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Has the Similarity of Business Cycles in Europe Increased with the Monetary Integration Process? A Use of the Classical Business Cycles

JULIEN GARNIER

BADIA FIESOLANA, SAN DOMENICO (FI)

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European University Institute
Badia Fiesolana
I-50016 San Domenico (FI)
Italy

Has the Similarity of Business Cycles in Europe Increased with the Monetary Integration Process? - A Use of the Classical Business Cycles.

Julien Garnier*

European University Institute, Florence, Italy.

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Abstract

We investigate to what extent the business cycles in Europe have become more synchronised since the sixties, using the classical business cycles framework. Four Bry & Boschan-like procedures for dating the turning points are compared. It is found that the cycles across countries have become more idiosyncratic through time, but this is less obvious for the countries of the Euro area. It is also found that the European cycles are increasingly independent from the US cycles. The main conclusion is the existence of a core group within the Euro area with more strongly linked cycles.

Keywords: classical cycles, turning points algorithms, comovements.

JEL codes: E32, F15.

1 Introduction

This paper is based on the classical business cycle framework. Its aim is to see whether the creation of the European Monetary System has been correlated with a greater similarity of the business

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cycles across Europe. In other words, the question I will try to answer is: has the nature of the business cycles been modified from the *pre* to the *post* EMS period, and have those cycles become more similar ? This is an important question since the homogeneity of the cycles may be seen as one of the requirements for the 'Euro monetary zone': this work can be directly related to the more general debate of the Optimal Currency Areas (OCA) and to the Lucas critique. If it is found that the business cycles in the European Union are homogenous on the whole period, this would tend to show that the EU is *intrinsically* an OCA. Inversely, we might find that the business cycles exhibit no homogeneity at all, and consequently that the EU is not an optimal monetary zone. If it is found that the cycles have become more similar through time, this would tend to suggest that the monetary integration process has had some influence on the homogenisation of the business cycles. The implication would be that this process increases in itself the probability of being an OCA.

The classical business cycle approach deals with the cycles in levels. We are required to find the turning points (henceforth TPs) first. We will denote the peaks by P and the troughs by T. For the US, this is quite simple as they are published by the NBER. They are often regarded as the 'official' turning points. No such dating is available for the other countries. Therefore, a computing method that automatically finds such dates is greatly needed. The Bry & Boschan algorithm (BB) is a practical tool for this purpose. Its basic rule is that a point in t is a turning point if it is the highest/lowest point within a period of $t \pm n$. We will use here a modified version of the procedure used in the article of Artis, Kontolemis & Osborn (1997, henceforth *AKO*), inspired by the BB algorithm. All these procedures are univariate applications. We will see below that this fact can be problematic.

Once the turning points have been found, it is possible to compute the phases of the series, i.e. the expansions (T-P) and the recessions (P-T), and to start studying the evolution of the cycles. The approach used is non-parametric and based on descriptive methods. At first, we will look at the shapes of the cycles and see if they have become more similar through time. Subsequently, the *timing* of the cycles will be considered. The idea is to see how the expansion/recession phases are coordinated across countries.

The series used for this study is the seasonally adjusted index of industrial production, provided by the OECD. The data set comprises 18 countries and the sample starts in January 1962 and ends January 2001. The panel is composed of the 12 Euro countries minus Ireland[1], three countries that

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[1] That is: Austria, Belgium, Finland, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal and

belong to the EU but not to the Euro (Denmark, Sweden and the UK), two European countries outside the EU (Norway and Switzerland) and two 'external' countries (Japan and the US). This division of the panel into different areas should make it easier to evaluate the influence of the monetary integration. One might believe that if this influence exists, it should be more important for the Euro group than for the external countries. Of course, if this classification is clearer, it is also wrong. Half of the Euro countries did not belong to the EEC at the beginning of the sample and most of them only entered in the second period (Greece in 1979, Spain and Portugal in 1986, Austria and Finland in 1995). The positive aspect of this is that if the monetary integration has some influence on the business cycles, we should find weaker results for the 'latecomers'. In the following, we will make a distinction between countries that belong to the EEC from the beginning of the sample (the former Federal Republic of Germany –FRG–, France, Italy, Belgium, the Netherlands and Luxembourg) and the others.

To assess the evolution of the cycles, the sample will be divided in two sub-samples, before and after March 1979. This date corresponds to the creation of the European Monetary System (EMS) and of the Exchange Rate Mechanism (ERM), which is the first[2] real attempt to create an explicit monetary system at the European level. This date can be seen as the starting point of the monetary integration.

The classical business cycle framework, initiated by the empirical work of Burns & Mitchell (1946), has recently been the subject of a revival of interest following the articles of Harding and Pagan (1999, 2000a, 2000b, 2001). The methodology adopted here is based on AKO, with the period of analysis updated to January 2001. As Harding & Pagan point out, the advantage of using the classical cycles approach is the freedom from arbitrary assumptions about the trend. Indeed, one of the problems of the 'detrending' (or 'filtering') techniques is that their results differ from one other (Canova, 1998). In particular, it has been argued that ad-hoc filters could create spurious cycles[3]. Here, the method does not remove any trend as it deals with cycles in levels. The next part is dedicated to the exposition of the procedure used to delimit those classical cycles. The procedure

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Spain. Concerning Ireland, the shape of the time series of its industrial production makes it difficult to find turning points in it. It is generally agreed in the business cycle literature (e.g. Harding & Pagan, 2001) that in some cases, it would be more useful to study the growth cycle.

[2] In fact, the 'European Snake', created in 1972, was already an attempt to create a certain homogeneity among the currencies of the European countries, but it had in fact been created in the context of the Bretton-Woods system.

[3] King & Rebelo (1993), Osborn (1995) or Harvey & Jaeger (1993) provide such results for the Hodrick-Prescott filter. A good overview of the problem can be found in Guay & St Amand (1997).

is also compared to other dating methods. In the third part, we use the type of plots presented by Burns and Mitchell (1946). These plots display the average cycles of the series considered. A more recent utilisation of this technique can be found for example in King & Plosser (1994) and Simkins (1994). The former article observes the behaviour of six US macroeconomic time series, and the latter checks the cyclical behaviour of the Kydland & Prescott model. The fourth part investigates the evolution of the *timing* of the cycles, and the last part concludes.

2 Finding turning points

2.1 Description of the procedure

The procedure[4] used here aims at replicating the BB-like procedures and in particular the one by AKO. We will try to show in the following part that our simplified version of the latter might be as efficient as the other procedures in capturing the turning points in an industrial production index series.

The algorithm proceeds in four main steps (see the appendix for details). The first one determines the outliers, i.e. the points x_t such that : $\Delta x_t \geq 3.5\sigma$, where Δ is the difference operator and σ is the standard deviation of x_t. These outliers are replaced by the average of the two adjacent observations[5]. Step 2 finds the turning points in a 12-month moving average. The smoothing allows to get rid of the idiosyncratic fluctuations that could modify the results. Step 3 uses first the unsmoothed series to find the turning points. The short cycles (less than 15 months from peak to peak or trough to trough) are then identified and eliminated, by keeping the highest (lowest) of the two peaks (troughs). Finally, each phase (P-T of T-P) is required to have an amplitude of at least one standard error of the series considered. When the procedure meets a phase of low amplitude, it eliminates its last turning point and keeps the first. I have followed Harding & Pagan and Watson's programs on this point. The last step compares the dates found in step 2 (smoothed series) and step 3 (raw series) and states the final set of turning points.

There are several differences between the AKO procedure and the one used here. The main one is the identification of flat segments (in step 3 of AKO) has been suppressed here. There are two reasons for this. First, it is not really justified nor explained by the authors. Second, I conjecture

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[4] The codes, written under GAUSS, are available upon request.

[5] Mark Watson uses the value given by the Spencer curve for that observation. I suspect that the difference between the two corrected values should be marginal.

that this is not necessary, because of the requirement, in step 3 of the procedure used here, that each phase should have an amplitude of one standard error. This should produce the same result. Another difference is that the enforcement of alternation has been placed at the end (step 4a), whereas it was used twice in the AKO procedure. Note that I had followed the AKO procedure on this point at the beginning, but the results were exactly the same as the ones presented here.

2.2 Results

Summary of the results for the turning points dating

Number of TPs found by ECRI*	67
Number of TPs found here**	162 (87)
Number of TPs found by BBW**	217 (116)
Proportion of ECRI dates captured by BBJG***	0.492
Proportion of ECRI dates captured by BBW***	0.597
Proportion of BBJG TPs well-identified***	0.379
Proportion of BBW TPs well-identified***	0.345
Total number of TPs in common between BBJG and BBW	148
Proportion of TPs of BBJG found by BBW	0.886
Proportion of TPs of BBJW found by BBJG	0.682

nb: the TPs found by AKO are not reported because their sample is shorter.
BBJG : procedure used here. *BBW* : BB proc written by Watson (1991)
* for 9 countries
** for 18 countries. In parentheses : for the 9 countries of the ECRI
*** a date is well identified if it is not distant by more than one term from the ECRI one.

The results are shown in the table above and in appendix B. We make a comparison with the dates found by the BB procedure of Mark Watson and –when available– with those published by the ECRI[6]. As the ECRI uses the same approach as the NBER, we can use it as a good benchmark to assess the other dating procedures. When there is a correspondence, the dates found by AKO are shown as well.

The turning point dates differ from those found by AKO, although the source of the data is the same (OECD). There are great differences from one country to another. For some of them, the

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[6] Economic Cycles Research Institute (www.businesscycles.com). This is a private organisation working on the analysis and the forecast of business cycles. To my knowledge, this is the only publicly available alternative to the NBER for dating (classical) business cycles. Note that the OECD publishes also TP dates, but based on the PAT method, which is closer to the growth cycles than the classical cycles framework.

results are similar (Germany, Italy, Luxembourg, the Netherlands, the UK, Japan, the US[7]), and for others they are quite different (Spain, Belgium). The origin of these differences might be twofold. *First*, there can be differences in the dataset. I have used my procedure with the dataset of AKO. The turning points were still divergent. The fact that the sample periods are not the same for the two datasets[8] could explain some of the differences for the early nineties. That is, the procedure keeps the highest (lowest) of two consecutive peaks (or troughs), because of the alternation (P-T-P...) requirement. For example, if the last turning point is a trough, we might find another trough immediately after if the sample was extended. If one states that it is lower than the last 'in-sample' one, then it would be selected at the expense of the previous one. Data revision has also occurred for some countries. To verify this, I have plotted for each country the series from the two datasets[9]. *Second*, the differences in the dates can be due to differences in the procedures themselves (see paragraph above). I have taken the same dataset as AKO with the two procedures. Some differences remain. Nevertheless, similar dates are found for most of the countries.

