On the Idiosyncrasy of Business Cycles Across EU countries*

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Abstract

This paper analyses the underlying dynamics of business cycles in the EU-15. Existing literature mainly focuses on the comovement of expansion and contraction phases, while this paper seeks to test the idiosyncrasy of business cycles by studying growth pattern and severities of industrial contractions. Hypotheses are tested using formal statistical methods while much existing literature in this field rely on judgements of correlation coefficients. The results obtained here do not point towards much idiosyncrasy of the European business cycles.

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1 Introduction

Up to the launch of the EMU's third stage many critics argued that a "one-size-fits-all" monetary policy would be incapable of ensuring economic stability due to too large disparities in economic and institutional fundamentals across the European countries. This discussion has once again become relevant with the prospects of ten new countries joining the EU from 2004. In the longer run even an enrolment to the EMU's third stage might be a possibility for these countries.

At the same time the debate whether to join the common currency or not has once again been sparked off in the UK, Sweden and Denmark. Recently, Townend (2002) emphasized that letting UK join the third stage might not be without problems. He specifically emphasized that "*[...] the economic conditions are obviously important, if the UK is to live comfortably with the 'one size fits all' monetary policy of the euro area*".

No doubt, it is important for economic fundamentals to some extend to be equal across countries and for business cycles to show some degree of cross-country-symmetry for a single monetary policy to be appropriate for this large group of countries. A large amount of studies have during the nineties focused on this problem and searched for the existence of a common European business cycle. These studies can roughly be grouped into two research approaches. One approach is the *traditional*[1] way of distinguishing between different phases of the business cycle by picking peaks and troughs with the Bry & Boschan (1971) procedure. This approach is related directly to the methodology of Burns & Mitchell (1946) and the NBER Business Cycle Dating Committee. The other dominant approach, that will be denoted the *modern* approach in this study, is stemming from the influential work of Hamilton (1989). It takes advance of regime switching models that assume the economy is to be found in one of a number of different states, and where the

[1] The approach that I in this paper denote "traditional" is often called the "classical" approach; however, with the term "*classical* business cycles" I shall refer to business cycles found from the *level* of some economic time series. Business cycles found on account of a *growth* or cyclical component, i.e. a cyclical component found by the Hodrick-Prescott filter as done in section 4.2, will be denoted a "growth cycle".

probability of moving from the current state to another is contingent on the current state.

The present paper applies the traditional approach to examine the behavior of the business cycle in the various EU member countries due to its greater robustness and transparency relative to the modern approach as argued by Harding & Pagan (2001, 2002). To some extend the paper complements the work of Artis *et al.* (1997, 1999), Christodoulakis *et al.* (1995) and Krolzig & Toro (2001). Artis *et al.* (1997) propose classical business cycle turning points for the G7 and a number of European countries based on industrial production, i.e. troughs and peaks found on account of the level of industrial production. Pearson's corrected contingency coefficient is used to determine the degree of comovement of expansions and contractions across countries, and the conclusion is in favor of a common business cycle – at least for a core group of European countries.[2] A similar conclusion is obtained by Artis *et al.* (1999) with the use of regime switching models. These papers show that troughs and peaks tend to take place at almost the same time in the various European countries.

However, what still remains to be examined in these studies is the behavior of the business cycle *between* the peaks and troughs – the underlying dynamics (UD). Two features are noteworthy when talking about the UD of the business cycle. First, the growth pattern may show substantial variation across countries; the transition from a peak to a trough, *et vice versa,* is likely to differ from country to country. Second, the severity of contractions, in this study defined as relative deviation of actual level of activity from its trend level, might show large variation across countries.

These features are important when considering the possibilities for the ECB of leading an appropriate monetary policy for the entire euro-zone at the same time. Roughly speaking the absence of a similar growth pattern will make the task of *timing* changes in the monetary policy difficult, while large variations in the

[2] The "core group" is by Artis *et al.* (1997) concluded to consist of France, Germany, Italy, Belgium, the Netherlands and Ireland.

severity of contractions across countries will make it more difficult to find the right *magnitude* of changes.[3]

This paper seeks to contribute to the existing literature by giving further insight into the UD of the European business cycle[4]. As argued here, this matter has only been partly treated. At the same time the analysis carried out here offers a way of testing hypotheses regarding the conformity of business cycles across countries by applying formal statistical methods. Most hypotheses in this field of research have so far been tested by evaluating whether a given correlation coefficient returns a "high" value or not, and more formal methods would definitely be preferable.

Using the traditional approach for selecting turning points in industrial production in the EU and examining the dynamics between the troughs and peaks, this paper does not in itself give support for the concern expressed by Townend (2002). In fact, only very few signs of individual countries' business cycles deviating significantly from the aggregated European business cycle are found. However more work must certainly be done in this area in order to conclude on the efficiency of leading a common monetary policy in the longer run. An issue which is discussed in the conclusion.

