economies of France, Germany and the UK over the period 1960-1988; the latter tests real business cycle propositions on data for the G-7 countries.

The paper reports some statistical regularities in business cycles for a sample of 19 countries. It appears that 1) the degree of linkage between business cycles within the ERM group has strengthened and that business cycle phases have become more synchronous through time; 2) the linkages in business cycles between the ERM countries and the US have weakened during the ERM period whilst those with Germany; and 3) these phenomena are not observed for the non-ERM countries. Finally, reinforcing the evidence afforded by the association of ERM membership and the shift in business cycle affiliation away from the US, we also find: 4) that on a country-by-country basis the strength of business cycle affiliation appears to be quite significantly (inversely) correlated with the volatility of the exchange rate.

The paper contains four sections. The first section gives a brief description of the data. In section 2, we introduce the three most commonly used de-trending methods employed in this paper: the phase-average-trend (PAT) method, the filter proposed by Hodrick and Prescott (1980) and linear trending. Graphical comparisons are given for the US, German French and UK business cycles. In section 3, we report evidence for the ERM countries in terms of the synchronization, the phase shift and the linkage between their business cycles. This evidence is provided on the basis of comparisons made across periods employing data derived by the OECD. The hypothesis that the strength of business cycle affiliation is associated with exchange rate volatility is tested in section 4, using a non-parametric rank correlation approach. Although other factors are important, the evidence strongly suggests that synchronization in business cycles is linked to lower volatility in exchange rates between countries. The paper is completed by a summary of the main results and conclusions.

1. Data and definitions

The data used in the current study are the OECD seasonally adjusted figures on monthly industrial production spanning the period from January 1961 (1961:1) to October 1995[3] (1995:10) for a sample of 19 countries. These are the US, Germany, France, Italy, the Netherlands, Belgium, Ireland, Spain, Portugal, Austria, Switzerland, Sweden, Norway, Finland, Greece, Luxembourg, the UK, Canada and Japan. The whole period is divided into two subperiods: the pre-ERM period (1961:1-1979:3) and the ERM period (1979:4-1995:10). Since the main purpose of the paper is to investigate the ERM effect on the international business cycle, most ERM countries are included.[4]

For the sake of convenient discussion later in this paper, we label as ERM countries all those which were the original participants in the mechanism, together with those additional members which survived at the end of our sample period. This definition thus excludes the UK, which joined in October 1990 but left in September 1992, but includes Italy, which left the ERM in 1992 but was an original member of the system.

Since the "ERM period" in this study refers to the whole of the 17 years from 1979 to 1995, the more controversial members admitted by our definition are the two late-comers: Spain and Portugal, which joined the ERM in June 1989 and in April 1992 respectively. It is true that these late-comers enjoyed some earlier informal association with the ERM prior to formal membership. Portugal targeted a basket of ERM currencies from October 1990, earlier following a trade-weighted basket, whilst Spain's managed float, Viñals has noted, "informally kept the peseta moving during most of 1986, 1987 and 1988 within a ±6% band with respect to ERM currencies" (*ibid.*, p13). Even so, and although these two late-comers are treated as members of the ERM in this study, it might be expected that the behaviour of the business cycle in these two countries would be different from that of other members of ERM group because of the shorter duration with which they have been in, or associated with, the ERM. Our definition of the ERM group also includes Austria which formally joined the ERM only in January 1995. However, for the whole period of the ERM Austria has followed a policy of targeting the DM; after some initial (upward) realignments, from 1981 the schilling/DMark rate "only fluctuated minimally" (Hochreiter and Winckler, 1995).

While the US cycle serves as the bench-mark cycle, the inclusion of data for other non-ERM European countries such as Switzerland, Sweden, Norway, Finland and the UK, and non-European countries such as Canada and Japan helps us to distinguish ERM-specific phenomena from general tendencies in the business cycle. In particular, the Nordic countries act as a control group which allows us to distinguish a business cycle within the ERM group from a

continental European cycle. Sweden, Norway and Finland chose to peg the ECU unilaterally late in our sample period and all three were forced off this peg in 1992: Norway pegged to the ECU in October 1990 and floated in December 1992; Finland pegged to the ECU in June 1991 and floated in September 1992 whilst Sweden pegged in May 1991 and floated in December 1992[5].

2. De-trending methods

The definition of the business cycle employed in the current paper is that of the growth cycle, representing cyclical movements around the long-run growth trend of an economy. The decomposition of observed series into a trend movement and cyclical component is one of the key issues in business cycle research. The central issue is what is meant by the cyclical component and how to choose the appropriate filter to use to isolate it. Statistical properties, such as the cross-correlation between two series, will be sensitive to the filter chosen. In this paper we adopt an agnostic position about the proper way to do such de-trending, and proceeding by using several of the more commonly used filters in business cycle research, conducting a sensitivity analysis over the results. The three most widely used techniques are the phase-average-trend estimation procedure proposed by Boschan and Ebanks (1978), the filter proposed by Hodrick and Prescott (1980) and linear trending (a special case of the HP filter).