The table above reveals that most of the TP dates found here are also identified by BBW but the latter finds more dates than those found in our procedure. Supposing that the TPs in common correspond to actual TPs, we can say that either our procedure does not capture enough dates, or BBW captures too many of them. For some countries (e.g. Switzerland) the dates are quite similar between our procedure and the BBW, but completely different with the dates of the ECRI. For a country like the UK, the BB-like procedures identify almost all the dates of the ECRI, but they also find more dates. In general, the BB procedures find more dates than the ECRI (73% more for the BB procedure of Watson and 29% more for the one used here), which suggests that the BB procedures overidentify the TPs.

We see that only half of the 'true' turning points are captured by the procedures. Besides, about one third of the TPs found are 'true' ones. This is a poor result at first sight, but one has to keep in mind that the ECRI (and the NBER) have a global view of the economy[10], whereas the BB procedures used here are only univariate. This points out that one has to be careful in the

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[7] One date is different from the AKO. I have found a peak in May 1979 and AKO in March 1980. But it can be seen that some data revision seems to have as occured and that May 1979 is actually higher than March 1980 in data used here (which was not the case in the dataset used by AKO).

[8] 1961:1 - 1993:12 for Artis et al. (1997), and 1962:1-2001:1 here

[9] These graphs are not reported here but are available on request.

[10] The ECRI uses several macro series (essentially output, income, employment and sales). For each of them, the Bry and Boschan procedure is computed and the final turning points are chosen on *"the basis of the best consensus"* among the different series.

interpretation of the results. The fact that the algorithms of the BB-type extensively use the rule of the highest/lowest points (e.g. if there is a choice between two peaks, the highest one will be selected), implies that the turning points do not necessarily coincide; in other words, the highest/lowest of two points may not necessarily be the same for the industrial production and the GDP series, even if the occurrence in time of a particular event is exactly the same. Making the assumption that the algorithms are not ill-defined and that it is not incorrect to apply BB-type procedures onto industrial production series, we can say that our procedure does a slightly better job than BBW. It is true that BBW captures more 'true' TPs than our procedure, but at the same time the total number of TPs identified is much higher. At the limit, a procedure that would capture *every* date of the sample would also capture all the true dates. It is more interesting to look at the proportion of true TPs amongst the ones identified by the procedure. This proportion is greater (37.9%) for our procedure than for BBW (34.5%) . For this reason, we will prefer our procedure for the remaining part of this paper.

3 Comparisons of cycles based on their shapes

We use here the type of plots used by Burns and Mitchell (1946) and also by King & Plosser (1994) and Simkins (1994). The idea is to make a representation of the typical classical cycle of a series. For one particular country, each phase (delimited by two turning points, P-T or T-P) is divided into four sub-periods and the average growth rate and duration of these sub-periods are taken[11]. The average expansion and recession phases are finally put together in order to make the graph. The graph has the form Trough-Peak-Trough.

For the first and last sub-periods, we take three months after the first turning points and three month before the second. The time in between is divided in two equal parts.

To avoid the bias that could result from the idiosyncratic movements and from the small number of elements included in the average, each series has been smoothed by a moving-average. A centred MA(7) has been arbitrarily taken. This choice is motivated by two reasons. First, each point must not capture too much information from the past and future observations. That is, the elements of one sub-period should not be substantially influenced by the elements of the adjacent sub-periods. Second, excessive idiosyncratic movements must be smoothed sufficiently. As a centred MA(7) takes the information one term before and one term after t, it seemed a good compromise between those

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[11]

two points.

The results of these graphs are shown in the appendix C. Note that some countries are absent. This was the case when there was not enough turning points (less than three) in the period considered. The sample has been divided in two in March 1979 (date of the creation of the ERM). If the monetary integration has had an influence in the second period, one should find a greater homogeneity in the shapes of the cycles within the group of countries that have moved towards this integration. Another possibility is that if the Euro area is intrinsically an OCA, the shapes of the cycles should be similar before and after 1979. Under this hypothesis, there should be differences between the shapes of the countries belonging to the OCA and those of the other countries. Of course, it is also possible that no clear pattern appears from the plots.

On overall, one has the impression that the shapes are more homogenous in the first period than in the second. However, if we look more specifically at the Euro group, the first period shows no clear pattern. The second period is more instructive. The Euro countries are increasingly similar. If one looks at the expansion periods, two ('Euro') groups appear. The first, for which the expansion period is slightly slower at the beginning than at the end of the phase, is composed of Austria, Italy, Luxembourg and Germany. The result is less clear for France, Greece and Portugal, which exhibit an almost linear expansion period. In the second group, we find the opposite pattern, with a stronger growth first. This is the case of Belgium, the Netherlands and Spain. It is interesting to note that a strong growth that slows at the end is also a characteristic of the US expansion phase and is a result often found in the literature. Furthermore, many 'non-Euro' countries have a shape similar to the one of the US. This is the case for Denmark, Sweden, Switzerland and Japan.

The recessions do not provide much information for no pattern can be seen: their shapes differ too much from one country to the other, and at the same time, their duration is about the same for most of the countries of the panel, around 20 months (between 15 and 40 months).

One should be aware of the limitations of this approach. The averages are calculated with very few elements and some strange behaviours can be observed[12]. This reminds us that we should be very careful in the interpretation. At best, these graphs can reinforce our intuition, but they are not sufficient.

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[12] Belgium in the first period for example. This is due to the fact that a phase is strictly defined as a period between two TPs, such that the period before the first turning point cannot be taken into account. For Belgium, the period of stagnation –observed on the stylised plot– is in fact preceded by a period of growth of six years, such that in reality, the pre-EMS period for this country is characterized by an increase of industrial output and not by stagnation.

It seems that a Euro pattern has appeared among a core group. At the same time, the countries that are not exhibiting this pattern seem to have a cycle more similar to the US one. However, such conclusions are tempered by the fact that many countries show strange behaviours, because of the small number of phases that enter into the calculations and also because of the missing values at the extremities of the samples. We have now to go beyond those first impressions. We will see whether they are confirmed by more precise measurement of the *timing* of the cycles.

4 Comparisons of cycles based on time synchronization

We study in this section the comovements of the cycles from one country to another and we see whether the European countries have become more synchronised or not. To see this, we will take two countries as references, the US and Germany, in the same spirit as Artis & Zhang (1996). The assumption is made that this latter country leads the European economy and that if a European cycle exists, it should be affiliated to the German cycle.

Two methods are computed to evaluate the comovements. Each one considers two series at a time and tries to see if they are independent. Two steps are needed for the second one, but it has the advantage of being always computable, which is not the case of the first method.

In order to capture the information from the periods *before* the first and *after* the last turning points, a procedure has been added here: if the first point of the sample is higher (/lower) than the first turning point and if this one is a trough (/peak), the procedure creates an 'artificial' peak (/trough) at the first observation. The equivalent is done at the end of the sample. This procedure has been essentially designed to take into consideration the two periods of expansions, in the early 60s and in the 90s, situated at the extremities of the sample. They would be eliminated otherwise and the results would be biased. Note that this procedure could obviously not be applied in the study of the shapes above.

4.1 Pearson's coefficient:

- Methodology :

This coefficient is given by the formula :

$$CC = \sqrt{\frac{\chi^2}{N + \chi^2}} \tag{1}$$

with,

$$\chi^2 = \sum_{i=0}^{1}\sum_{j=0}^{1} \frac{[n_{ij} - n_i.n._j/N]^2}{n_i.n._j/N} \tag{2}$$

Where n_{ij} is the number of periods where the states i and j occur at the same time, 0 denotes the periods of recessions and 1 those of expansions.

		Country k		
		Expansion	Recession	Subtotal
	Expansion	n$_{ee}$	n$_{er}$	n$_{e.}$
US or Germany	Recession	n$_{re}$	n$_{rr}$	n$_{r.}$
	Subtotal	n$_{.e}$	n$_{.r}$	N

As in Artis et al. (1997), we also compute the *corrected* coefficient. The reason is that the Pearson's coefficient is designed for continuous data. For finite dimensions, the coefficient is bounded above and is biased from its true value. This limit is proportional to the dimension of the table. Here, only two variables are considered. Therefore, the bias might be quite high. As the limit of the coefficient for such a dimension is $\sqrt{1/2}$, the corrected coefficient is given by:

$$CC_{cor} = \frac{CC}{\sqrt{1/2}}$$

We can observe that some values are missing in the tables of Pearson's coefficient (see the appendix for detailed results). This happens with small sub-samples when all the possible cases are not present. For example, if a country experienced no recession during the period studied, the number $n_{r.}$ (see table above) must be null too (e.g. the expansion period of the US after March 1991). By (2), this is impossible.

- Some results :

The tables below show the corrected Pearson's coefficients for all the countries with Germany and the US. The figures 1 and 2, more explicit, show the same results.

Note that the coefficient between Germany and the US has declined between the two periods. This might constitute a first argument towards the autonomy of the European cycle. The coefficient goes from 0.54 in the first period, to 0.34 in the second.