The rest of this paper goes as follows: In Section 2 the theoretical framework is described, data is presented in Section 3 and Section 4 provides the findings. Section 5 discusses and concludes.

2 Methodology

First, the patterns of the business cycles in the various EU member countries are compared. The comparison is done to the reference business cycle which is chosen

[3]However, even in the extreme case that all business cycles appear to be totally synchronous, that is business cycles with completely identical UD, optimal monetary policy is still likely to differ across countries due to different transmission mechanisms. This is another way of saying that the same output gap in two countries might not necessarily call for the same interest rate level. One must therefore be careful not to draw too strong conclusions without considering the heterogeneity of transmission mechanisms across countries.

[4]Mayby – since I rely solely on data for industrial production – the business cycles considered in this study should be called "industrial cycles". I relax on this distinction for now, but discuss this matter in Section 5.

to be the OECD EU-15 aggregate. Second, it is examined whether the severity of contractions in terms of deepness differs across countries.

2.1 Pattern of the European business cycles

One possible way to find a pattern of the business cycle is to distinguish between different growth phases over the business cycle. Today the official US peaks and troughs are determined by the NBER Business Cycle Dating Committee. The methodology behind this follows the Burns & Mitchell (1946) definition in the sense that business cycles are not determined from the development in a single time series. Bry & Boschan (1971) developed an algorithm aiming at mimicking the peak and trough dates found by the NBER and in line with the initial requirements proposed by Burns & Mitchell (1946). In short, the algorithm is a mechanical way of determining turning points in a highly smoothed time series, but it breaks with the NBER and Burns & Mitchell (1946) methodology since it, in fact, relies on a single time series. I use a slightly modified version of this algorithm to find troughs and peaks, and I apply it to only industrial production in the various countries.[5,6] See the next section for a presentation of the data.

Having found the troughs and peaks of the time series it is straightforward to split the business cycles into sub-phases in accordance with Burns & Mitchell (1946, pp. 144). More specifically, the three months centered on a peak is denoted Phase 1, while the three months centered on a trough is denoted Phase 5. Phase 2 to Phase 4 are phases of equal length covering the time span from Phase 1 to Phase 5, while Phase 6 to Phase 8 cover the time from Phase 5 to Phase 1.[7,8,9]

[5] See Appendix A for an overview of details on the Bry & Boschan methodology and for an elaboration of the modifications used in this study.

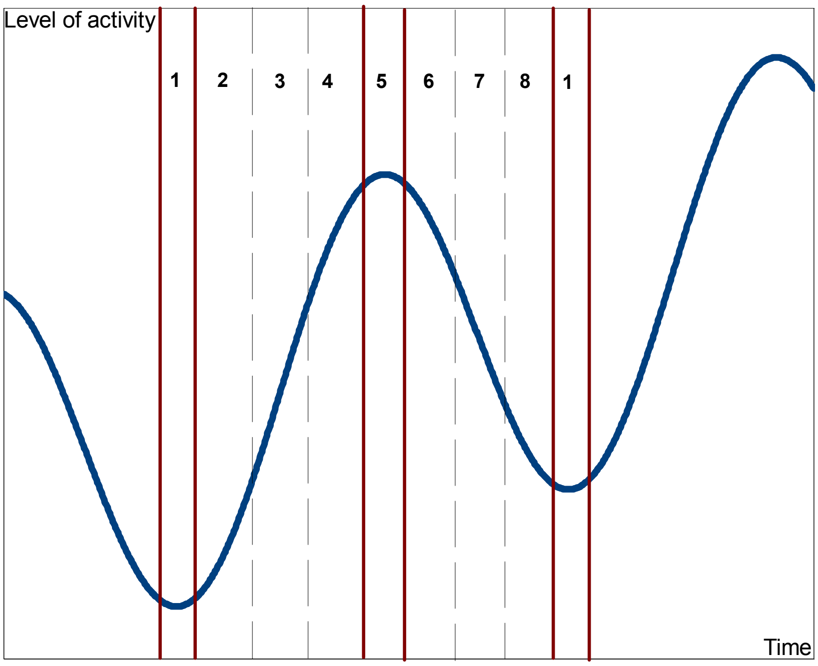
[6] The algorithm is written in MATLAB and can be obtained from the author upon request.

[7] Symmetry is imposed in the sense that the length of Phase 2 is required to equal the length of Phase 4. Similarly Phase 6 and Phase 8 are required to be of equal length. Therefore the length of Phase 3 (Phase 7) may differ with 1 month from Phase 2 and Phase 4 (Phase 6 and Phase 8). This happens if the duration in months of an expansion/contraction phase divided by three is not an integer.

[8] In this context one should be aware of the interesting papers by Sichel (1993) and Layton & Smith (2000) who suggest that the US business cycle consists of three phases; contraction, rapid expansion and normal expansion.