The phase-average-trend (PAT) estimation procedure provides a fairly flexible growth trend that is substantially free of the shorter-term cyclical movements in the series. This method was designed specifically to separate long-term trends from medium-term cycles, with the latter defined according to the criteria programmed in the Bry-Boschan (1971) computer routine for selecting cyclical turning points. Briefly, the basic steps in the PAT procedure involve 1) selecting the turning points using the Bry and Boschan (1971) routine; 2) splitting the series into phases, defined as the number of months between successive turning points; 3) calculating the phase-average, defined as the means of the observations in each phase; 4) computing a three-term moving average by using these phase-averages; and, 5) finally, obtaining the trend. A detailed description of the PAT procedure can be found in Boschan and Ebanks (1978). The principal statements of results in the text are obtained by using the cyclical series supplied by the OECD, which employs a modified version of the PAT procedure (see Nilsson (1987)).

The Hodrick-Prescott filter (HP filter) decomposes the raw series into a stochastic growth component and a cyclical one. The HP filter can be specified as:

$$\min_{g_t} \left[\sum_{t=1}^{N} (y_t - g_t)^2 + \lambda \sum_{t=2}^{N-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \right]$$

where y_t denotes the raw series, g_t the growth component and $(y_t - g_t)$ the cyclical component. The first part measures the fitness and the second is a measure of smoothness. The parameter, λ, interpreted as the signal-to-noise ratio, determines the weight of fitness relative to that of smoothness. As λ goes to infinity the HP filter collapses to a linear trend. For quarterly data, Hodrick and Prescott (1980) set λ=1600, arguing that a 5% deviation from trend per quarter is moderately large as it represents one-eighth of a one percent change in the growth rate in a quarter.

These methods are widely used and easy to implement; they are, however, not free from criticism. For the PAT procedure, the identification of peaks and troughs is a crucial step, since the method first splits the series into phases which are defined as the number of months between successive turning points. The Bry-Boschan routine specifies a minimum duration of five months for a phase and fifteen months for a cycle. The rules adopted may be sensitive to the turning points selected, particularly for those called 'minor turning points'. Although there is no need to define the turning points in the HP filter, the filter may seriously alter the measures of comovements between series (see, for example, King and Rebelo (1993)). The robustness /sensitivity of the results from different filters was assessed in a formal way in our earlier paper (Artis and Zhang 1997) and there is no evidence that the main conclusions are sensitive to the choice of filter.

All the cyclical components used in our paper are measured by a cyclical index: $1.0+(X_t - trend_t)/trend_t$, where X_t is the raw series. By way of example, Figures 1-4 graph the US, the German, the French and the UK business cycles, in which these components are de-trended by the filters discussed above. At the top of each figure is the series de-trended by the OECD using the modified PAT procedure. In the middle, there are two cyclical indices de-trended by the HP filter when λ=500000 and λ=50000 respectively. The large values for λ may be justified on two grounds: 1) that monthly industrial production is a volatile series; 2) that the trend of industrial production can be assumed to be basically upwards. Finally, we also graph the cyclical components derived as deviations from a linear trend. Since the growth rates of industrial production in almost all the industrial countries slowed down during the '80s and '90s, a separate linear trend is applied to the different periods (the pre-ERM and the ERM period). The four series have very similar cyclical movements; in particular, the OECD series and the series de-trended by HP filter(λ=500000) are very similar.

By using a 2×2 contingency table, Artis and Zhang (1997) show that the results are quite robust across different de-trending methods in the sense that changes in correlation with the US and the German cycle are consistent between

the different de-trending methods[6]. Therefore, in this paper we concentrate on the results achieved using the OECD-adjusted series.

The discussion which follows relies heavily on the evidence provided by correlations between the cyclical components, across countries and across periods. These correlations provide basic information on three features. The degree of synchronization between any two cycles is measured by the contemporaneous cross-correlation. The phase shift is measured by the lead /lag at which the maximum correlation is obtained, while the maximum correlation itself is used to measure the degree of linkage between two cycles.

3 The linkage of the business cycle

3.1 Synchronization

A general finding is that the business cycles in the major countries have become more synchronized as a result of increased international trade, openness of financial markets and global capital flows (see, for example, Zarnowitz (1985)); however, Baxter and Stockman (1989) have on the contrary observed decreases in the contemporaneous cross correlation of business cycles and argue that business cycles became more country-specific in the post-1973 period.

The degree of synchronization between two cycles is measured by the cross-correlation at displacement 0, the results of which are reported in Table 1. Figures 5 and 6 show, respectively, the contemporaneous cross-correlations with the German and the US cycles before and after the creation of the ERM. By construction, observations close to the diagonal indicate a similar degree of synchronization with both benchmark cycles (the higher, the further to the NE the observation is located), whilst displacement from the diagonal can be interpreted as a difference of synchronization between the two benchmark cycles. There are a number of interesting regularities which may be described as follows:

In the pre-ERM period: With the exception of Canada, the Netherlands, Italy and the Nordic countries, all the countries are located near or slightly below the 45° line in Figure 5, suggesting that business cycles in these countries are in phase slightly more often with the US cycle than with the German cycle. A high degree of synchronization in the Canada-US cycles and the Netherlands-Germany cycles is shown in Figure 5 by the displacement from the diagonal in the different directions of these two observations, with the second largest pairs being the US-UK and Germany-Austria. This is not surprising given that the economies of these countries have traditionally been closely linked over time. The lowest degrees of synchronization both with the US and with the German cycle are observed for the Italian cycle and the cycles in the Nordic countries, suggesting that the business cycle in these countries in the earlier period had a strong idiosyncratic element.