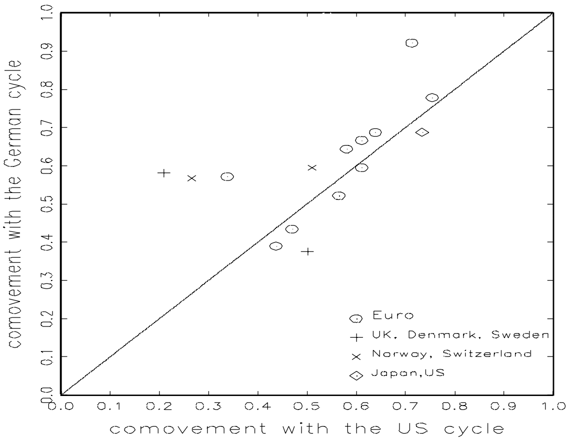

Figure 1: Pearson's corrected coefficient - First period (1962 - 1979)

	First period		*Second period*	
	Ge	US	*Ge*	US
Au	0.6872	0.6387	0.8978	0.3511
Be	0.9211	0.7131	0.3666	0.2475
Fi	0.6661	0.6106	0.1236	0.4501
Fr	0.5949	0.6106	0.8551	0.2902
Ge	0.9913	0.5409	1	0.275
Gr	0.4342	0.4697	0.8417	0.2816
It	0.3896	0.4369	0.2925	0.5241
Lux	0.5712	0.3381	0.444	0.1616
Net	0.6438	0.5801	0.4121	0.0758
Po	0.778	0.7544	0.4659	0.1009
Sp	0.5216	0.5647	0.1048	0.1507
De	0	0	0.362	0.3211
Swe	0.3749	0.501	0.0764	0.135
UK	0.5814	0.2086	0.445	0.1523
No	0.5949	0.5104	0.7714	0.6061
Swi	0.568	0.2655	0.4011	0.5542
Ja	0.6872	0.734	0.3488	0.1424
US	0.4654	0.9903	0.3394	1

Pearson's corrected coefficient

In the first period, most of the countries are grouped around the 45° line, whereas there is a

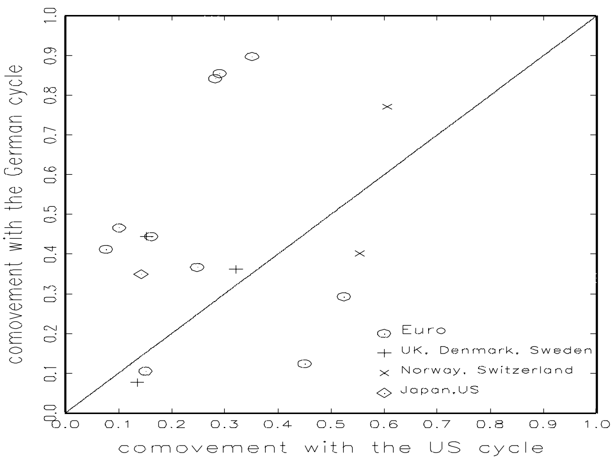

Figure 2: Pearson's corrected coefficient - Second period (1979 - 2001)

strong movement towards the German cycle in the second. The case of France is quite representative. In the first period, its coefficient is higher with the US than with Germany, but the difference is small (0.59 against 0.61). In the second, it is much more correlated with the German cycle. The fact that three countries of the Euro group are more synchronous to the US cycle suggests the existence of two groups within the Euro area. Those countries are Finland, Italy and Luxembourg. There is a possibility that the countries which are not under the influence of Germany can be 'caught' by the American cycle.

If we look at the Euro countries that are *above* the line, we see that the level of the coefficients *vis-à-vis* the German cycle decreases between the two periods (0.68 to 0.6 on average). But at the same time, the coefficient with the US decreases more in the second period for these countries (0.58 to 0.21). Therefore, it seems that the 'core' Euro countries have a greater independence towards the US cycle, but that the links within the group have not necessarily been reinforced.

The 'EU-non-Euro' countries are also interesting : the UK is more correlated with Germany in both periods , unlike Sweden, which has a higher coefficient with the US (the Denmark coefficient cannot be calculated in the first period because only one turning point was captured).

Note the place of Japan, which has been taken as a control country. Its coefficient against Germany and the US is the same in the first period. In the second period it is more correlated with the German than the US cycle. This result it quite surprising as the Japanese economy is rather closed, and it exchanges more with the Asian countries and with the US than with Western Europe. Such a result seems to be the fact of coincidence and points out a weakness of this approach: the number of observations is too small to allow general statements about the European cycles.

The fact that the Pearson's coefficient cannot be computed in some cases limits its impact. We will see next the Harding & Pagan concordance that has the advantage of being always computable.

4.2 Harding & Pagan's concordance

- Methodology :

The formula for this index is:

$$I_{jr} = \frac{1}{T}[\#(S_{jt} = 1, S_{kt} = 1)] + \frac{1}{T}[\#(S_{jt} = 0, S_{kt} = 0)]$$

$$= \frac{1}{T}\left\{\sum [S_{jt}S_{kt} + (1 - S_{kt})(1 - S_{kt})]\right\} \tag{3}$$

Where T is the sample size, S_{it} is a dummy variable taking the value 1 if the series is in an expansion phase and zero if it is in a recession phase, for the country i at time t and k represents the US or Germany. The index shows how the specific variable j behaves in relation to the reference series, k. If the index is one, it is exactly pro-cyclical. Conversely, if it is null, the index indicates a counter-cyclical series.

If the two series are statistically independent, the expected index is equal to the probability that the series happen to be in the same phase at a given time t :

$$E[I_{jkt}] = E[S_{jt}]E[S_{kt}] + (1 - E[S_{jt}])(1 - E[S_{kt}]) \tag{4}$$

Each expectation can be measured by the number of time units where the state occurs, divided by T. It is then easy to compare the *concordance* index and the *expected* index. If the former is higher than the latter, it can be said that there is a link between the cycles, because the number of periods where the series are in the same phases is higher than if the series were totally independent. Conversely, if the ratio between the two is less than one, we can suppose that there is a counter-cyclical relation between the two series. Of course, we cannot say anything about the level of this ratio, and it would be better to derive some test to see if the ratio is significantly different from one. This is the subject of the next paragraph. The aim here is simply to make a comparison between the ratio obtained with the US and with German series. The idea is to check whether European integration has led the European countries to a greater synchronisation with Germany than with the US. If we find that the series are more dependent from the former than from the latter, we could effectively suspect a relation between the implementation of the EEC / EU and the synchronisation of the cycle.

- Some results :

As before, we only give here the coefficient between the US, Germany and the other countries. All the other results are given in the appendix.

	First period		*Second period*	
	Ge	US	*Ge*	US
Au	1.1827	1.1319	1.6897	1.1816
Be	1.4822	1.3696	1.2673	0.824
Fi	1.1689	1.1181	1.0329	1.0992
Fr	1.1282	1.1181	1.4673	1.1095
Ge	1.5392	1.2063	1.7128	1.1163
Gr	1.0627	1.0644	1.7187	1.1832
It	1.1041	1.1115	1.1556	1.2429
Lux	1.2886	1.1471	1.29	0.914
Net	1.1552	1.1045	1.2838	0.9557
Po	1.2537	1.2028	1.1986	0.9672
Sp	1.1307	1.1357	1.0201	0.9773
De	0	0	1.1459	0.8969
Swe	1.1249	1.1491	0.9583	1.0617
UK	1.251	1.0743	1.3034	0.9109
No	1.1282	1.0776	1.6216	1.4657
Swi	1.1493	1.0504	0.7483	0.6928
Ja	1.1827	1.1883	1.1896	0.9375
US	1.1768	1.4727	1.1392	1.4885

(5)

Harding and Pagan's ratio

The ratio between the US and Germany goes from 1.2063 in the first period to 1.1163 in the second. This confirms what we had seen in the previous part. The German economy is more independent from the US in the second period.

Alike the previous part, we see on figures 3 and 4 the general movement of the Euro countries towards Germany in the second period. Note that the scale of these plots should not be compared

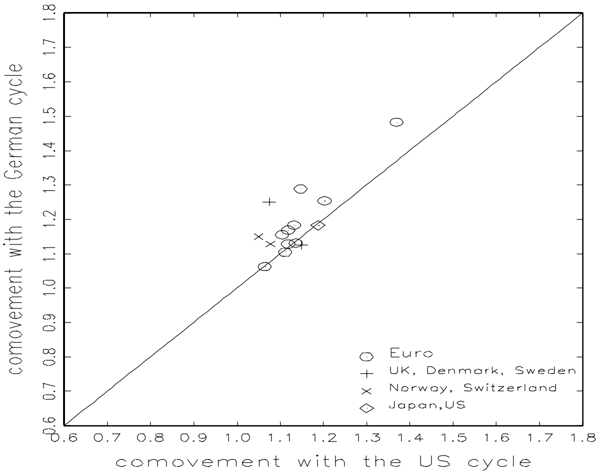

Figure 3: Concordance index - First period (1962 - 1979)

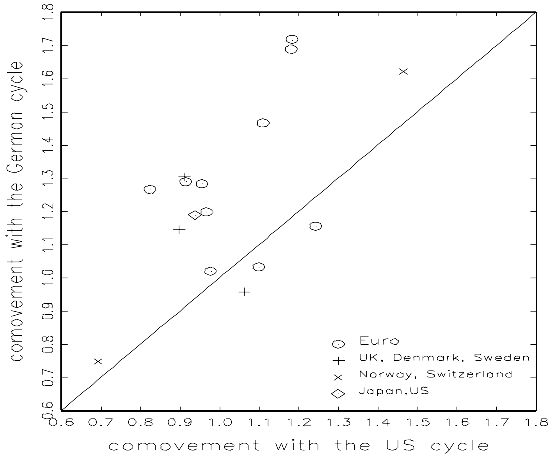

Figure 4: Concordance index - Second period (1979 - 2001)

to the previous ones. As before, two Euro countries are more correlated with the US than with Germany: Finland and Italy. Note once again the place of Japan, which is closer to the German than the US cycle.

If we look at the ratios of the Euro countries, the average comovements with Germany is 1.23 whereas it is 1.15 for the US in the first period. In the second period, the ratio increase to 1.35 for the former and decreases to 1.05 for the latter. This suggests that the dependence with the US cycle has decreased, whereas it has increased *vis-à-vis* the German cycle. If one looks at the average comovements for the group of European countries that do not belong to the monetary system, the figure with respect to Germany is stable (1.16 to 1.15) whereas is decreases with respect to the US (1.09 to 1.00). Therefore, it seems that the European cycles have acquired more independence towards the US, while gaining in coherence. The fact that greater trade and financial flows have been experienced since 1979 reinforces the impression that one might get from such a result.