[9] This approach has been criticized as being "measurement without theory", cf. Koopmans

Figure 1. The 8 phases of the business cycle



Balke & Wynne (1995) applies the same approach when analyzing whether an RBC model is capable of mimicking symmetries of the US business cycle by estimating average growth rates in each phase. I follow this approach to obtain average growth rates estimates in each phase using phase dummies and apply Chow tests, cf. Chow (1960), to compare growth rates in the different phases with the reference business cycle, which is the EU-15 business cycle.

That is, for each country, i, I estimate the model

$$\begin{pmatrix} \gamma_{EU} \\ \gamma_i \end{pmatrix} = \begin{pmatrix} X_{EU} & 0 \\ 0 & X_i \end{pmatrix} \begin{pmatrix} \beta_{E15} \\ \beta_i \end{pmatrix} + \begin{pmatrix} \varepsilon_{EU} \\ \varepsilon_i \end{pmatrix} \tag{1}$$

where γ_{EU} and γ_i are vectors containing the monthly growth rates of industrial production in EU respectively country i, X_i are $(n_i \times 8)$ matrices containing dummy

(1947), but at least the terminology is very well established in this field, and comparisons are thereby possible. By the end of the day, the modern approach – regime switching models – is also a result of more or less arbitrarily choices involving the number of states as an analog to the eight phases considered here.

variables describing which phase the corresponding growth rate belongs to, n_i is the number of observations regarding country i, and ε_i are white noise error terms. The OLS estimates of β_{EU} and β_i will be identical with the average growth rates in the corresponding phase.

However, OLS must be applied with caution; error terms are sure to be serially correlated and standard inferences cannot be made since standard deviations are incorrectly computed by standard formulas. In order to correct the standard deviations I use the Newey-West covariance estimator. When constructing the heteroscedasticity and serial correlation consistent covariance matrix, I follow Sichel (1993) and Newey & West (1987) and allow for a serial correlation up to order six. This results from taking the integer part of the sample size raised to the 1/3 power.

15 comparisons are thereby done; one between the business cycle in each member country, i, and the total EU-15 business cycle by testing the hypotheses $\beta_{j,EU} = \beta_{j,i}$ for $j = 1, 2, ..., 8$ where j is the number of the corresponding phase.

2.2 Severity of contractions

Measuring the severity of the typical contraction is done by constructing a measure of the deepness of the business cycle identical to the one used by Sichel (1993) in his study of the US business cycle.

In this aspect it is not appropriate to work with the *levels* of time series – instead *the relative deviation of actual output from trend output* is of interest. Therefore, for this operation one should apply a detrended time series and focus on the cyclical component defined as the relative distance from actual output to the output trend level.[10]

To ensure this distinction between a trend component and a cyclical component, I rely on the Hodrick-Prescott filter, which is widely used in this context, cf. Hodrick & Prescott (1997). I set the smoothing parameter equal to 129.600 as suggested by Ravn & Uhlig (2002) when working with monthly observations. I eliminate the

[10] This measure of the business cycle is often referred to as growth cycles and is widely used when evaluating the predictions of a CGE model.

first and last three years of observations due to the end-point problems related to the Hodrick-Prescott filter, cf. Baxter & King (1999) and Cogley & Nason (1995).

The Hodrick-Prescott filter has been subject to much scepticism. The conclusions in Cogley & Nason (1995) certainly give rise to concern about the properties of the filter. However, it still appears to be widely used in this field of the literature due to the lack of definitive better alternatives, and an obvious advantage by applying this filter is therefore the possibility of comparing results with other studies. For the same reason we also relax on the possibility of choosing the smoothing parameter in order to minimize the distortion of the filter, cf. Pedersen (2001). Deviating from commonly accepted values will make it less easy to compare with results obtained in other studies.

As Sichel (1993) I use the coefficient of skewness

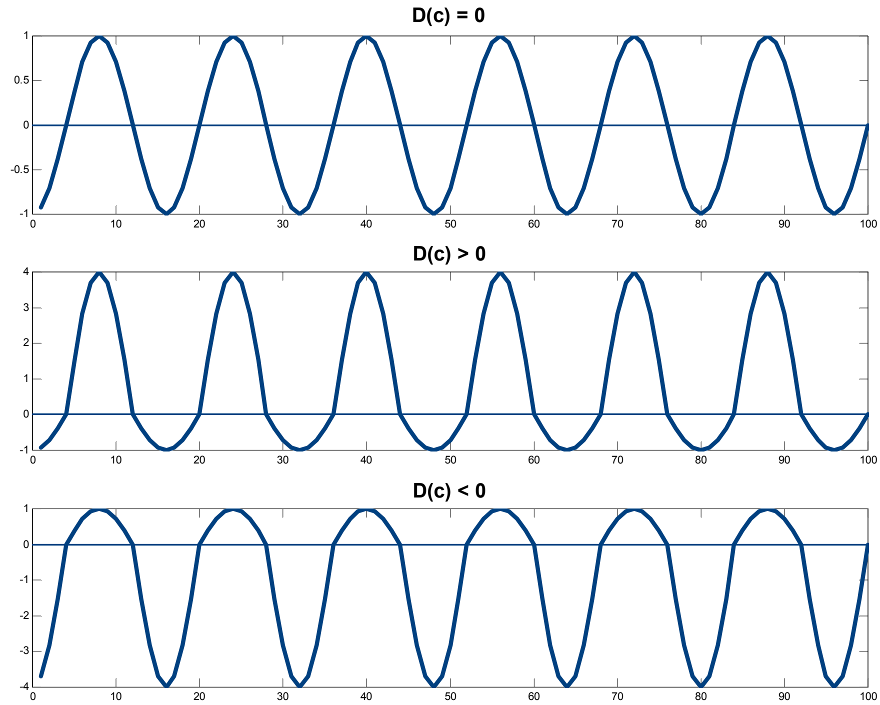
$$D(c) = \frac{\frac{1}{T}\Sigma_{t=1}^{T}(c_t - \mu_c)^3}{\sigma_c^3} \tag{2}$$