Table 1. Cross-correlation with the US /German business cycle

	Contemporaneous correlation		Maximum correlation		Maximum correlation	
	US	Germany	US	Lead/lag[1]	Germany	Lead/lag[1]
Pre-ERM period:	61:1-79:3					
Germany	.45	--	.45	0[2]	--	--
France	.51	.48	.52	-1	.48	0
Italy	.37	.15	.38	-4	.18	-4
Netherlands	.29	.78	.31	-2	.78	0
Belgium	.53	.58	.52	0	.58	0
Ireland	.58	.48	.58	0	.51	+3
Spain	.63	.38	.66	-2	.46	-5
Portugal	.53	.47	.56	-2	.49	-3
Austria	.40	.68	.45	-4	.68	0
Switzerland	.52	.40	.52	0	.44	+1
Sweden	-.06	.27	.33	-10	.31	-7
Norway	.13	.13	.36	-8	.31	-10
Finland	.21	.34	.46	-8	.49	-8
Greece	.56	.32	.57	+1	.34	+2
Luxembourg	.56	.64	.64	-3	.66	-1
UK	.68	.61	.69	-1	.61	0
Canada	.85	.48	.85	0	.48	+1
Japan	.45	.49	.47	-2	.50	+1
ERM Period:	1979:4 - 1995:10					
Germany	.15	--	.47	-22[2]	--	--
France	.37	.65	.43	-3	.65	0
Italy	.46	.56	.63	-6	.56	0
Netherlands	.43	.80	.53	-7	.81	+1
Belgium	.29	.74	.39	-7	.74	0
Ireland	.44	.04	.44	0	.21	+19
Spain	.38	.51	.39	-3	.62	+7
Portugal	-.13	.65	.50	-24	.66	+1
Austria	.23	.78	.46	-12	.78	-1
Switzerland	.71	.16	.72	-1	.53	+21
Sweden	.60	.16	.60	0	.53	+19
Norway	.39	.37	.41	-4	.41	+10
Finland	.60	-.08	.64	-4	.59	+20
Greece	.35	.48	.51	-10	.48	-1
Luxembourg	.45	.54	.48	-3	.59	+10
UK	.59	.35	.59	0	.73	+21
Canada	.89	.14	.88	0	.58	+23
Japan	.18	.76	.39	-11	.77	+1

1. The figures indicate the number of months that the business cycle in the US or Germany leads(-) /lags(+) the cycles in other countries.
2. When the German-US correlation is calculated, -/+ indicates the US cycle leads /lags the German cycle.

In the ERM period: The shift, in this period, of all the ERM countries with the exception of Ireland to a position above the diagonal is systematic. The cycles in all these countries have become more synchronized with the German cycle. The correlations are moreover comparatively high: for example, the France-Germany correlation is 0.65 compared to 0.37 for the France-US one. It is interesting to note that whilst the business cycles of the two late-comers (Spain and Portugal) have also become less synchronized with the US cycle and more synchronized with the German cycle, the degree of synchronization with the German cycle in the ERM period is less than that of other ERM countries. This suggests that whilst the synchronization of the business cycle in Spain and Portugal with the rest of the ERM group may have created an encouraging economic environment in which to manage their participation in the ERM, the shorter duration of their association with it produced a less strong identification with the German cycle.

The locations of Canada, the UK and Ireland in Figure 6 are also of interest, for they suggest that a comparable phase shift has not happened for these cycles. They are still synchronous with the US cycle and in fact, these correlations are quite stable across the period: 0.85 and 0.89 for Canada-US, 0.68 and 0.59 for UK-US and 0.58 and 0.44 for Ireland during the pre-ERM and ERM periods respectively. The locations of the Nordic countries also suggest some interesting regularities: first, there are similarities in the business cycles within these countries as they are grouped in Figure 6 and, secondly, the cycles in these countries have become more synchronized with the US cycle, but not with the German one. Although Ireland is a member of the ERM, a clear-cut shift in phase with the US is not found for this economy[7]. On the contrary, the Japanese cycle is in phase more often with the German cycle than with the US one in the latter period.

