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The Idiosyncrasy of Business Cycles Across EU Countries

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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 deepness of industrial production. Hypotheses are tested using formal statistical methods while much existing literature in this field rely on judgements of correlation coefficients. The results obtained here does not give much rise to concern about the possibility of the ECB to choose an appropriate timing and magnitude of changes in monetary policy in order to satisfy the economic development in its member countries.

Keywords: Business Cycles, Monetary Policy, European Union
JEL Classifications: E32, E52

*I owe Claus Thustrup Kreiner many thanks a bunch of useful comments and for good discussions of issues dealt with in this paper. A great deal of the conclusions in this study is obtained using the Bry-Boschan algorithm for MATLAB. The effort programming this algorithm is not mine, however; therefore also many thanks to Mark Watson for kindly providing the algorithm in Gauss. Address for correspondence: Jesper.Linaa@econ.ku.dk.

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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 up to ten new countries joining the EU maybe already 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. Very recently, Townend [2002], emphasized that letting UK join the third stage might not necessarily be without problems. Townend [2002] 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 extent 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 directions of research: the *traditional*¹ way of distinguishing between different phases of the business cycle by picking peaks

¹The 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 on basis of 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".

and troughs with the Bry & Boschan [1971] procedure related to the methodology of Burns & Mitchell [1946] and the NBER Business Cycle Dating Committee. The *modern* approach, stemming from the influential work of Hamilton [1989], 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 probability of moving from one state to another is contingent on the current state.

This paper applies the traditional approach to examine the behavior of the business cycle in the various EU member countries. To some extent the paper complements the work of Artis *et al.* [1997, 1998], 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. The same conclusion is obtained by Artis *et al.* [1998] with the use of regime switching models. In a convincing way these papers show that troughs and peaks take place at almost the same time in the various European countries.

However, what still remains to be examined is the behavior of the business cycle *between* the peaks and troughs. Two approaches are worth taking care of, when talking about the underlying dynamics of the business cycle. First, the growth pattern is likely to show a large degree of variation across countries; the transition from a peak to a through, *et vice versa*, is likely to differ from country to country. Second, the severity of recessions might show large variation across countries. The

first approach is important since a lack of a uniform growth pattern will make the choice of *timing changes* in monetary policy a difficult task for the ECB if it is to take care of the economic development in all its member countries. The second approach is of importance when picking the optimal *size of changes* in monetary policy.

This paper seeks to contribute to the existing literature by giving further insight into the underlying dynamics of the business cycle. At the same time the analysis offers a way of testing hypotheses regarding the conformity of business cycles across countries by using formal statistical methods. Most hypotheses in this field of research have so far been tested by evaluating whether a given correlation coefficient returns a “low” value or not, and more formal methods would 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 concludes that not much evidence gives 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 is found. This is a conclusion that enhances the findings of Artis *et al.* [1997, 1998].

Together with Artis *et al.* [1997, 1998] this paper comes up with two results in favor of the possibility of leading a common monetary policy. First, the conclusions of Artis *et al.* [1997, 1998] indicate that the *timing* of changes in monetary policy can be set almost appropriate for all countries at the same time. A conclusion that is enhanced by the present study. Second, this paper adds hereto that the severity of recessions are almost equal across countries, which means that also the *magnitude* of adjustments of monetary policy, i.e. the size of rate changes, can be set to a value

acceptable for most countries.

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

2 Theoretical framework

First, the underlying 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 to be the OECD EU-15 aggregate. Second, it is examined whether the severity of recessions in terms of deepness or horizontal asymmetry, differ across countries. In both aspects data for industrial production is used.

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. For doing so I revert to the methodology of Burns & Mitchell [1946]. The Burns & Mitchell definition of a business cycle can be summarized in the highly quoted section of Burns & Mitchell [1946, pp. 3].