where μ_c is the observed mean of c_t, σ_c is the standard deviation of c_t, which is the cyclical component at time t, and T is the size of the sample.[11]

Figure 2 gives examples of three time series. The upper panel shows a time series, where the maximum distance from the mean to the peak value is equal to the maximum distance from the mean to the trough value. The middle panel shows the case where the maximum distance from the mean to the peak value is greater than the distance from the mean to the trough value, while the opposite case is illustrated in the lower panel. The three examples will provide values of $D(c)$ equal to zero, greater than zero respectively less that zero.

[11] The terms are raised to the third power to ensure that "large" deviations are given more weight than "small". "Normally" one would just raise it to the second power to achieve this property, but in the present case we need the sign in order to distinguish between expansions and contractions.

Figure 2. A symmetric, "high" and "deep" business cycle – Three examples



An estimate of $D(c)$ is obtained by regressing

$$z_t = \frac{(c_t - \mu_c)^3}{\sigma_c^3} \tag{3}$$

on a constant. Regressing (3) on a constant reveals the average of $\{z_1, z_2, ..., z_T\}$ as the parameter estimate, which is just equal to (2). However, the regression delivers standard deviations of the parameter estimates that can be used when testing hypotheses. Once again serial correlation is expected, and so the Newey-West estimator is used. Analogous to (1) the model

$$\begin{pmatrix} Z_{EU} \\ Z_i \end{pmatrix} = \begin{pmatrix} I_{EU} & 0 \\ 0 & I_{Z_i} \end{pmatrix} \begin{pmatrix} \zeta_{E15} \\ \zeta_i \end{pmatrix} + \begin{pmatrix} \omega_{EU} \\ \omega_i \end{pmatrix} \tag{4}$$

is estimated. Z_{EU} and Z_i are vectors containing the values of z_t, $t = 1, 2, ..., T$ for EU respectively country i, I_{EU} and I_i are dummy variables containing ones, while ω_{EU} and ω_i are white noise terms. Again the comparison is done by applying the method suggested by Chow (1960), that is testing the hypotheses $\zeta_{E15} = \zeta_i$.

3 Data

Data for industrial production in the EU countries in the period April l979 - October 2001, hereafter 1979:4 - 2001:10 is used. This beginning of the period is chosen to respect the findings of Artis & Zhang (1997) who conclude that the ERM has promoted the synchronism of the European business cycles, and that the similarity of European business cycles is to be found in another regime hereafter. The latter conclusion is also obtained by Juselius (2003).

Data is drawn from OECD Main Economic Indicators, see Appendix B for specific codes and for mnemonics used in this paper. The time series for the EU-15 industrial production is a weighted average of participating countries' working days adjusted industrial production, cf. Eurostat (2000).

Looking at industrial production instead of the overall measure of activity – GDP – has two advantages. First, data for industrial production is released on a monthly basis instead of GDP, which is only released on a quarterly basis. Second, policy makers might – at least in the short run – pay more attention to this figure, since the release of industrial production leads the release of GDP. To some extend GDP figures can be said to contain a large amount of already known information before its release, and monetary policy may very well have been changed ahead of the release. This makes industrial production data interesting in a monetary policy context.

The obvious disadvantage by using industrial production instead of overall activity measured by GDP is that industrial production does only tell about the economic conditions in a part of the supply side of the economy. Furthermore, the share of industrial output relative to overall output has in general dropped over the last decades and therefore the aggregate business cycle may to a higher degree differ from the industrial business cycle than years ago.

In this paper, the analysis is restricted to the members of the EU, which are the 12 countries participating in the EMU's third stage as well as the UK, Sweden and Denmark who has chosen to stand out. It would be obvious to extend the analysis to include the Eastern European countries that are to join the EU and who one day even might be members of the euro-zone. Unfortunately, there do not seem to exist any time series for industrial production going satisfactory long back in time for this purpose, so this operation will have to be unexplored.