To summarise, the predominant result obtained suggests the emergence of a European business cycle in the period since the formation of the ERM: the business cycles have become more group-specific in the ERM period than before. It is in this sense that we may now be able to refer to a "European business cycle". But whilst the business cycles of the ERM countries have become more synchronised in the ERM period, this phenomenon (with the exception of Japan) has not occurred between the non-ERM countries and the US. For reasons suggested earlier, this should not be surprising, given that disturbances and policy impulses are transmitted more quickly through the channel of the exchange rate mechanism within the ERM countries. It is also suggested that the prediction that business cycles in the major countries are likely to be more synchronised due to the openness of financial markets may need further investigation. It is true that activities in the financial markets have become more highly integrated worldwide and that stock market indices are

widely used as leading indicators of the real economy. However, the poor performance in predicting real economic activity and the wide range of the lead time between the leading indicators and the real business cycle do not suggest that the business cycles worldwide have become more synchronised[8].

3.2 Lead /lag relationships

Contemporaneous correlation measures provide useful information for measuring the degree of synchronization between two cycles. Although we find evidence that systematic differences of synchronization in business cycles may have occurred across periods, it is uncertain how the phases shift. We can provide an explicit measure of phase shift by finding the lead /lag at which the maximum correlation is obtained. Table 1 also reports these figures which may be used as rough guide to the lead /lag relationship and a number of interesting regularities are described as follows:

Pre-ERM period: With the single exception of the Nordic countries, the maximum correlations with the US cycle are located within a range of only a few months; the range with respect to the German cycle is only slightly larger. This is clear evidence that the business cycles as a whole are in this period synchronous worldwide. One of the main reasons may be the incidence of the two oil shocks in this period: one in 1973 and the other in 1979. These shocks were international in character and spread across countries. On the other hand, one might expect that business cycles would become less synchronous in the absence of common shocks of this type.

In the ERM period: The business cycles in terms of their phases may be classified into groups: the ERM group and the non-ERM group. The cycles in the ERM group (with the exception of Ireland) are in phase with the German cycle and out of phase with the US cycle. In fact, the maximum correlations are located at exactly 0 displacement for France, Italy and Belgium; at the range -1 and +1 month for the Netherlands and Portugal. The range with respect to the US cycle runs from -3 to -24 months. While the cycles in the ERM group are synchronous, there exist cycles, those in the US, Canada, the UK, perhaps Ireland and the Nordic countries, which represent another international business cycle. The US cycle is synchronised with those cycles both in the pre-ERM and in the ERM period. This phenomenon may be regarded as providing further support for an ERM effect on business cycles - the ERM only appears to have affected the behaviour of business cycles in the ERM countries. (Japan again appears to be an outlier to this statement).

Baxter and Stockman (1989) observe that business cycles in the post-1973 period have been more country-specific and argue that this is because the source of shock may have changed whilst government policies may have differed in a

way that affects the international character of business cycles. Gerlach (1988) suggests that there is evidence of a world business cycle. Our findings are "mid-way" between these views in that, Japan on one side, we find that the business cycle has become more group-specific, with disparities emerging between the groups rather than within them - or at least, not within the "European" (ERM) group, where disparities have narrowed considerably. Of course, our observation period is different from that employed in these earlier studies, in particular in the inclusion of observations drawn from the period of the "hard ERM" and the idiosyncratic German shock associated with that country's unification and the associated fiscal and monetary policies.

4. Business cycle and exchange rate regime

The burden of the paper so far has been that exchange rate fixity is conducive to the transmission of business cycles across national frontiers. Whilst it is clearly not the only factor, for we can think of several others (trade linkages, similarity of industrial structures, frequency of common shocks, financial structure etc.), in this section of the paper we attempt to assess the strength of the argument further by confronting the rank of the business cycle affiliation with a ranking by exchange rate volatility. This test can be viewed as a means of responding to the observation that neither of our sample periods is homogeneous. For example, within the ERM regime some countries clearly adopted the discipline afforded in more rigourous fashion than others, whilst differences emerged over time in the frequency of agreed realignments and so on. The comparative paucity of data, especially relative to the number of business cycles to be observed is, however, something of a limitation on what can be done. In particular, the pre-ERM period combines a segment of the Brettan Woods era of exchange rate fixity (1961 to 1971/2) with a period of generalized floating (after 1973). The period of generalized floating within the pre-ERM era is comparatively short in terms of cyclical experience, lasting barely the length of a normal cycle and marked at the onset by a particularly large common shock in the form of the first OPEC crisis. Bearing this in mind what we offer in the subsequent tabulations is a non-parametric analysis of the "floating exchange rate period" in which exchange rate volatility rankings for that period are compared with business cycle correlations for the whole pre-ERM period (1961-79); this is compared with a similar analysis of the ERM period?[9]

The synchronization of business cycles is measured by the contemporaneous cross-correlation coefficient and the volatility of exchange rate is measured by the standard deviation of $\log(x_t/x_{t-1})$, where x denotes the

exchange rate. We have a sample of n pairs of cross-correlations in business cycle and exchange rate volatility, (X_1, Y_1), (X_2, Y_2), ... , (X_n, Y_n), where X_i denotes the correlation in business cycle between country i and the US (Germany); Y_i denotes the volatility of the exchange rate for the currency in country i against the US dollar (deutsche mark). The hypothesis that the synchronization in business cycle is associated with low volatility in exchange rate may be tested by using the information in these n pairs. In this paper, we use the non-parametric approach of rank correlation, Kendall's $\hat{\tau}$[10], to test the hypothesis mentioned above. The rank correlation coefficient may be expressed as:

$$\hat{\tau} = \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{U_{ij} V_{ij}}{n(n-1)}$$

where $U_{ij}=\text{sgn}(X_j-X_i)$ and $V_{ij}=\text{sgn}(Y_j-Y_i)$. The coefficient, $\hat{\tau}$, is used to test the null hypothesis (H_0: $\hat{\tau}=0$) that X and Y are independent against one of the following alternatives: H_1: $\hat{\tau}<0$ that X and Y are inversely associated or H_1: $\hat{\tau}>0$ that they are directly associated.