“Business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phases of the next cycle; this sequence of changes is recurrent but not periodic;

in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own”

Several points are worth noting in relation to this definition. First, business cycles cannot be determined from a single time series, unless this in itself reflects “the aggregate economic activity”. This will very likely never be the case. Second, a business cycle is defined to two overall phases; the expansion phase and the contraction phase. This distinction requires a way of determining peaks and troughs of a given time series. Third, “aggregate economic activity of nations” calls for a measure of the business cycle related to the *levels* of the observed time series.²

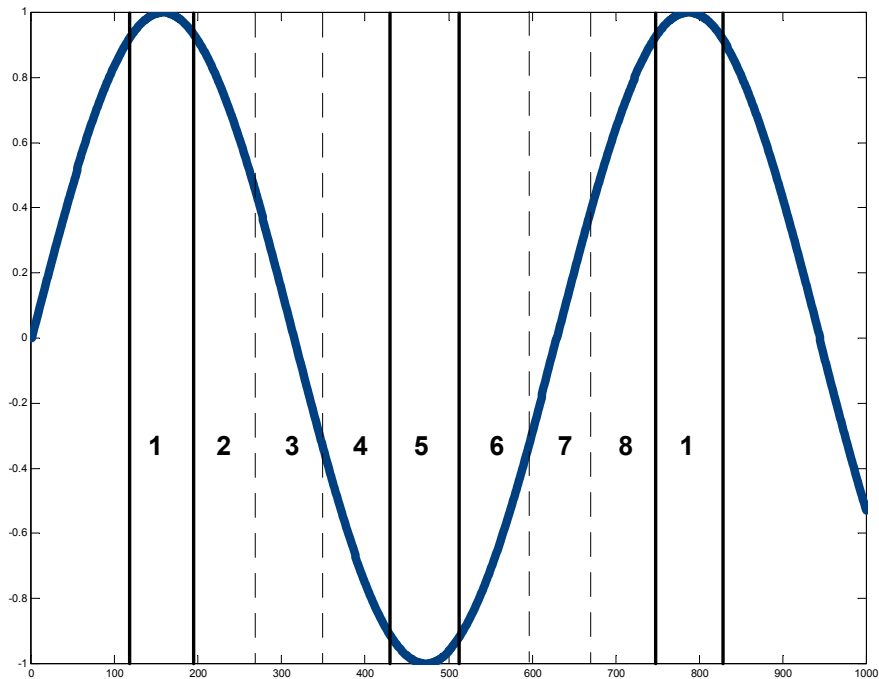
Today the official US peaks and troughs are determined by the NBER Business Cycle Dating Committee. The methodology behind this follows the Burns & Mitchell [1946] definition in the sense that a business cycle are not determined from the development in a single time series. Bry & Boschan [1971] developed 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.³ See the next section for a presentation of the data.

²For a further discussion of these issues, see Pedersen [1999, ch. 5].

³See appendix A for an overview of details on the Bry & Boschan methodology and for an elaboration of the modifications used in this study.

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 from “phase 1” to “phase 5”, while “phase 6” to “phase 8” cover the time from “phase 5” to “phase 1”.^{4,5}

Figure 1. The 8 phases of the business cycle



Finally, I follow Balke & Wynne [1995] and obtain average growth rates estimates in each phase using phase dummies and apply Chow tests, cf. Chow [1960],

⁴Symmetry 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 observation from phase 2 and phase 4 (phase 6 and phase 8).

⁵In 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.

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

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

where γ_{EU} and γ_i are vectors containing the growth rates of industrial production in EU respectively country i , X_i are $(n_i \times 8)$ matrices containing dummy variables describing which phase the corresponding growth rate belongs to, n_i is the number of observations regarding country i , and ε_i are error terms. The OLS estimates of β_{EU} and β_i , $\hat{\beta}_{EU}$ and $\hat{\beta}_i$, will be identical to average growth rates in the corresponding phase. Standard deviations of the OLS estimates must be obtained using the Newey-West covariance estimator to eliminate serial correlation. 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 $j = 1, 2, \dots, 8$ where j is the number of the corresponding phase.

2.2 Severity of recessions

Measuring the severity of the typical recession is done by constructing a measure of the deepness of the business cycle identical to the one that Sichel [1993] used for his study of the US business cycle.