4 Results

4.1 Pattern of the European business cycles

Industrial production is a highly volatile figure. To eliminate some of the volatility a 3 month centered moving average is used. The determination of peaks and troughs is still based on the raw series, but before estimating (1) the moving average is applied. This transformation of data is visualized in Appendix D. The estimates of β_i for $i = E15$, DEU, FRA, ITA, ESP, NLD, BEL, AUT, LUX, FIN, PRT, GRC, UK, SWE, DNK are reported in Table 1.[12] Examining Table 1 reveals only very few "wrong" signs of the estimates. This is hardly surprising since the method of dividing the time series into various phases dependent on the relative position of the particular phase to the previous peak (trough) and the next trough (peak) almost defines the sign of growth. On the contrary, the signs of the growth rates in Phase 1 and in Phase 5 are not obvious. *A priori* these should be expected to lie close to zero since these phases cover the period where growth goes from being negative (positive) to being positive (negative). However, remember that these phases include not only the turning points of the time series, but also its two surrounding observations, and if these are not numerically equally large the estimate should differ from zero. Furthermore, growth in the turning point will in general not be zero itself.

[12] Ireland is not included in this part of the analysis. The reason is that Ireland experiences a trough in 1980:12 and a peak in 2001:2. Thereby, there is not enough turning points to constitute a full cycle, and therefore no sub-phases have been determined.

Table 1 – Average growth rates

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
E15	0,02	-0,13	-0,30	-0,36	-0,25	0,27	0,25	0,24
	(0,1116)	(0,1265)	(0,1048)	(0,0777)	(0,1965)	(0,0562)	(0,0444)	(0,0534)
DEU	0,12	**-0,54**	-0,20	-0,47	-0,17	0,37	0,36	0,32
	(0,1328)	(0,1087)	(0,1869)	(0,1225)	(0,1004)	(0,0534)	(0,0922)	(0,0915)
FRA	0,15	-0,27	-0,45	-0,37	-0,10	**0,14**	0,25	0,12
	(0,0398)	(0,0403)	(0,1667)	(0,0901)	(0,1264)	(0,0542)	(0,0829)	(0,0593)
ITA	0,21	-0,36	-0,15	-0,25	-0,33	0,45	0,36	0,26
	(0,1088)	(0,2487)	(0,0459)	(0,1174)	(0,1515)	(0,1161)	(0,0689)	(0,0852)
ESP	0,14	-0,40	-0,34	-0,33	-0,17	0,32	0,36	**0,43**
	(0,0729)	(0,1544)	(0,2559)	(0,1669)	(0,1404)	(0,1014)	(0,0793)	(0,0838)
NLD	**0,66**	-0,56	-0,36	**0,17**	-0,26	**0,54**	0,28	0,14
	(0,2824)	(0,2509)	(0,0777)	(0,2792)	(0,3138)	(0,1318)	(0,1162)	(0,0908)
BEL	**0,58**	**-0,40**	-0,34	-0,27	-0,19	**0,43**	0,29	0,21
	(0,2155)	(0,0857)	(0,2504)	(0,1482)	(0,0916)	(0,0498)	(0,1173)	(0,1154)
AUT	**0,55**	-0,30	-0,21	-0,18	-0,32	0,41	**0,51**	**0,49**
	(0,1246)	(0,1444)	(0,0970)	(0,1472)	(0,1482)	(0,0905)	(0,0898)	(0,1073)
LUX	**1,18**	-0,42	-0,28	-0,03	-0,63	0,68	0,24	0,42
	(0,4236)	(0,5094)	(0,1151)	(0,3149)	(0,3904)	(0,2570)	(0,1448)	(0,2011)
FIN	**0,71**	**-0,51**	-0,28	**-0,77**	-0,09	**0,55**	0,42	0,43
	(0,1247)	(0,0851)	(0,3722)	(0,2244)	(0,0448)	(0,0960)	(0,1339)	(0,1231)
PRT	0,30	-0,26	-0,43	-0,23	0,16	**0,60**	0,27	**0,50**
	(0,2606)	(0,2068)	(0,3086)	(0,1702)	(0,2025)	(0,1619)	(0,0919)	(0,1079)
GRC	**0,54**	-0,16	-0,34	**0,01**	-0,41	0,21	0,21	0,22
	(0,2164)	(0,2517)	(0,1952)	(0,1755)	(0,1757)	(0,1138)	(0,1144)	(0,1555)
UK	0,11	**-0,54**	-0,56	-0,26	-0,06	0,30	0,24	0,17
	(0,0733)	(0,1481)	(0,1679)	(0,0911)	(0,0901)	(0,0925)	(0,0608)	(0,0495)
SWE	0,34	-0,43	-0,17	-0,16	-0,44	**0,61**	0,36	0,36
	(0,1792)	(0,3759)	(0,1719)	(0,1693)	(0,2539)	(0,1282)	(0,1061)	(0,1223)
DNK	**0,86**	-0,57	-0,56	-0,36	**0,23**	0,37	0,33	0,42
	(0,1739)	(0,2875)	(0,2913)	(0,1963)	(0,1761)	(0,1403)	(0,1451)	(0,1613)