Tables 2 and 3 report the results of the rankings of cross-correlations in business cycle affiliation and volatility in the exchange rate across the two periods and across two benchmark countries, together with the Kendall's $\hat{\tau}$ coefficients, where the cross-correlation of the business cycle is ranked in decreasing order while volatility in the exchange rate is reported as ranked in increasing order. There are a number of interesting results worth reporting:

As expected, all the $\hat{\tau}$ coefficients are negative, indicating that a higher degree of synchronization in business cycles is related to a lower volatility in the exchange rate. For example, the correlations of business cycle in the pairs of Canada-US, Netherlands-Germany and Austria-Germany are ranked among the highest and the volatility in exchange rates in these pairs is among the lowest, irrespective of the periods investigated.

In the pre-ERM period, the Kendall's $\hat{\tau}$ coefficient is not significantly from zero when the US business cycle and currency are used as the benchmark while $\hat{\tau}$ is statistically significant at the 10% level, although not at the 5% level, when the German cycle and currency are used as the benchmark. Given the inconsistency in the data sets used to compute X and Y, these coefficients might be read with a little caution: however, the alternative business cycles correlative ranking, based on the short sample of 1973-79 gives qualitatively the same result (see Table A, Appendix A).

In the ERM period, the inverse association between X and Y strengthens with both Kendall coefficients reduced: τ is -0.220 in the ERM period compared

with -0.131 in the pre-ERM period when the US is used as the benchmark; -0.392 compared with -0.275 when Germany is used as the benchmark. That there are two exchange rate regimes existing during this period, a quasi-fixed exchange rate bloc within the ERM countries and a floating exchange rate regime against the US dollar is indicated by the fact that the exchange rates of the ERM currencies are far less volatile against the deutsche mark than against the US dollar, while the other major currencies such as Japanese yen and pound sterling have a similar degree of volatility both against the US dollar and the deutsche mark. As a result of this, the most striking fact in Table 3 is that the rankings of the ERM countries with the US cycle are located among the bottom bloc, while those with the German cycle are among the top bloc, suggesting how business cycle affiliation has been changed during the ERM period.

It is also of interest to note that there is one "outlier" in each panel in Table 3: the Switzerland-US and Japan-Germany pairs. The business cycle in Switzerland is very much synchronized with the US cycle, but the exchange rate of the Swiss francs against the US dollar is quite volatile, which is also true for the pair Japan-Germany. When the two countries are excluded, the inverse association between X and Y strengthens even further: from $\hat{t}$=-0.220 and $\hat{t}$=-0.392 to $\hat{t}$=-0.360 and $\hat{t}$=-0.507 respectively. These "outliers" indicate that the synchronization in business cycle cannot be solely related to the exchange rate regime and that other factors (sheer coincidence aside) must play a role.

Table 2. Rankings of correlation in business cycle and volatility in exchange rate: Pre-ERM period

With the US cycle /currency					With the German cycle /currency			
Rankings in correlation		Correlation	Rankings in volatility	Volatility ($\times 10^{-2}$)	Rankings in correlation		Correlation	Rankings in volatility	Volatility ($\times 10^{-2}$)
1	Canada	.845	1 Canada	.937	1	Netherlands	.775	1 Austria	.461
2	UK	.682	2 Greece	1.309	2	Austria	.678	2 Belgium	.875
3	Spain	.633	3 Finland	1.723	3	Luxembourg	.644	2 Luxembourg	.875
4	Ireland	.582	4 UK	2.046	4	UK	.614	4 Netherlands	1.014
5	Greece	.560	5 Ireland	2.046	5	Belgium	.580	5 Norway	1.379
6	Luxembourg	.559	6 Italy	2.081	6	Japan	.494	6 Sweden	1.641
7	Portugal	.531	7 Norway	2.217	7	France	.482	7 France	1.807
8	Belgium	.526	8 Sweden	2.225	8	Ireland	.477	8 Switzerland	1.839
9	Switzerland	.515	9 Japan	2.346	9	Canada	.477	9 Finland	1.948
10	France	.512	10 Spain	2.374	10	Portugal	.470	10 Portugal	2.367
11	Japan	.454	11 France	2.378	11	US	.446	11 UK	2.541
12	Germany	.446	12 Belgium	2.418	12	Switzerland	.399	12 Ireland	2.541
13	Austria	.401	12 Luxembourg	2.418	13	Spain	.380	13 Japan	2.603
14	Italy	.368	14 Netherlands	2.440	14	Finland	.337	14 Greece	2.644
15	Netherlands	.290	15 Austria	2.575	15	Greece	.317	15 Italy	2.712
16	Finland	.213	16 Germany	2.707	16	Sweden	.267	16 US	2.903
17	Norway	.132	17 Portugal	2.947	17	Italy	.149	17 Canada	3.120
18	Sweden	-.065	18 Switzerland	2.972	18	Norway	.126	18 Spain	3.304
		$\hat{r}$=-0.131					$\hat{r}$=-0.275*		