4.3 Attempt to test the concordance (Harding & Pagan 2000a)

4.3.1 Testing the independence between the phases of two series

The measures of comovement we have seen above have the disadvantage of not being meaningful *alone*. One needs to do comparisons, as we did here with Germany and the US as benchmarks. What would be helpful at this stage of the study would be a test that would tell us whether or not there is actually a relation between the phases. Consequently, we will try in this section to implement such a test. This was suggested by Harding & Pagan (2000a, p.11). The idea is to take a binary variable representing the phases of a series (expansion/recession) and to regress it on another variable of the same type. The null hypothesis is that the coefficient linking them is zero.

To see why this test is consistent with the approach of Harding & Pagan, consider the following. Equation 3 can be rewritten as :

$$\hat{I} = \frac{1}{T}\left\{2\sum_{t=1}^{T} S_{jt}S_{kt} + T - \sum_{t=1}^{T} S_{jt} - \sum_{t=1}^{T} S_{kt})]\right\} \tag{6}$$

Similarly, equation 4 becomes :

$$\begin{aligned} E[I_{jk}] &= 2E[S_{jt}]E[S_{kt}] + 1 - E[S_{kt}] - E[S_{kt}] \\ &= 2\hat{\mu}_j\hat{\mu}_k + 1 - \hat{\mu}_j - \hat{\mu}_k \end{aligned} \tag{7}$$

for the sample considered.

As we have seen above, (6) and (7) are equal if the two series are perfectly independent. So the *mean corrected* concordance equals zero under the null of independence, and is :

$$\begin{aligned} \hat{I}_{mc} &= \frac{1}{T}\left\{2\sum_{t=1}^{T} S_{jt}S_{kt} + T - \sum_{t=1}^{T} S_{jt} - \sum_{t=1}^{T} S_{kt}\right\} - (2\hat{\mu}_j\hat{\mu}_k + 1 - \hat{\mu}_j - \hat{\mu}_k) \\ &= \frac{2}{T}\sum_{t=1}^{T} S_{jt}S_{kt} - 2\hat{\mu}_j\hat{\mu}_k \\ &= \frac{2}{T}\sum_{t=1}^{T}(S_{jt} - \hat{\mu}_j)(S_{kt} - \hat{\mu}_k) \end{aligned} \tag{8}$$

This last equation is proportional to the estimated OLS coefficient $\hat{\beta}$ in the regression of $(S_{jt} - \hat{\mu}_j)$ against $(S_{kt} - \hat{\mu}_k)$. See the appendix. In other words, regressing the first series on the second, provided that both of them are centred around their mean, would be sufficient to implement a test that would be consistent with the approach of the two authors.

The problem is that it is highly probable to find serial correlation in the series under study. In such a case, a simple t-ratio test cannot be done and one needs to compute instead t-ratios that are robust to serial correlation.

4.3.2 Computing covariance matrices

Many methods exist to correct the problem of autocorrelation (and heteroscedasticity), e.g. maximum likelihood estimation, Feasible Generalised Least Squares or GMM. We will not use them because they require some information about the structure of the covariance, which is not available here. Moreover, in this particular test, the OLS method has to be used for the estimation of β. In that case, the solution is to find an estimator of the appropriate asymptotic covariance matrix. The Newey-West estimators for autocorrelation is the most commonly used tool to compute the robust covariance matrix of $\hat{\beta}$.

Some more recent techniques allow to estimate covariance matrices that are robust to serial correlation and heteroscedasticity at the same time. We will use here one of them, provided by Den Haan[13] for the article of Den Haan & Levin (2000). The idea in this kind of articles is to pre-whithen the errors before computing the covariance matrices. As we have just said above, the problem is that the number of lags have to be determined first. In general, one uses a first order VAR. The procedure of Den Haan & Levin estimates a specific lag for each independent variable, using the Akaike's and Schwarz's information criteria.

4.3.3 Results

The results of the 324 tests[14] are given in the appendix. Note that the null hypothesis is rejected very scarcely, which suggests that the test suffers from a low power. A first result is that the proportion of rejection is higher in the Euro area than elsewhere. Surprisingly, there is more rejection in the first period than in the second. For example, in the Euro area the null of no link is rejected 22.7% of the time (25 rejections for 110 tests) whereas in the second period, the proportion falls to 13.6%. But at the same time, the decrease in the number of rejections for the tests involving non-Euro

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[13] http://weber.ucsd.edu/~wdenhaan

[14] The procedure of Den Haan allows to chose between the Schwartz criterion and the AIC. As these two were giving exactly the same results, the tests reported have been done with one of them only (AIC).

countries is even more accentuated: from 10.2% in the first period to 2.6%. That is, H_0 is rejected 2.2 times more often for the Euro group compared to the other countries in the first period and 5.3 times more often in the second.

Looking more in details within the Euro group, we see that a ‘core’ group appears once again. In other words, there is more often a link statistically significant in a ‘core’ group composed of Austria[15], Luxembourg, France, Germany, and the Netherlands. The proportion of rejection for the tests involving only countries of this ‘core’ group falls from 0.7 (14 rejections out of 20 tests) in the first period, to 0.55 in the second period. This decline shall not hide the fact that the level of rejection is much higher for this small group of countries than in the rest of the Euro group and *a fortiori* than in the rest of the panel.

Regarding these figures, everything looks as if the business cycles had become more idiosyncratic across countries, but that this phenomenon was less accentuated within the Euro area. In that case, we could say that the monetary integration has helped creating *some* links between the member countries compared to elsewhere. However, the effect may be too weak to allow any conclusion about the relation between integration and comovements.

It should be noted that the rejection/non-rejection of the hypothesis itself does not give all the information about the dependence relations between two cycles. The non-rejection of the null does not necessarily means its *acceptance*, and it does not inevitably imply that the two series are actually independent. It is still possible that the true distribution of the t-ratios is different from the t-distribution on which the test is based. In other words, we do not have information about Type II errors.

5 Conclusion

- The study suggests, while comparing the period before the creation of the EMS (1962-1979) and the one after (1979-2001), that the cycles have become more idiosyncratic internationally. But at the same time, this phenomenon is less accentuated for the Euro group. Moreover, within it, a smaller group shows some indices of increased business cycles synchronisation. A general conclusion would be that the monetary integration process has been correlated with stronger business cycles links, but only for the countries mostly involved in this process.

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[15] This country is a ‘latecomer’ and appears certainly because of its traditional economical links with Germany than because of the creation of the EMS.

This *core group* of countries is composed of: Austria, France, Germany, Luxembourg and the Netherlands. The other Euro countries have more heterogenous cycles (in particular Spain, Belgium and Greece).

- Concerning the shapes of the cycles no real similarity could be observed between the Euro countries during the first period. Yet in the second period, a greater homogeneity in the shapes of the cycles was present, in particular for Austria, Germany, Italy and Luxembourg. The results for France, Greece and Portugal are less clear.

- The study of time synchronization for the Euro countries has shown that the comovements with the German cycles have decreased (Pearson's coefficient) or increased (Concordance) in the second period. This result seems contradictory but recall that the comovements with the US decrease even more, such that for the two method there is more synchronization towards the German cycle. Only three countries (Finland, Italy and Luxembourg) were more synchronised in the second period with the US cycle than with the German one. No clear results were observed for the other countries.

- A robust t-ratio test of the dependence between the cycles has also been conducted. It confirms somehow the result of the Pearson's coefficient in the previous part: a) more rejection of the null of independence is observed within the Euro group, but b) the hypothesis is rejected less often in the second period than in the first.

- To answer the question raised in the introduction about the optimal currency area, the cycles of the Euro countries have followed the general movements trough time towards more independence, which suggests that the Euro area is not intrinsically an OCA. At the same time, this movement was less important in the Euro group. Besides, as a kernel of more strongly linked countries appears within it, we can suggest that the Euro area might become an OCA in the future. From this point of view, future studies including the launching of the single currency should give us more insight.

These results should not hide several methodological limitations. In particular concerning the dating procedure. The fact that different dates from those published by the ECRI have been found questions the ability of univariate applications to capture the overall business cycle dates. Talking about the *business* cycles here is perhaps a bit excessive, and it would be better to simply talk about the cycles of the *industrial sector*. There is a close correspondence between the two in many cases, but this is not enough to generalise the results.

A second problem is directly linked to the previous one and is more general. If the dates vary from one procedure to the other whereas the dating for the US are quite similar, this should tend to confirm the idea exposed by Hamilton (2001) that such algorithms can not be generalised to any other country. The BB procedure has been designed to reproduce the NBER dating process for the US turning points. The modified versions of this procedure (including the one used here) reach this goal as well. But the apparent sensitivity of the results to the method used for the other countries questions our ability to apply the BB procedure everywhere.

This gives us some perspective for future work. First, it might be of some interest to develop a procedure for a *vector* of variables. Second, the approach used here only describes what is happening, and it seems that one cannot go much beyond that with such methods. A proper econometric model would be needed, such as Markov Switching.

Appendices

A Description of the dating procedures

A.1 Bry & Boschan (1971)

1. Determination of extremes and substitution of values.
2. Determination of cycles in 12-month moving average (extremes replaced).
    (a) Identification of points higher (or lower) than 5 months on either side.
    (b) Enforcement of alternation of turns by selecting highest of multiple peaks (or lowest of multiple troughs).
3. Determination of corresponding turns in the Spencer curve (extremes replaced).
    (a) Identification of highest (or lowest) value within ± 5 months of selected turns in 12-months moving average.
    (b) Enforcement of minimum cycle of duration of 15 months by eliminating lower peaks and higher troughs of shorter cycles.
4. Determination of corresponding turns in short-term moving average of 3 to 6 months, depending on MCD (months of cyclical dominance.
    (a) Identification of highest (or lowest) value within ± 5 months of selected turns in Spencer curve.
5. Determination of turning points in unsmoothed series.
    (a) Identification of highest (or lowest) value within ± 4 months, or MCD term, whichever is larger, of selected turn in short-term moving average.
    (b) Elimination of turns within 6 months of beginning and end of series.
    (c) Elimination of peaks (or troughs) at both ends of series which are lower (or higher) than values closer to end.
    (d) Elimination of cycles whose duration is less than 15 months.
    (e) Elimination of phases whose durations is less than 5 months.
    (f) Statement of final turning points.