Standard deviations in parantheses

Different from EU-15 growth at a ***10 percentage significance level***

5 percentage significance level

1 percentage significance level

Another conclusion to be drawn from Table 1 is that of the bigger countries almost no growth rates in any phase differ significantly from the EU-15 business cycle[13]. This is neither hardly surprising since the EU-15 industrial production by definition is a weighted average of industrial production in the individual member countries. In a monetary policy context this is, however, the problem in a nutshell;

[13]Probabilities of F-tests can be found in appendix C.1.

when attaching the largest weights to the largest countries before aggregating and using this aggregate for designing monetary policy, the risk of ignoring the economic development in the smaller countries arises. This has been subject to much debate in many years ahead of the launch of the EMU's third stage – and still is.

The risk cannot be rejected from this analysis, but based on data for industrial production this does on the other hand not appear to be enormous. Following the results obtained here it appears that Finland tops the list of countries having most growth phases to differ significantly from the corresponding growth in the entire EU-15 when testing at a 10 percentage significance level. Four out of eight phases differ significantly in Finland. Hereafter follow the Netherlands, Belgium and Austria with three phases each to differ.

As a matter of fact Phase 1 appears to be the phase that differs the most across countries; in 7 out of 14 countries a significantly different estimate is obtained when allowing for a 5 percentage level of significance. This means that it is at the time when growth slows down and the expansion becomes a contraction the business cycle differs across countries. On the contrary, only Denmark stands out when talking about the trough of the business cycle, i.e. Phase 5 growth.

Drawing a special attention to the three countries not participating in the third stage of the EMU – UK, Sweden and Denmark – the analysis does not reveal any information pointing towards any circumstances making an entry to the third stage harder than for any other participating countries regarding the overall growth pattern. As the most "extreme" case, Denmark differs in two phases if allowing for a 10 percent significance level. The Swedish and British business cycles only differ in one phase each.

This results highlights the differences between the analysis carried out here and the analyses carried out by Artis *et al.* (1997) and Artis & Zhang (1997). These two studies find that peaks and troughs in the British business cycle are not very synchronized with the peaks and troughs in the "core" countries, while the focus in the present study is the dynamics *between* the troughs and peaks.

4.2 Severity of contractions

As proposed in the introduction, the pattern of growth over the business cycle is relevant for the *timing* of changes in monetary policy, while the deepness of the business cycle is of interest in relation to the *size* of changes in monetary policy. Analyzing how sharply industrial production drops below its trend level during a recession will therefore give some information about how expansionary monetary policy should be in order to stabilize fluctuations in the short run.

Table 2 offers estimates of the coefficient of skewness as defined in (2). It is seen, with the exception of Germany, Austria and Ireland, that in almost all countries output drops further below trend during contractions than it rises above trend during expansions. This is consistent with the stylized fact that over time production rises, and that glooms are shorter than blooms.

However, Table 2 also reveals that the severity of recessions in no country is estimated to be significantly different from the reference – the EU-15. Again we must be careful when translating this conclusion into monetary policy lessons. But at least industrial production does not highlight heterogeneities of the European business cycle and is thereby in itself not giving rise to concern about the possibility of leading a common monetary policy.

Table 2 – Coefficient of deepness

E15	DEU	FRA	ITA	ESP	NLD	BEL	AUT
-0,66	0,00	-0,38	-0,23	-0,49	0,15	-0,80	0,17
(0,6939)	(0,6189)	(0,5137)	(0,4082)	(0,6104)	(0,3388)	(0,6541)	(0,3633)

LUX	FIN	PRT	GRC	IRL	UK	SWE	DNK
-0,20	-0,30	-0,12	-1,01	0,20	-0,32	-0,44	-0,09
(0,4998)	(0,4773)	(0,4696)	(1,0745)	(0,5182)	(0,3933)	(0,6570)	(0,4686)

Standard deviations in parantheses

Not a single hypothesis suggesting that any country has a contraction deeper than the contraction in the total EU-15 area is accepted. This would require hypotheses to be tested at a 29 percent significance level in which the recession in Austria and the Netherlands would be significantly less deep than the EU-15 business cycle.[14]

5 Concluding remarks

This study has searched to apply relatively traditional methods in a new way in order to compare the UD of the European business cycle across countries. The debate about business cycle asymmetries across European countries has been going on for years up to the launch of the EMU's third stage, and the debate has once again become relevant due to the inclusion of the Eastern European countries in the EU.