1. Cross-correlation with the US /German business cycle is ranked in decreasing order (period: 61:1-79:3).
2. Volatility against the US /German currency is ranked in increasing order (period: 73:1-79:3).
3. '*' indicates that $\hat{r}$ is significant at the 10% level (one-sided).
4. For n=18, the 10% significance level of $\hat{r}$ is -0.242; the 5% level is -0.294 and the 1% level is -0.412 (one-sided).

Table 3. Rankings of correlation in business cycle and volatility in exchange rate: ERM period

With the US cycle /currency					With the German cycle /currency				
Rankings in correlation		Correlation	Rankings in volatility	Volatility ($\times 10^{-2}$)	Rankings in correlation		Correlation	Rankings in volatility	Volatility ($\times 10^{-2}$)
1	Canada	.890	1 Canada	1.012	1	Netherlands	.803	1 Austria	0.208
2	Switzerland	.707	2 Norway	2.427	2	Austria	.779	2 Netherlands	0.304
3	Finland	.602	3 Sweden	2.631	3	Japan	.760	3 Belgium	0.739
4	Sweden	.601	4 Greece	2.703	4	Belgium	.742	3 Luxembourg	0.739
5	UK	.592	5 Finland	2.743	5	Portugal	.654	5 France	0.762
6	Italy	.461	6 Spain	2.750	6	France	.650	6 Ireland	1.097
7	Luxembourg	.450	7 Portugal	2.790	7	Italy	.556	7 Switzerland	1.170
8	Ireland	.442	8 Ireland	2.820	8	Luxembourg	.542	8 Norway	1.266
9	Netherlands	.427	9 Italy	2.840	9	Spain	.515	9 Portugal	1.471
10	Norway	.394	10 France	2.889	10	Greece	.483	10 Italy	1.590
11	Spain	.382	11 UK	2.891	11	Norway	.374	11 Spain	1.608
12	France	.374	12 Netherlands	2.905	12	UK	.348	12 Finland	1.752
13	Greece	.354	13 Germany	2.920	13	Sweden	.165	13 Greece	1.917
14	Belgium	.286	14 Belgium	2.927	14	Switzerland	.157	14 Sweden	1.946
15	Austria	.231	14 Luxembourg	2.927	15	US	.154	15 UK	2.152
16	Japan	.182	16 Austria	2.932	16	Canada	.142	16 Japan	2.591
17	Germany	.154	17 Japan	3.028	17	Ireland	.043	17 Canada	2.883
18	Portugal	-.125	18 Switzerland	3.243	18	Finland	-.086	18 US	2.920
		$\hat{\tau}$=-0.220					$\hat{\tau}$=-0.392**		
		$\hat{\tau}$=-0.360** (Switzerland excluded)					$\hat{\tau}$=-0.507*** (Japan excluded)		

1. Cross-correlation with the US /German business cycle is ranked in decreasing order (period: 79:4-95:10).
2. Volatility against the US /German currency is ranked in increasing order (period: 79:4-95:9).
3. '***' indicates that $\hat{\tau}$ is significant at the 1% level and '**' at the 5% significance level (one-sided).
4. For n=18, the 10% significance level of $\hat{\tau}$ is -0.242; the 5% is -0.294 and the 1% is -0.412 (one-sided).

In Table 4, we report the results of a rank correlation of business cycle affiliation across periods and across different benchmark cycles. It is of importance to note that the rankings with the US cycle and than with the German cycle are independent during the pre-ERM period; while in the ERM period, they are inversely correlated at the 1% significance level, confirming more formally that low rankings of the ERM countries with the US cycle become high rankings with the German cycle. In Table 4, we further examine whether the European business cycle exists before the creation of the ERM. This hypothesis may be tested by computing the $\hat{\tau}$ coefficient between the rankings with the German cycle in the pre-ERM period and those in the ERM period: $\hat{\tau}$=0.333 (significant at the 5% level) if all countries are included and $\hat{\tau}$=0.150 if the Netherlands and Austria are excluded, suggesting that for the rest of the countries the pre-ERM business cycle rankings are independent of the ERM rankings. These findings once again clearly indicate that 1) a group-specific European business cycle for the ERM countries became detached from the US cycle and followed the German cycle more closely, and 2) that the European business cycle only emerges in the ERM period and not in the pre-ERM period.