A.2 Artis et al. (1997)

1. Determination of extreme values (those for which the log-change with respect to adjacent month is greater than 3.5 standard errors of the log-differenced series).
2. Determination of cycles in the series smoothed with an MA(7).
    (a) Identification of peaks/troughs within ± 12 month.
    (b) Enforcement of alternation of turning points (same as before).
3. Determination of turning points on unsmoothed series.
    (a) Points higher/lower within ± 12 month.
    (b) Enforcement of alternation of peaks and troughs.
    (c) Identification of flat segment (those for which it is not possible to say if the phase is "expansionary" or "contractionary").
    (d) Identification and exclusion of outliers from the first set of turning points.
    (e) New enforcement of alternation.
    (f) Identification of short cycles (less than 15 month).
    (g) Enforcement of an amplitude of the phases superior to one standard error of the (log) changes.
4. Comparison of the turning points taken from the smoothed and the unsmoothed series and elimination of the points that do not correspond to similar turns (±5 month of the moving average)
    - statement of the final set of turning points.

A.3 Procedure used here:

1. Elimination of outliers: same as AKO.
2. Determination of cycles in MA(7).
    - Identification of peaks/troughs within ± 12 month.
3. Determination of turning points on unsmoothed series.

  (a) Points higher/lower within ± 12 month.
  (b) Identification of short cycles (less than 15 month).
  (c) Enforcement of an amplitude of the phases superior to one standard error of the (log) changes.

4. Comparison of turning points: same as AKO.
   (a) Enforcement of alternation.
   (b) Statement of the final set of turning points.

B Turning points dates

Table B.1 : Turning points dates

ECRI	Own	BBW	AKO	ECRI	Own	BBW	AKO	ECRI	Own	BBW	AKO
Austria				Belgium				Finland			
Peaks				*Peaks*				*Peaks*			
n.a	Jun-74	Jun-74		n.a		Dec-70		n.a	Jul-74	Jul-74	
	Dec-79	Dec-79			Jan-74	Jan-74	Apr-74			Jan-82	
		Dec-82			Feb-77	Feb-77	Oct-76		Jan-90	Jan-90	
		Mar-86				Dec-79	Dec-79				
	Dec-90	Dec-90				Jul-86					
	Jun-95	Jul-95			Nov-90	Nov-90	Mar-90				
					Feb-92	Feb-92					
						Feb-95					
						Jul-98					
Troughs				*Troughs*				*Troughs*			
n.a	Oct-75	Oct-75		n.a		May-71		n.a	Sep-75	Sep-75	
		Jul-81			Aug-75	Aug-75	Jul-75			Jul-82	
	Dec-82	Dec-82					Sep-77		Oct-91	Oct-91	
		Jan-87			Jan-79	Jan-79					
	Dec-92	Jun-93					Dec-80				
						Apr-84					
					Jan-87	Jan-87					
					Feb-91		Aug-91				
					Nov-93	Nov-93	os				
						Feb-96					
						Feb-99					
France				Germany				Greece			
Peaks				*Peaks*				*Peaks*			
		Apr-64		*Mar-66*	**Mar-66**	**Mar-66**	**Mar-66**	n.a	Feb-74	Feb-74	
Jul-74	**Jul-74**	**Aug-74**	**Aug-74**	*Aug-73*	**Aug-73**	**Aug-73**	**Aug-73**		Apr-80	Apr-80	
	Sep-76	Jan-77	Jan-77	*Jan-80*	**Dec-79**	**Dec-79**	**Dec-79**			May-82	
Aug-79	**Jul-79**	**Aug-79**	**Aug-79**			Jul-86				Dec-85	
Apr-82	Dec-81	Dec-81	Dec-81	*Jan-91*	**Jan-91**	**Jan-91**	**Jun-91**		Feb-90	Feb-90	
		Apr-86			Dec-94	Dec-94				Mar-00	
	Jan-91	Jan-91				Jul-98					
Feb-92			**Apr-92**								
	Jun-95	Jun-95									
Troughs				*Troughs*				*Troughs*			
		Jan-65		*May-67*	**May-67**	**May-67**	**May-67**	n.a	Jul-74	Jul-74	
Jun-75	**May-75**	**May-75**	**May-75**	*Jul-75*	**Jul-75**	**Jul-75**	**Jul-75**			Apr-81	
	Dec-77	Dec-77	Dec-77	*Oct-82*	**Nov-82**	**Nov-82**	**Nov-82**		May-83	May-83	
Jun-80	Nov-80	Apr-81	Nov-80			Jan-87				Jul-87	
	Aug-82	Aug-82	Aug-82		Jul-93	Jul-93			Jul-93	Jan-93	
Dec-84				*Apr-94*							
Aug-93	**Aug-93**	**Aug-93**			Oct-95	Oct-95					
	Dec-95	Dec-95									

source : OECD

na : not available.

Bold : no more than 3 months of difference with ECRI dates.

nb: the dataset of AKO stops in December 1993.

Table B.1 (II)

ECRI	Own	BBW	AKO	ECRI	Own	BBW	AKO	ECRI	Own	BBW	AKO
Italy				Luxembourg				Netherlands			
Peaks				*Peaks*				*Peaks*			
Jan-64	**Jan-64**	**Jan-64**	**Jan-64**	n.a	Feb-65	Feb-65	Feb-65	n.a	Aug-74	Aug-74	Aug-74
		Jul-69			Jan-70	Mar-70	Mar-70			Sep-76	Sep-76
Oct-70		Jan-71			Aug-74	Aug-74	Aug-74		Nov-79	Nov-79	Mar-80
Apr-74	**Jun-74**	**Jun-74**	**Jun-74**		May-76	May-76	May-76			Jan-85	
	Jan-77	Jan-77	Jan-77		Dec-79	Dec-79	Dec-79		Jan-87	Jan-87	Jan-87
May-80	**Mar-80**	**Mar-80**	**Mar-80**			Feb-82			Feb-91		Feb-91
	Dec-89	Dec-89	Dec-89		Dec-84	Dec-84	Oct-85			Jan-92	
Feb-92		**Feb-92**			Jun-90	Jun-90			Dec-95	Dec-95	
	Dec-95	Dec-95					May-92				
	Oct-97	Oct-97			Aug-95	Aug-95					
						Feb-98					
Troughs				*Troughs*				*Troughs*			
Mar-65	Aug-64	Aug-64	Aug-64	n.a	Aug-67	Aug-67	Aug-67	n.a	Aug-75	Aug-75	Aug-75
Aug-71					Oct-70	Oct-70	Oct-70			Nov-77	May-78
Apr-75	**Apr-75**	**Apr-75**	**Apr-75**		Aug-75	Aug-75	Aug-75		Nov-82	Nov-82	Nov-82
	Nov-77	Nov-77	Jun-77		Dec-76	Dec-76	Dec-76			Mar-86	
May-83	**May-83**	**May-83**	**Jun-83**		Apr-81	Apr-81	Apr-81		Apr-88	Apr-88	Apr-88
	Apr-91	Apr-91				Dec-82			Dec-92	Jun-93	
Oct-93		**Jul-93**			Feb-85		Oct-85				
	Dec-96	Dec-96			Aug-93	Aug-93					
						May-96					
	Dec-98	Dec-98			Jul-98	Jul-98					
Portugal				Spain				Denmark			
Peaks				*Peaks*				*Peaks*			
n.a		Apr-66			Aug-74	Aug-74	Aug-74	n.a	Apr-76	Aug-76	
	Jan-74	Mar-74		*Mar-80*		Aug-79			Jul-86	Jul-86	
	Nov-84	Nov-84				Jul-89	Jan-90			Nov-90	
	Aug-90	Aug-90		*Nov-91*		**Dec-91**	**Oct-91**		Jan-92		
		Nov-99			May-95	May-95			Jan-95	Jan-95	
Troughs				*Troughs*				*Troughs*			
n.a		Feb-67			Apr-75	Apr-75	Aug-75	n.a		Dec-74	
	Aug-75	Aug-75				Aug-82			Apr-77	Apr-77	
	Sep-85	Sep-85		*May-84*					Dec-87	Dec-87	
	Oct-93	Oct-93				Mar-91	Mar-91		May-93	May-93	
				Dec-93		Apr-93			Jan-96	Jan-96	
					Apr-96	Apr-96					

Table B.1 (III)

ECRI	Own	BBW	AKO	ECRI	Own	BBW	AKO	ECRI	Own	BBW	AKO
Sweden				UK				Norway			
Peaks				*Peaks*				*Peaks*			
Oct-70	Jul-70	Feb-71			Mar-66	Mar-66	Jul-66	n.a		May-68	
	Jul-74	Jul-74			Oct-70	Jan-71	Jan-71		Oct-74	Nov-74	
Jun-75				*Sep-74*	**Jun-74**	**Jun-74**	**Jun-74**		Jan-77	Jan-77	
Feb-80		**Mar-80**		*Jun-79*	**Jun-79**	**Jun-79**	**Jun-79**		May-79	Oct-79	
	Aug-85	Aug-85			Jan-84	Jan-84	Jan-84		Aug-87	Aug-87	
Jun-90		**Jun-90**		*May-90*	**Jun-90**	**Jun-90**	**Jun-90**		Nov-89	Aug-90	
						Jun-98				May-98	
Troughs				*Troughs*				*Troughs*			
Nov-71	Aug-71	Aug-71			Nov-66	Nov-66	Nov-66	n.a		Feb-69	
Nov-77	Jul-78	Jul-78			Feb-72	Feb-72	Feb-72		Dec-75	Dec-75	
		Aug-82		*Aug-75*	**Aug-75**	**Aug-75**	**Aug-75**		May-78	May-78	
Jun-83				*May-81*	**May-81**	**May-81**	**May-81**		Mar-83	Mar-83	
Jul-93	Dec-92	Dec-92			Aug-84	Aug-84	Aug-84		Aug-88	Aug-88	
				Mar-92		**Aug-91**			Dec-91	Dec-91	
					Feb-99	Feb-99					
Switzerland				Japan							
Peaks				*Peaks*							
		Feb-68		*Nov-73*	**Jan-74**	**Jan-74**	**Jan-74**				
Apr-74						Feb-80					
	Feb-75	Feb-75			Oct-81	Nov-81	Nov-81				
		Apr-77			May-85	May-85	May-85				
Sep-81					May-91	May-91	May-91				
	Apr-85	Jun-85		*Apr-92*							
Mar-90				*Mar-97*	**May-97**	**May-97**					
	Mar-93	Jul-93									
Dec-94	**Nov-94**	Mar-95									
Troughs				*Troughs*							
	Aug-68	Aug-68				Dec-62					
Mar-76		Nov-76		*Feb-75*	**Mar-75**	**Mar-75**	**Mar-75**				
	Sep-78	Sep-78				Aug-80					
Nov-82					Oct-82	Oct-82	Oct-82				
	Apr-87	Apr-87			Aug-86	Aug-86	Aug-86				
Sep-93				*Feb-94*	**Jan-94**	**Jan-94**					
	May-94	May-94			Apr-99	Dec-98					
Sep-96											
	May-99	May-99									