It is shown that the UD of the business cycle does not differ much across countries. Although conclusions in a first-best situation should be based on the broader measure of activity, GDP, this is a result that does not speak against the possibility of timing changes in monetary policy appropriately for the growth situation in most countries at the same time. Furthermore, it is shown that neither the severity of contractions, measured in terms of deepness, differs much across countries, and hence does not speak against the possibility of finding an optimal level of monetary policy adjustment at a given point in time.

It is therefore tempting to conclude that it is possible for the ECB to find an optimal interest rate level, but one must certainly be careful when drawing this conclusion due to different transmission mechanisms across countries, cf. among others Angeloni *et. al.* (2002).

Another problem is that we have only worked with the real side of the economy in this study. The ECB monetary target is to keep price developments stable in the medium term, and despite that some determination of inflation in the medium-term is very likely to be stem from economic activity, it is also given that this is only a partial contribution. A persistent high level of economic activity will tend to reduce unemployment, and will by the end of the day result in wage pressures in the labor market driving up inflation. But likewise, a current high level of inflation calls for

[14] Probabilities of F-tests can be found in Appendix C.2.

more aggressiveness by employees and unions when bargaining. This is a matter of great concern for the ECB, and the ECB has, in fact, several times expressed concern over oil price shocks due to the so-called "second round effects".

Therefore the analysis carried out here can be said to cover only one side of the determinants of medium-term inflation. Therefore, it is by far given that the development of prices show the same degree of comovement across countries as industrial production does, and different results may be obtained when taking this into account. This would be an obvious study to do. *A priori* one could expect this study to mount out in a quite different conclusion when taking recent data for inflation into account. Inflation in Germany is currently well below the euro-zone average, despite the fact that Germany accounts for roughly 1/3 of the index, and therefore – since short-term nominal interest rates are identical – real interest rates are well above average in Germany compared to almost any other member country of the euro-zone.

A further problem is related to the discussion in Juselius (2003) where it is argued that a large part of the development in activity in the period observed here is convergence dynamics after the introduction of the EMS. If this is the case one must think about whether the results obtained here – and in the remaining literature in this area – reflects business cycles or business cycles *and* convergence dynamics. If the latter is the case one should consider to find an appropriate way to decompose the time series into convergence dynamics component and a component reflecting the "true" activity measure.

6 Appendix

A The Bry & Boschan (1971) algorithm

PROCEDURE FOR PROGRAMMED
DETERMINATION OF TURNING POINTS

I. Determination of extremes and substitution of values.
II. 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).
III. Determination of corresponding turns in Spencer curve (extremes replaced).
  A. Identification of highest (or lowest) value within $\pm$ 5 months of selected turn in 12-month moving average.
  B. Enforcement of minimum cycle duration of 15 months by eliminating lower peaks and higher troughs of shorter cycles.
IV. 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 $\pm$5 months of selected turn in Spencer curve.
V. Determination of corresponding turns in unsmoothed series.
  A. Identification of highest (or lowest) value within $\pm$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 duration is less than 5 months*
VI. Statement of final turning points.

Source: Bry & Boschan (1971, Table 1, pp. 21).

* Requirement V.E is modified in this study: Instead of requiring a given phase to have a length of at least 5 months, it is in this study required to have a length of at least 6 months. If a phase, i.e. a contraction, consisting of only 5 months is observed, there would not be enough observations for reserving two observations for Phase 1, one observation for Phase 2, Phase 3 and Phase 4 each, *and* one observation for Phase 5 – this would require at least 6 observations. Remember that the two months surrounding a turning point is included in that particular phase, cf. Figure

1.

B Data sources

All data are drawn from the OECD Main Economic Indicators database at UniDa, http://unida.uni-c.dk/

	Country	Code			Country	Code
AUT	Austria	autprpein01ios		ITA	Italy	itaprpein01ios
BEL	Belgium	belprpein01ios		LUX	Luxembourg	luxprpein01ios
DNK	Denmark	dnkprpein01ios		NLD	Netherlands	nldprpein01ios
FIN	Finland	finprpein01ios		PRT	Portugal	prtprpein01ios
FRA	France	fraprpein01ios		ESP	Spain	espprpein01ios
DEU	Germany	deuprpein01ios		SWE	Sweden	sweprpein01ios
GRC	Greece	grcprpein01ios		GBR	UK	gbrprpein01ios
IRL	Ireland	irlprpein01ios		E15	EU-15	e15prpein01ios