In this aspect it is not appropriate to work with the *levels* of time series since it on the contrary is *the deviation from natural output* that is of interest. Therefore,

one should instead apply detrended time series and focus on the cyclical component defined as the distance between the actual production and the output trend level.⁶

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 [1997] when working with monthly observations. I eliminate the first and last three years of observations due to the end-point problems related to the Hodrick-Prescott filter, cf. Baxter & King [1995] and Cogley & Nason [1995].

As Sichel [1993] I use the coefficient of skewness

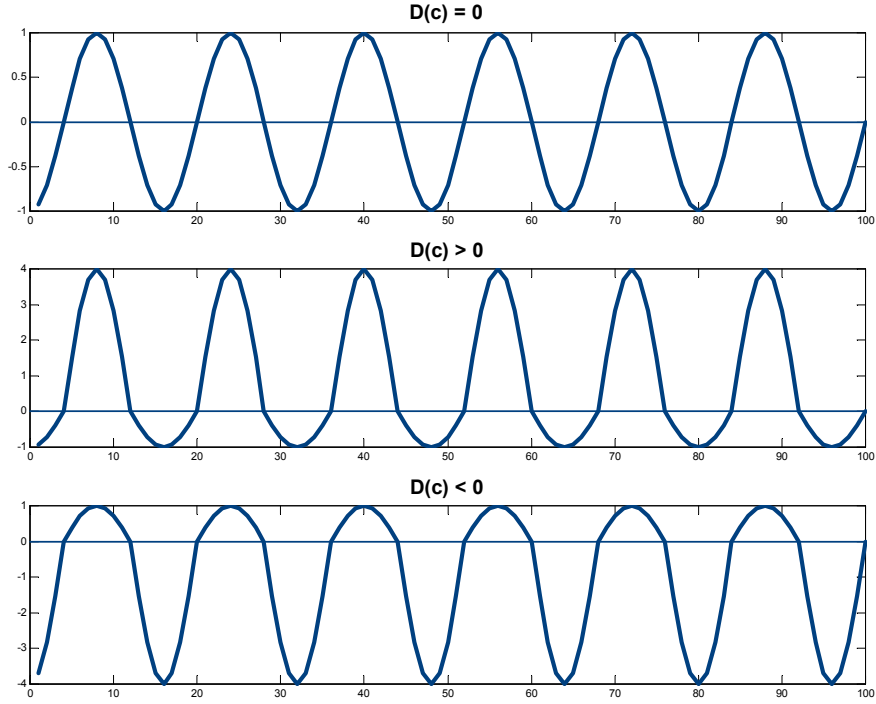
$$D(c) = \frac{\frac{1}{T} \sum_{t=1}^T (c_t - \bar{c})^3}{\sigma(c)^3} \quad (2)$$

where \bar{c} is the mean of c_t , $\sigma(c)$ is the standard deviation of c_t and T is the size of the sample.

Figure 2 below gives three examples of a given time series. The first graph shows a time series, where the maximum distance from the mean to the peak value is equal the maximum distance from the mean to the trough value. The middle graph shows an example 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 last graph. The three examples will provide values of $D(c)$ equal to zero, greater than zero respectively less than zero.

⁶This measure of the business cycle is often referred to as growth cycles and is widely used when evaluating the predictions of a CGE model.

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



Following Sichel [1993], I obtain an asymptotic standard deviation – the Newey-West estimator – of $D(c)$ by regressing

$$z_t = \frac{(c_t - \bar{c})^3}{\sigma(c)^3} \quad (3)$$

on a constant using the Newey-West standard error. The parameter estimates will then be identical to $D(c)$ in (2). Analogous to (1) the model

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

is estimated. Z_{EU} and Z_i are vectors containing the values of z_t for EU respectively country i , I_{EU} and I_i are vectors containing ones, while ω_{EU} and ω_i are 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 1979 - October 2001, hereafter 1979:4 - 2001:10 is used. This beginning of the period is chosen to respect the findings of Artis & Zhang [1997] that concludes that the ERM in general has promoted the synchronicity of the European business cycles, and that the similarity of European business cycles is to be found in another regime hereafter.