US

NBER	Own	BBW	AKO	ECRI
Peaks				
Dec-69	Aug-69	**Oct-69**	**Oct-69**	**Dec-69**
Nov-73	**Oct-73**	**Nov-73**	**Nov-73**	**Nov-73**
Jan-80	May-79	Jun-79	**Mar-80**	**Jan-80**
Jul-81	**Jul-81**	**Jul-81**	**Jul-81**	**Jul-81**
	Apr-89	Apr-89	Apr-89	
Jul-90		**Sep-90**		**Jul-90**
Troughs				
Nov-70	**Nov-70**	**Nov-70**	**Nov-70**	**Nov-70**
Mar-75	**Mar-75**	**Mar-75**	**Mar-75**	**Mar-75**
Jul-80	**Jul-80**	**Jul-80**	**Jul-80**	**Jul-80**
Nov-82	**Dec-82**	**Dec-82**	**Dec-82**	**Nov-82**
		Oct-89		
Mar-91	**Mar-91**	**Mar-91**	**Mar-91**	**Mar-91**

C Typical cycles

The average growth rate of each sub-period can be represented as follows:

$$g_{k,s}^{p} = \frac{1}{N(t_{k,(s+1)_i} - 1 - t_{k,s_i})} \sum_{i=1}^{N} \sum_{t=t_{k,s_i}}^{t_{k,(s+1)_i}-1} \frac{y_{t_{k,s_i}} - y_{t_{k,s_i}-1}}{y_{t_{k,s_i}-1}}, \; p = \text{expansion, recession.}$$

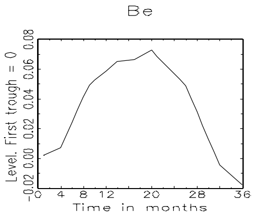
Where N is the number of phases of the p-type, $y_{k,t}$ is the index of country k at time t, t_{k,s_i} is the date of beginning of the subperiod s of the phase i for the country k.

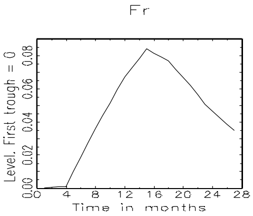
Similarly, the average duration is

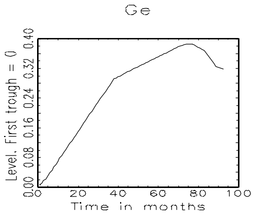
$$d_{k,s}^{p} = \frac{1}{N} \sum_{i=1}^{N} \left(t_{k,(s+1)_i} - 1 - t_{k,s_i}\right)$$

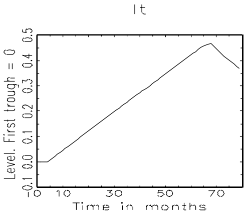
C.1 First period

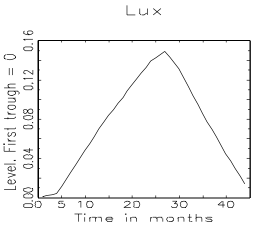
C.1.1 Euro group

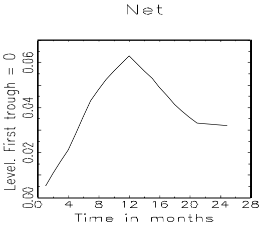


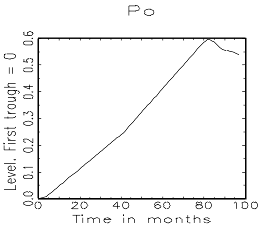




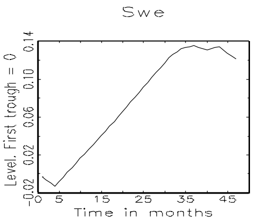


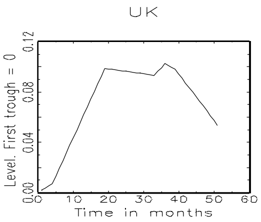




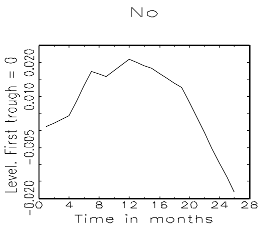


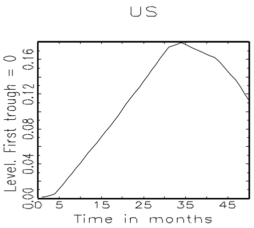
C.1.2 EU without Euro group





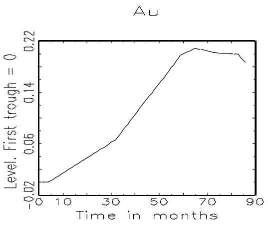
C.1.3 Non EU countries

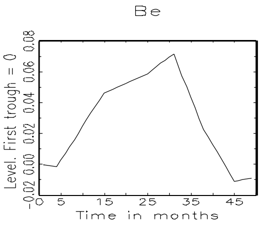


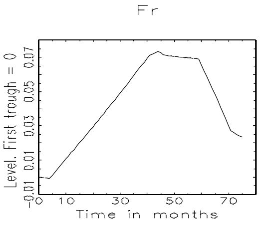


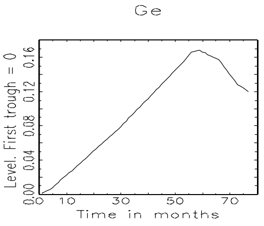
C.2 Second period

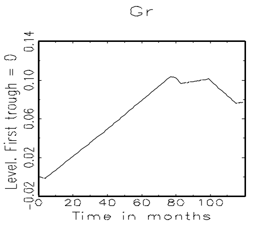
C.2.1 Euro countries

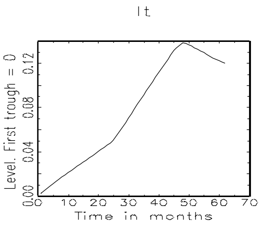


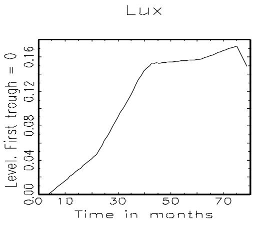


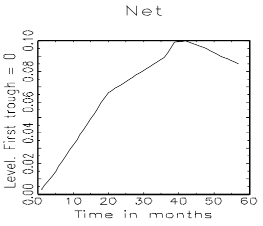


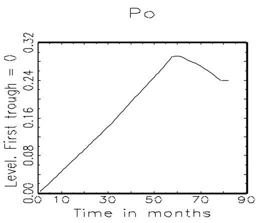


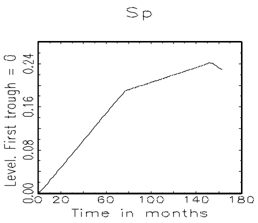




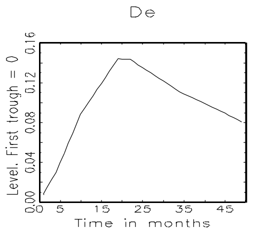


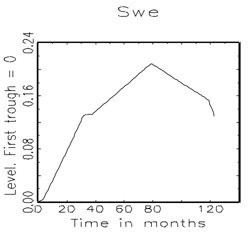


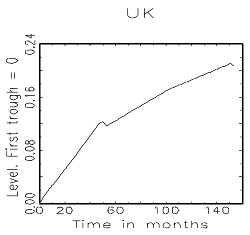




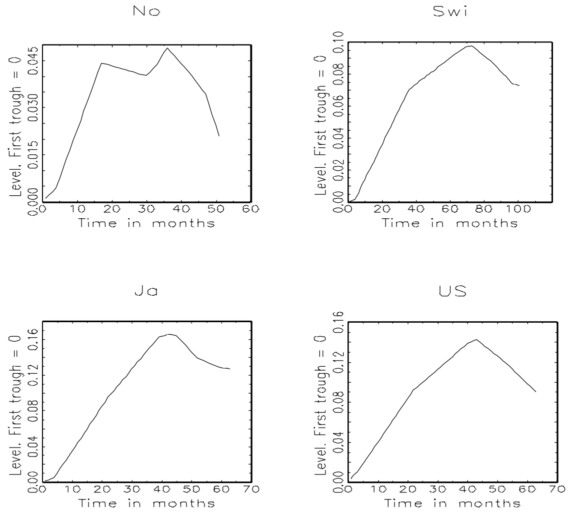
C.2.2 EU without Euro group







C.2.3 Non EU countries



D Pearson's coefficient

Pearson s (corrected) coefficient

First period

	Au	*Be*	*Fi*	*Fr*	*Ge*	*Gr*	*It*
Au	0.983	0.5654	0.982	0.5602	0.6872	0.6999	0.5353
Be	0.8316	0.9913	0.8266	0.7931	0.9211	0.9572	0.8587
Fi	0.9452	0.5737	0.9809	0.6062	0.6661	0.5268	0.5191
Fr	0.8482	0.6226	0.8856	0.9886	0.5949	0.5268	0.824
Ge	0.5693	0.5793	0.5658	0.2674	0.9913	0.5761	0.2389
Gr	0.0801	0.3888	0.0789	0.0913	0.4342	0.9517	0.035
It	0.6732	0.6944	0.6494	0.7887	0.3896	0.3238	0.9893
Lux	0.3962	0.1633	0.4503	0.1926	0.5712	0.1685	0.0229
Net	0.9009	0.5863	0.9376	0.595	0.6438	.	0.5032
Po	0.8502	0.7192	0.8445	0.5007	0.778	0.959	0.4753
Sp	0.7792	0.4861	0.8178	0.6523	0.5216	.	0.718
De	0	0.9307	0	0.6162	0	0	0.8402
Swe	0.7967	0.4451	0.8106	0.7492	0.3749	0.0733	0.522
UK	0.61	0.2308	0.6099	0.2579	0.5814	0.1223	0.2292
No	0.9239	0.7173	0.9376	0.8021	0.5949	.	0.7143
Swi	0.8026	0.4843	0.8085	0.6302	0.568	.	0.4427
Ja	0.6729	0.6286	0.6415	0.4759	0.6872	0.959	0.5191
US	0.3917	0.1925	0.3705	0.2095	0.4654	0.5875	0.2381