C Tests of growth being equal to growth in EU-15

C.1 Pattern of the European business cycles

Probabilities for F-values for tests of growth being equal to EU-15 growth

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
E15	...	...	...	...	...	...	...	...
DEU	0,5087	0,0132	0,6438	0,4245	0,7240	0,2405	0,2505	0,4513
FRA	0,2630	0,3055	0,4425	0,9097	0,5257	0,0842	0,9741	0,1439
ITA	0,1848	0,4018	0,1904	0,4604	0,7439	0,1801	0,1709	0,7979
ESP	0,3391	0,1762	0,8824	0,8845	0,7466	0,6817	0,2141	0,0595
NLD	0,0347	0,1302	0,6158	0,0709	0,9762	0,0659	0,7582	0,3320
BEL	0,0201	0,0760	0,8819	0,5915	0,7958	0,0373	0,7165	0,8338
AUT	0,0007	0,3706	0,5280	0,2922	0,7633	0,2191	0,0086	0,0392
LUX	0,0082	0,5822	0,8952	0,3152	0,3780	0,1237	0,9743	0,3854
FIN	0,0000	0,0131	0,9766	0,0824	0,4281	0,0148	0,2122	0,1545
PRT	0,3407	0,5816	0,6726	0,5073	0,1461	0,0547	0,7730	0,0272
GRC	0,0320	0,9082	0,8264	0,0537	0,5333	0,6012	0,7498	0,9205
UK	0,4999	0,0377	0,1767	0,4370	0,3951	0,8492	0,9858	0,3465
SWE	0,1142	0,4517	0,5223	0,2798	0,5592	0,0168	0,3383	0,3616
DNK	0,0000	0,1615	0,3898	0,9771	0,0710	0,5483	0,5801	0,2827

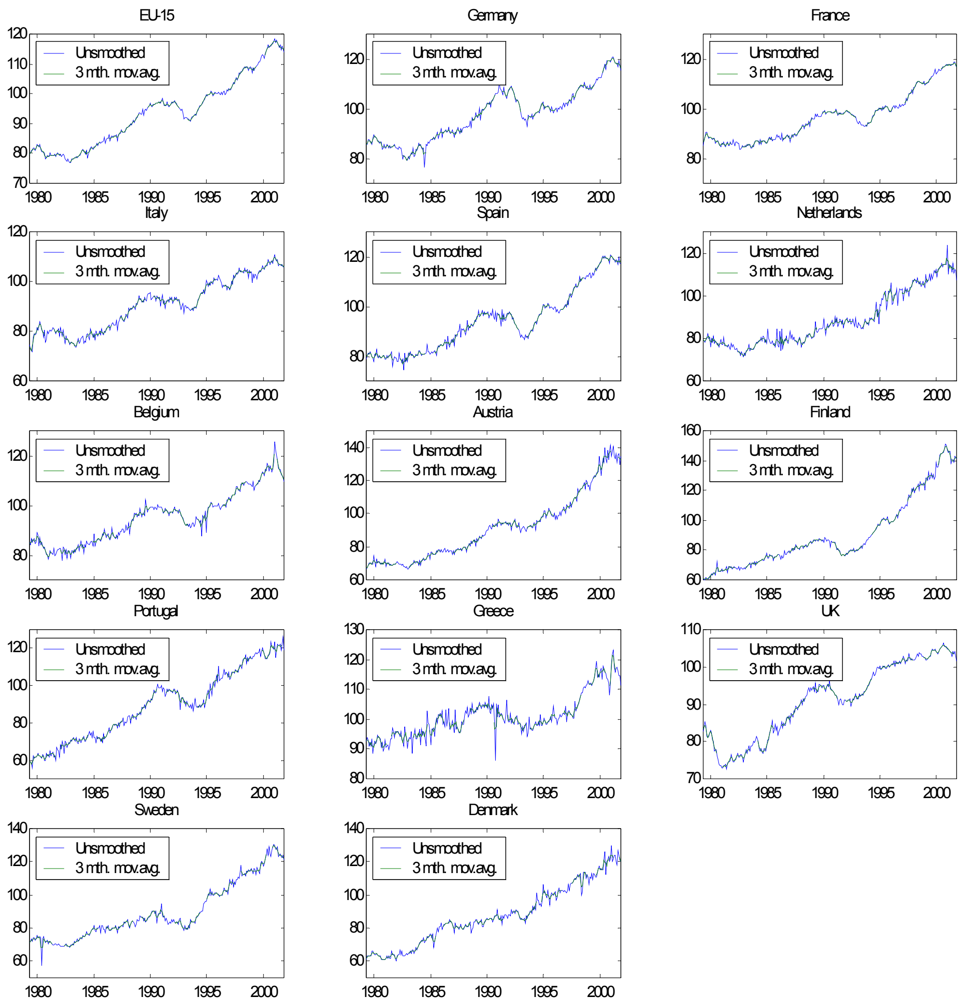
C.2 Severity of recessions

Probabilities for F-values for tests of deepness being equal to EU-15 deepness

E15	DEU	FRA	ITA	ESP	NLD	BEL	AUT
...	0,4827	0,7521	0,5974	0,8588	0,2953	0,8807	0,2901

LUX	FIN	PRT	GRC	IRL	UK	SWE	DNK
0,5898	0,6758	0,5226	0,7810	0,3253	0,6687	0,8223	0,4958

D Smoothing industrial production



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