Table 4. Rank correlation of business cycle

Rankings with the US cycle: pre-ERM Rankings with the German cycle: pre-ERM	Rankings with the US cycle: ERM period Rankings with the German cycle: ERM period
$\hat{\tau}$=0.177	$\hat{\tau}$=-0.451***
Rankings with the US cycle: pre-ERM Rankings with the US cycle: ERM period	**Rankings with the German cycle: pre-ERM Rankings with the German cycle: ERM period**
$\hat{\tau}$=0.046	$\hat{\tau}$=0.333** $\hat{\tau}$=0.150[1]

1. Netherlands and Austria are excluded from the sample.
2. '***' indicates that $\hat{\tau}$ is significant at the 1% level and '**' at the 5% significance level (one-sided).

5. Conclusions

How far is an exchange rate regime likely to affect the character of economic fluctuations in the participating economies? Standard international monetary economics suggests that a successful nominal exchange rate peg will entail the transmission of shocks from one economy to another; the peg removes a means of buffering external shocks and may require policy measures to be taken which have precisely the effect of facilitating the import of such shocks. In a hegemonic system this suggests that the smaller economies may be exposed to the business cycle generated in the leader country, whilst both may suffer from common shocks generated elsewhere. These insights underlie the literature on optimum currency areas, and have been much in evidence in the debate over the putative formation of the European Monetary Union (e.g see Tavlas (1993)).

Despite the theoretical presumption, tests of the effect of exchange rate regimes on the character of economic fluctuations have not hitherto been entirely supportive of it - perhaps partly because of the identification problem involved in the sample separation required and partly because of the difficulties that are involved in controlling for other factors that would affect the nature of economic fluctuations. These must include factors such as trade and financial integration, increases in which are generally held to predispose in favour of the emergence of linkage between countries in the evolution of their business cycles, independently of the exchange rate regime. A change in the relative size - and hence influence - of the key country's economy could also be significant[11].

In this paper we have examined the question whether the functioning of the Exchange Rate Mechanism (ERM) of the European Monetary System has produced a strengthening of the linkages between the participating economies, resulting in a dilution of the effect of the US business cycle on these economies in favour of a stronger effect from the business cycle of Germany. Dividing the sample period between a pre- and a post-ERM period, and relying upon standard measures such as contemporaneous and maximum cross correlations, it is clearly observable that the synchronicity and linkage between the ERM economies and Germany has grown strongly between the two periods whilst the linkages with the US cycle have diminished for these countries. The UK, a member of the ERM only for a short period (October 1990 - August 1992), is shown not to have significantly changed its "business cycle affiliation" - possibly a partial explanation of its withdrawal from the ERM. Ireland, also, is a partial exception to the general rule. The nominal exchange rate peg of the ERM agreement and the degree to which these arrangements were credible in the period examined appear to provide the most plausible explanation for the results we find, especially as the Nordic countries, which only adopted a peg against the ECU towards the end of sample period and were unsuccessful in sustaining it, do not exhibit the same change in business cycle affiliation.

Whilst our results seem therefore to provide strong support to the hypothesis that ERM membership has promoted a shift of business cycle affiliation to that of the anchor country of the system, some important caveats must be borne in mind. First of all, we are unable in this study to control for every factor that might be important in influencing business cycle affiliation. The position of the ERM latecomers - Spain and Portugal - might be regarded as most telling in this respect. Although both countries apparently followed informal policies prior to their formal adherence to the ERM that can be interpreted as extending their de facto period of membership of the system, even with this assistance, neither can be regarded as having belonged to the system for very long; some other factors - trade and financial integration, partly independent of ERM membership, probably assisted in their case to shift their business cycle affiliation. Moreover, the position of Japan shows that business cycle affiliations need not be associated with exchange rate fixity. A second, important qualification is this: strictly, our results do not in themselves support an unequivocal causal interpretation. Whether membership of the ERM itself produced a shift in business cycle affiliation or whether the shift in business cycle affiliation permitted sustained participation in the ERM is not settled by our findings. In assigning relative weight to these two interpretations (which, indeed, are not mutually exclusive) additional evidence, including that provided by economic theory, must be brought to bear.

July 1996

1. Because the adoption of an exchange rate regime is itself an endogenous decision, and because the widespread abandonment of the Bretton Woods system coincided with the first oil shock, Baxter and Stockman (1989) additionally examine two other episodes of change in exchange rate regime where the problem of two-way causation is less acute.

2. It is arguable that it was because the business cycle in the UK was insufficiently "European" that the UK was obliged to leave the ERM in 1992; the delinking of the British from the German business cycles is cited in Artis *et al* (1995) in this connection.

3. The series run from 61:1-95:4 for Belgium; from 61:1-95:9 for Ireland; from 61:1-95:9 for Spain; from 1968:1 to 1995:9 for Portugal; from 67:1-95:10 for Switzerland; from 62:1-95:9 for Greece and from 62:1-95:9 for Luxembourg.

4. Denmark is excluded from this study for data reasons: the available series are too short.

5. Prior to pegging to the ECU all three countries maintained a policy of targeting a basket of currencies with weights related to trade shares. In the case of Sweden the US dollar was accorded a higher weight than trade alone would have indicated, resulting in the share of non-ERM currencies in the basket accounting for about one half of the total. Whilst similar summary information is not available for the exchange rate baskets of Finland and Norway it is reasonably clear that their exchange rate policies could not be regarded as providing surrogate membership of the ERM and casual inspection of the time series of these countries' bilateral DM exchange rates shows that their behaviour is nothing like that of the "paradigm" ERM DM bilateral (see also table 3).