	Lux	Net	Po	Sp	De	Swe	UK
Au	0.3825	0.9602	0.9168	0.9441	.	0.5248	0.6985
Be	0.5006	0.8249	0.9836	0.8233	.	0.5787	0.5604
Fi	0.4402	0.9796	0.8966	0.9711	.	0.5353	0.6786
Fr	0.4927	0.8657	0.7982	0.9711	.	0.6942	0.587
Ge	0.4989	0.5648	0.7288	0.5762	.	0.0186	0.5455
Gr	0.1658	0.0735	0.6076	0.081	.	0.1519	0.0223
It	0.1383	0.6249	0.6167	0.9035	.	0.4498	0.3812
Lux	0.9936	0.5116	0.3205	0.4696	.	0.1321	0.3347
Net	0.5055	0.9781	0.8514	1	.	0.4984	0.6355
Po	0.3069	0.8413	0.9853	0.8315	.	0.3577	0.5524
Sp	0.3953	0.8614	0.7276	0.9679	.	0.3938	0.5139
De	.	0	0	0	.	.	0
Swe	0.3394	0.7798	0.67	0.7152	.	0.9941	0.7944
UK	0.3023	0.6128	0.5406	0.5762	.	0.4164	0.9915
No	0.3289	0.954	0.8259	0.9309	.	0.7507	0.612
Swi	0.5092	0.8149	0.672	0.686	.	0.8185	0.52
Ja	0.1498	0.6076	0.8966	0.7166	.	0.2157	0.3947
US	0.2378	0.3484	0.6066	0.4459	.	0.0847	0.1217

	No	Swi	Ja	US
Au	0.616	0.1584	0.8853	0.6387
Be	0.8222	0.5661	1	0.7131
Fi	0.6092	0.147	0.855	0.6106
Fr	0.7178	0.5023	0.855	0.6106
Ge	0.1594	0.2013	0.7442	0.5409
Gr	0.0984	0.217	0.6894	0.4697
It	0.6082	0.3048	0.7138	0.4369
Lux	0.0378	0.1654	0.2345	0.3381
Net	0.6045	0.1349	0.8211	0.5801
Po	0.4444	0.0567	1	0.7544
Sp	0.435	0.0862	0.817	0.5647
De	0.8739	.	0	0
Swe	0.7732	0.7696	0.5603	0.501
UK	0.1989	0.2654	0.4748	0.2086
No	0.9903	0.7292	0.7396	0.5104
Swi	0.7879	0.991	0.4472	0.2655
Ja	0.2122	0.2997	0.9808	0.734
US	0.0019	0.5354	0.718	0.9903

Pearson s (corrected) coefficient

Second period

	Au	*Be*	*Fi*	*Fr*	*Ge*	*Gr*	*It*
Au	1	0.314	0.2232	0.7327	0.8978	0.8435	0.6556
Be	0.314	1	0.8116	0.1102	0.3666	0.2755	0.2259
Fi	0.1662	0.5331	1	0.1894	0.1236	0.475	0.3514
Fr	0.7785	0.2017	0.2034	1	0.8551	0.765	0.0624
Ge	0.8978	0.3666	0.1695	0.8179	1	0.88	0.3141
Gr	0.8004	0.2466	0.2206	0.6461	0.8417	1	0.7664
It	0.6297	0.2115	0.5032	0.0044	0.2925	0.7786	1
Lux	0.6825	0.0875	0.0691	0.562	0.444	0.7701	0.3808
Net	0.8821	0.0766	0.308	0.2618	0.4121	0.6235	0.4259
Po	0.3111	0.0615	0.4851	0.5923	0.4659	0.4872	0.2216
Sp	0.1008	.	0.1823	0.215	0.1048	.	0.0292
De	0.0603	0.0271	0.3086	0.3735	0.362	0.0128	0.4031
Swe	0.1368	0.805	0.8298	0.0617	0.0764	0.3267	0.2984
UK	0.4259	0.2075	0.0297	0.5191	0.445	0.7109	0.2421
No	0.7883	0.1876	.	0.6442	0.7714	0.8651	0.8054
Swi	0.5168	0.3616	0.7261	0.3439	0.4011	0.4094	0.1618
Ja	0.4033	0.3942	0.2156	0.4149	0.3488	0.4385	0.0035
US	0.4246	0.148	0.8781	0.3059	0.3394	0.4454	0.6265

	Lux	Net	Po	Sp	De	Swe	UK
Au	0.6825	0.876	0.7454	.	0.1521	0.4043	0.3876
Be	0.0875	0.0889	0.5143	0	0.5954	0.563	0.1188
Fi	0.3165	0.1242	0.4542	.	0.3003	0.4983	0.2046
Fr	0.614	0.3111	0.7828	0.8177	0.525	0.2073	0.5157
Ge	0.444	0.4081	0.7224	0.7639	0.589	0.1502	0.4208
Gr	0.7209	0.5705	0.8029	0	0.0209	0.4575	0.5985
It	0.3613	0.409	0.0956	0.0167	0.4064	0.1403	0.2046
Lux	1	0.6228	0.5536	0.5916	0.0827	0.4114	0.8056
Net	0.6289	1	0.0758	0.8636	0.0876	0.2887	0.1879
Po	0.5302	0.0944	1	.	0.274	0.3801	0.3598
Sp	0.2046	0.0986	0.1957	1	0.3795	0.3269	0.2824
De	0.0805	0.0216	0.1948	0.9042	1	0.2353	0.1377
Swe	0.1604	0.2183	0.2445	.	0.2986	1	0.3426
UK	0.8315	0.2192	0.4013	0.4286	0.0473	0.5438	1
No	0.6188	0.7344	0.3504	0	0.5317	.	0.5568
Swi	0.1821	0.0126	0.4633	.	0.0143	0.7773	0.3107
Ja	0.309	0.2521	0.5154	0.4162	0.1028	0.0222	0.2476
US	0.1038	0.0092	0.0698	.	0.3155	0.5212	0.1429

	No	Swi	Ja	US
Au	0.7457	0.503	0.6554	0.3511
Be	0.2475	0.763	0.5271	0.2475
Fi	0.4793	0.5394	0.1073	0.4501
Fr	0.6337	0.3618	0.5646	0.2902
Ge	0.7294	0.3033	0.5407	0.275
Gr	0.7892	0.4317	0.5943	0.2816
It	0.7387	0.1168	0.1281	0.5241
Lux	0.5789	0.0925	0.4067	0.1616
Net	0.6894	0.0597	0.3614	0.0758
Po	0.1015	0.4228	0.4754	0.1009
Sp	.	0.3292	0.2302	0.1507
De	0.3124	0.0612	0.0353	0.3211
Swe	0.1692	0.7835	0.0027	0.135
UK	0.5503	0.2727	0.3411	0.1523
No	1	0.7365	0.2202	0.6061
Swi	0.6133	1	0.3232	0.5542
Ja	0.0292	0.321	1	0.1424
US	0.6061	0.5638	0.0375	1

E Harding & Pagan ratio

The ratio is the concordance coefficient (see eq. 3) over its expected value.

Harding and Pagan s concordance

First period

	Au	*Be*	*Fi*	*Fr*	*Ge*	*Gr*	*It*
Au	1.2108	1.2093	1.1979	1.1015	1.1827	1.0268	1.1009
Be	1.3257	1.7563	1.3051	1.3766	1.4822	1.1631	1.3756
Fi	1.1823	1.1993	1.1837	1.104	1.1689	1.0133	1.0908
Fr	1.1273	1.2937	1.1282	1.2925	1.1282	1.0133	1.2248
Ge	1.1541	1.2581	1.1443	1.0718	1.5392	1.0821	1.0669
Gr	1.0067	1.0767	0.9938	0.9917	1.0627	1.0684	1.0033
It	1.1219	1.3023	1.1096	1.2097	1.1041	1.024	1.3202
Lux	1.125	1.0736	1.136	1.067	1.2886	0.9716	0.9918
Net	1.1545	1.1894	1.1556	1.0938	1.1552	1	1.0808
Po	1.1801	1.3087	1.1677	1.0976	1.2537	1.0826	1.0965
Sp	1.1299	1.1242	1.1311	1.107	1.1307	1	1.1079
De	0	0.1339	0	0.6203	0	0	0.2941
Swe	1.2069	1.3003	1.196	1.2947	1.1249	1.0067	1.1936
UK	1.1702	1.1083	1.1606	1.0702	1.251	1.016	1.0651
No	1.1683	1.3854	1.1556	1.2105	1.1282	1	1.1835
Swi	1.2245	1.2978	1.2008	1.3215	1.1493	1	1.19
Ja	1.1098	1.2228	1.0971	1.0784	1.1827	1.0826	1.0908
US	1.0926	1.0929	1.0822	1.0514	1.1768	1.0821	1.0614

	Lux	Net	Po	Sp	De	Swe	UK
Au	1.117	1.1707	1.1986	1.1553	.	1.1529	1.1952
Be	1.1965	1.285	1.4855	1.2222	1	1.4035	1.2773
Fi	1.1276	1.1708	1.1843	1.1555	.	1.1463	1.1814
Fr	1.1448	1.1151	1.1287	1.1555	1	1.2698	1.1273
Ge	1.2378	1.1346	1.2325	1.1518	.	1.0077	1.2311
Gr	0.9725	0.9946	1.0626	0.9934	.	0.9769	0.9969
It	1.0422	1.0973	1.1209	1.1367	1	1.167	1.1026
Lux	1.7719	1.1472	1.1096	1.1491	1	1.0683	1.1602
Net	1.138	1.1568	1.1562	1.1556	.	1.1247	1.1541
Po	1.1009	1.1555	1.2574	1.1547	.	1.1091	1.1648
Sp	1.113	1.1323	1.1317	1.1372	.	1.1001	1.1295
De	1	0	0	0	1	1	0
Swe	1.1677	1.1693	1.1733	1.1538	1	1.7367	1.3172
UK	1.1398	1.151	1.1625	1.1518	.	1.182	1.5513
No	1.0932	1.1429	1.1424	1.1191	1	1.3286	1.1406
Swi	1.2378	1.1766	1.1747	1.0766	1	1.6835	1.1707
Ja	1.0415	1.0846	1.1843	1.1162	.	1.0552	1.0964
US	1.1002	1.0719	1.1686	1.1067	.	1.0325	1.0442

	No	Swi	Ja	US
Au	1.1223	1.0606	1.1333	1.1319
Be	1.4536	1.3556	1.3993	1.3696
Fi	1.1125	1.0527	1.1193	1.1181
Fr	1.189	1.2529	1.1193	1.1181
Ge	1.0452	0.9079	1.2026	1.2063
Gr	0.9903	0.9529	1.0647	1.0644
It	1.1593	1.1322	1.129	1.1115
Lux	1.0138	1.0827	1.0674	1.1471
Net	1.1028	1.0448	1.1054	1.1045
Po	1.0916	0.9766	1.2061	1.2028
Sp	1.0713	0.9766	1.1378	1.1357
De	0.2364	1	0	0
Swe	1.3453	1.623	1.1098	1.1491
UK	1.0574	0.8616	1.1167	1.0743
No	1.3476	1.436	1.0781	1.0776
Swi	1.4849	1.8329	1.051	1.0504
Ja	1.0358	0.8907	1.1912	1.1883
US	0.9995	0.6948	1.1861	1.4727

Harding and Pagan s concordance

Second period

	Au	*Be*	*Fi*	*Fr*	*Ge*	*Gr*	*It*
Au	1.7725	1.2276	1.1303	1.4414	1.6897	1.7061	1.3808
Be	1.2276	1.8251	0.2999	1.0777	1.2673	1.1916	1.1616
Fi	1.0546	0.6667	1.3623	1.0434	1.0329	1.2386	1.1017
Fr	1.4716	1.1432	1.0729	1.5627	1.4673	1.5791	1.0278
Ge	1.6897	1.2673	1.0634	1.4464	1.7128	1.7697	1.1664
Gr	1.6545	1.1711	0.9513	1.4696	1.7187	1.9997	1.6051
It	1.3655	1.1511	1.2031	1.002	1.1556	1.6182	1.7677
Lux	1.4121	1.0619	1.0478	1.3439	1.29	1.6055	1.2456
Net	1.6699	0.9466	0.8087	1.1633	1.2838	1.4847	1.2987
Po	1.1566	1.0431	1.186	1.2282	1.1986	1.3304	0.905
Sp	0.9898	1	0.9668	1.0355	1.0201	1	1.0059
De	0.9732	0.9822	0.9048	1.1309	1.1459	0.9927	0.8275
Swe	0.9113	0.352	1.3515	1.03	0.9583	0.7635	0.8268
UK	1.2844	1.1475	0.9794	1.3396	1.3034	1.5571	1.1617
No	1.6469	0.8712	1	1.4574	1.6216	1.7682	1.679
Swi	0.7329	1.2461	0.4728	0.8077	0.7483	0.7689	0.8986
Ja	1.228	1.2903	0.9009	1.2029	1.1896	1.3072	0.9981
US	1.2164	0.896	1.2302	1.1144	1.1392	1.2925	1.2835

	Lux	Net	Po	Sp	De	Swe	UK
Au	1.4121	1.6635	1.4054 .		1.0749	1.2942	1.2579
Be	1.0619	0.9379	1.3839	0	1.3962	0.6831	1.0839
Fi	1.115	0.9492	1.1295	1	0.9098	1.2284	1.0818
Fr	1.377	1.1937	1.3415	1.1871	1.2229	1.1145	1.3372
Ge	1.29	1.2809	1.3182	1.154	1.2661	1.085	1.286
Gr	1.5551	1.4354	1.6543	0	0.9856	0.7907	1.4501
It	1.2328	1.2861	0.9628	0.9928	0.8212	0.9191	1.1365
Lux	1.9382	1.4754	1.3729	0.65	0.9453	0.6969	1.6904
Net	1.4811	1.9939	0.9534	0.2542	0.9426	0.7915	1.1338
Po	1.2963	0.9458	1.5901	1	1.1117	1.22	1.2081
Sp	1.0536	0.9701	0.9617	1.3661	1.083	0.8931	1.0844
De	1.0406	0.9879	1.0793	1.2559	1.6182	1.1404	1.0755
Swe	0.8943	0.849	1.1434	1	1.1771	1.9942	0.7614
UK	1.7239	1.1565	1.2633	1.2798	1.0316	0.5844	1.9981
No	1.4368	1.6056	1.226	0	0.6214	1	1.4135
Swi	1.118	0.9913	0.6822	1	1.0092	0.3479	1.2238
Ja	1.1954	1.1725	1.283	0.8268	1.0506	0.9852	1.1671
US	0.9465	0.9947	1.0198	1	0.9005	1.2505	0.9167

	No	Swi	Ja	US
Au	1.5993	0.747	1.3659	1.1816
Be	0.8283	1.5685	1.4016	0.824
Fi	1.2676	0.7091	0.9663	1.0992
Fr	1.4487	0.7704	1.2791	1.1095
Ge	1.5765	0.8048	1.2866	1.1163
Gr	1.6686	0.7309	1.4306	1.1832
It	1.6014	1.0747	1.0672	1.2429
Lux	1.4048	1.0655	1.263	0.914
Net	1.5565	1.0422	1.2499	0.9557
Po	1.0587	0.7156	1.2359	0.9672
Sp	1	1.1277	0.947	0.9773
De	0.8454	0.9602	1.016	0.8969
Swe	0.8804	0.34	0.9983	1.0617
UK	1.4079	1.1868	1.2344	0.9109
No	1.9781	0.4576	1.1353	1.4657
Swi	0.6239	1.9824	1.2208	0.6928
Ja	1.0184	1.2322	1.8418	0.9375
US	1.4657	0.6821	0.9845	1.4885

F t-ratio tests

To see this why $\hat{I}_{mc}$ is proportional to $\hat{\beta}$, let $J_t = S_{jt} - \hat{\mu}_j$ and $K_t = S_{kt} - \hat{\mu}_k$.

$$J_t = \alpha + \beta K_t + u_t \tag{9}$$

which gives,

$$\hat{\beta} = \sigma_K^{-2} \sum_{t=1}^{T} J_t K_t$$

using (8),

$$\hat{\beta} = \frac{\hat{I}_{mc} T}{2\sigma_K^2}$$

where T and σ_K^2 are strictly positive constants. Therefore, $\hat{\beta}$ and $\hat{I}_{mc}$ are proportional.

F.1 Results

Nota : The dependent variables are in columns, and the independent ones in rows.

First period

Harding and Pagan s test using DenHaan and Levin robust t-ratio

	Au	*Be*	*Fi*	*Fr*	*Ge*	*Gr*	*It*	*Lux*	*Net*	*Po*	*Sp*	*De*	*Swe*	*UK*	*No*	*Swi*	*Ja*	*US*
Au		-	-	*	**	*	-	-	**	-	-	-	-	-	*	-	-	-
Be	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fi	-	-		-	-	-	-	-	-	*	-	-	*	-	*	-	-	-
Fr	**	-	-		**	*	-	*	-	*	-	-	-	*	**	-	-	-
Ge	**	-	-	*		**	-	*	-	-	-	-	-	*	-	-	-	-
Gr	-	-	-	-	*		-	-	-	-	-	-	-	-	*	-	-	-
It	*	-	-	-	-	**		-	*	-	-	-	-	-	**	-	-	-
Lux	*	-	-	-	*	-	-		*	-	-	-	-	**	-	-	-	-
Net	**	-	-	-	-	*	-	*		-	-	-	-	-	**	-	-	-
Po	-	-	-	-	*	-	-	-	-		-	-	-	-	-	-	*	-
Sp	-	-	-	-	-	-	-	-	-	-		-	-	*	-	-	-	-
De	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Swe	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
UK	-	-	-	-	-	-	-	**	-	-	-	-	-		-	-	-	-
No	*	-	-	*	-	*	*	-	*	-	-	-	-	-		-	-	-
Swi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Ja	-	-	-	-	-	-	-	-	*	*	-	-	-	-	-	-		-
US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Significance levels: - : non rejection
*** : 1% Blank: test could not be conducted
** : 5%
* : 10%

Second period

Harding and Pagan s test using DenHaan and Levin robust t-ratio

	Au	*Be*	*Fi*	*Fr*	*Ge*	*Gr*	*It*	*Lux*	*Net*	*Po*	*Sp*	*De*	*Swe*	*UK*	*No*	*Swi*	*Ja*	*US*
Au		-	-	-	**	*	-	-	**	-	-	-	-	-	-	-	-	-
Be	-		-	-	-	-	-	-	-	-		-	-	-	-	-	-	-
Fi	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fr	*	-	-		**	-	-	*	-	-	-	-	-	*	-	-	-	-
Ge	**	-	-	*		*	-	-	-	-	-	-	-	-	-	-	-	-
Gr	-	-	-	-	-		-	-	-	-		-	-	-	-	-	-	-
It	-	-	-	-	-	*		-	-	-	-	-	-	-	*	-	-	-
Lux	*	-	-	-	-	*	-		*	-	-	-	-	**	-	-	-	-
Net	**	-	-	-	-	-	-	*		-	-	-	-	-	-	-	-	-
Po	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Sp	-		-	-	-		-	-	-	-		-	-	-		-	-	-
De	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Swe	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
UK	-	-	-	-	-	-	-	*	-	-	-	-	-		-	-	-	-
No	-	-	-	-	-	*	-	-	-	-		-	-	-		-	-	-
Swi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Ja	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Significance levels: *- : non rejection*

**** : 1%* *Blank: test could not be conducted*

*** : 5%*

** : 10%*

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