6. Formally, we have a sample of n pairs of correlations, (X_1, Y_1), (X_2, Y_2), ..., (X_n, Y_n), where X_i denotes the correlation between country i and the US, and Y_i denotes the correlation between country i and Germany. The sign is '+', if $X_i < Y_i$; and '-', if $X_i > Y_i$. There are two sequences of signs (+ or -) for two different de-trending methods and the results are robust across different de-trending methods if two sequences are similar.

7. The Irish industrial production series shows a definite change in smoothness before and after 1975: the series is very smooth in the pre 1975 period and becomes volatile after 1975. This is because monthly figures were not available in the earlier period and were interpolated from quarterly data. The correlation in the earlier period is certainly overestimated.

8. In predicting the latest troughs for the G-7 using a sequential probability model, Artis *et al* (1995) show that what is observed is in fact the opposite: the leading indices became more synchronised worldwide, but the business cycles themselves have shifted in phase significantly. For example, the first trough calls for the US, Canada, UK, France and Italy emerged almost simultaneously and again the second trough call for Japan, Germany, France and Italy also emerged around the same time. The latest troughs in the G-7, however, are at least two and a half years apart. It is also found in the paper that turning point prediction for the European countries has become more difficult than before and less accurate than for the non-European G-7 members. This may suggest that the behaviour of the business cycle in the 1980s and 90s has changed.

9. For good measure, in Appendix A, a tabulation of the floating exchange rate period using the business cycle correlations for the short 1973-79 period is also shown. The conclusions to be drawn are not greatly affected by the ranking used.

10. One potential advantage of this approach is that each observation is given the same weight and test results are not distorted by a small number of observations.

11. However, it does not seem plausible that it was the sheer growth in size of the German economy that accounts for our findings. For, although when valued at current exchange rates, Germany's GDP grew from less than one-seventh to over one quarter the size of US GDP between 1960 and 1991, this result is a reflection of the appreciation of the DM/US$ exchange rate; the growth in real GDP is each of the two countries was virtually identical over the period (at roughly 240%).

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Appendix A. Rank correlation for the period 73:1-79:3

Table A. Rankings of correlation in business cycle and volatility in exchange rate: Period: 73:1-79:3

With the US cycle /currency					With the German cycle /currency			
Rankings in correlation		Correlation	Rankings in volatility	Volatility ($\times 10^{-2}$)	Rankings in correlation	Correlation	Rankings in volatility	Volatility ($\times 10^{-2}$)
1	Canada	.919	1 Canada	.937	1 US	.903	1 Austria	.461
2	Germany	.903	2 Greece	1.309	2 Canada	.901	2 Belgium	.875
3	Ireland	.881	3 Finland	1.723	3 Japan	.886	2 Luxembourg	.875
4	UK	.860	4 UK	2.046	4 France	.876	4 Netherlands	1.014
5	France	.848	5 Ireland	2.046	5 Ireland	.820	5 Norway	1.379
6	Japan	.839	6 Italy	2.081	6 Belgium	.780	6 Sweden	1.641
7	Luxembourg	.745	7 Norway	2.217	7 UK	.765	7 France	1.807
8	Belgium	.712	8 Sweden	2.225	8 Netherlands	.762	8 Switzerland	1.839
9	Spain	.694	9 Japan	2.346	9 Luxembourg	.739	9 Finland	1.948
10	Austria	.684	10 Spain	2.374	10 Italy	.732	10 Portugal	2.367
11	Italy	.661	11 France	2.378	11 Spain	.718	11 UK	2.541
12	Netherlands	.654	12 Belgium	2.418	12 Austria	.711	12 Ireland	2.541
13	Greece	.560	12 Luxembourg	2.418	13 Portugal	.470	13 Japan	2.603
14	Portugal	.531	14 Netherlands	2.440	14 Switzerland	.399	14 Greece	2.644
15	Switzerland	.515	15 Austria	2.575	15 Greece	.316	15 Italy	2.712
16	Finland	.232	16 Germany	2.707	16 Finland	.295	16 US	2.903
17	Norway	.093	17 Portugal	2.947	17 Norway	.198	17 Canada	3.120
18	Sweden	-.196	18 Switzerland	2.972	18 Sweden	-.033	18 Spain	3.304
		$\hat{\tau}$=-0.131				$\hat{\tau}$=0.248* (10% significance level: 0.242)		

Rankings with the US cycle and Rankings with the German cycle: $\hat{\tau}$=0.779*** (the 1% significance level: 0.426)

1. Cross-correlation with the US /German business cycle is ranked in decreasing order.
2. Volatility against the US /German currency is ranked in increasing order.
3. '*' indicates that $\hat{\tau}$ is significant at the 10% level and '***' at the 1% significance level (one-sided).

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