Data is drawn from OECD Main Economic Indicators, see appendix B for specific codes and for mnemonics used in this paper.

Looking at industrial production instead of the overall measure of activity – GDP – has at least 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 should – 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 extent 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.

The obvious disadvantage by using industrial production instead of overall activity measured by GDP is that industrial production does only tell about the economic climate in a part of the economy. Furthermore, the share of industrial output relative to overall output has in general dropped over the last decades. 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 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 expected to join the EU and who one day even might be a member 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 can be seen 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 1.⁷

⁷Ireland 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

Examining Table 1 reveals only very few “wrong” signs of the estimates. This is not surprising; 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, 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 might not in itself be zero.

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 cycle⁸. 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. This is, however, the problem in a nutshell; when attaching the largest weights to the largest countries before aggregating and using this time series for designing monetary policy, the risk of ignoring the economic development in the smaller countries arises.

The risk cannot be rejected from this analysis, but it 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 zone. Four out of eight phases differ significantly in Finland. Hereafter follow 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

⁸Probabilities of F-tests can be found in appendix C.1.

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 reveals no information pointing towards much convergence problems 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 result enhances the findings of Artis *et al.* [1997, 1998] and speaks in favor of the possibility of *timing* changes in monetary policy appropriate for the growth situation in most countries at the same time.

4.2 Severity of recessions

While the pattern of growth over the business cycle is relevant for the *timing* of changes in monetary policy, the severity, or deepness, of the business cycle is of interest in relation to the *size* of changes in monetary policy. Yet, neither calculating the coefficient of skewness as defined in (2) for the various countries gives rise to any immediate concern about the homogeneity of the European business cycle.

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 recession deeper than

the recession in the total EU-15 area can be accepted. This would require hypotheses to be tested at a 29 percent significance level in which the recession in Austria would be significantly less deep than the EU-15 business cycle.⁹ This is an important observation that gives an indication of to what extent a typical recession will hurt employment and activity in general. The results presented in Table 2 therefore do not give rise to much concern about the possibility of leading a common monetary policy in order to neutralize the negative impact of a recession on employment. The results instead point towards that the optimal level of monetary medicine to be donated from the ECB does not differ much between countries.

5 Concluding remarks

This study has in a new way applied traditional methods to test the European business cycle conformity 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 expected inclusion of the Eastern European countries in the EU.

It is shown that the underlying dynamics of the business cycle does not differ much across countries. This result speaks in favor of the possibility of timing changes in monetary policy appropriate for the growth situation in most countries at the same time. Furthermore, it is shown that neither the severity of recessions, measured in terms of deepness, differs much across countries. This speaks in favor of the possibility of finding an optimal level of monetary policy adjustment at a given point in time.

⁹Probabilities of F-tests can be found in appendix C.2.

The conclusion therefore is that the findings obtained here do not give rise to much concern about the possibility of designing a single European monetary policy appropriate for most countries. However, this study – just as most of the studies in this field – founds its conclusions on time series of industrial production. This is a problem since the ECB has committed themselves very strictly to let the development of prices in the medium-term run be of primary concern.

It is by far given that the development of prices show the same degree of co-movement across countries as industrial production does, and different results may be obtained when taking this into account. Research on the homogeneity of development in prices should be given a high priority in the future.

The study also supports the conclusion of Artis *et al.* [1997] that emphasizes the need for taking inter-country effects into account when searching for sources behind business cycles, since only few business cycles are confined to single countries.

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 ± 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 ± 5 months of selected turn in Spencer curve.
 - V. Determination of corresponding turns 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 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	nldrpein01ios
FIN	Finland	finprpein01ios	PRT	Portugal	prtprpein01ios
FRA	France	fraprpein01ios	ESP	Spain	esprpein01ios
DEU	Germany	deuprpein01ios	SWE	Sweden	sweprepein01ios
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

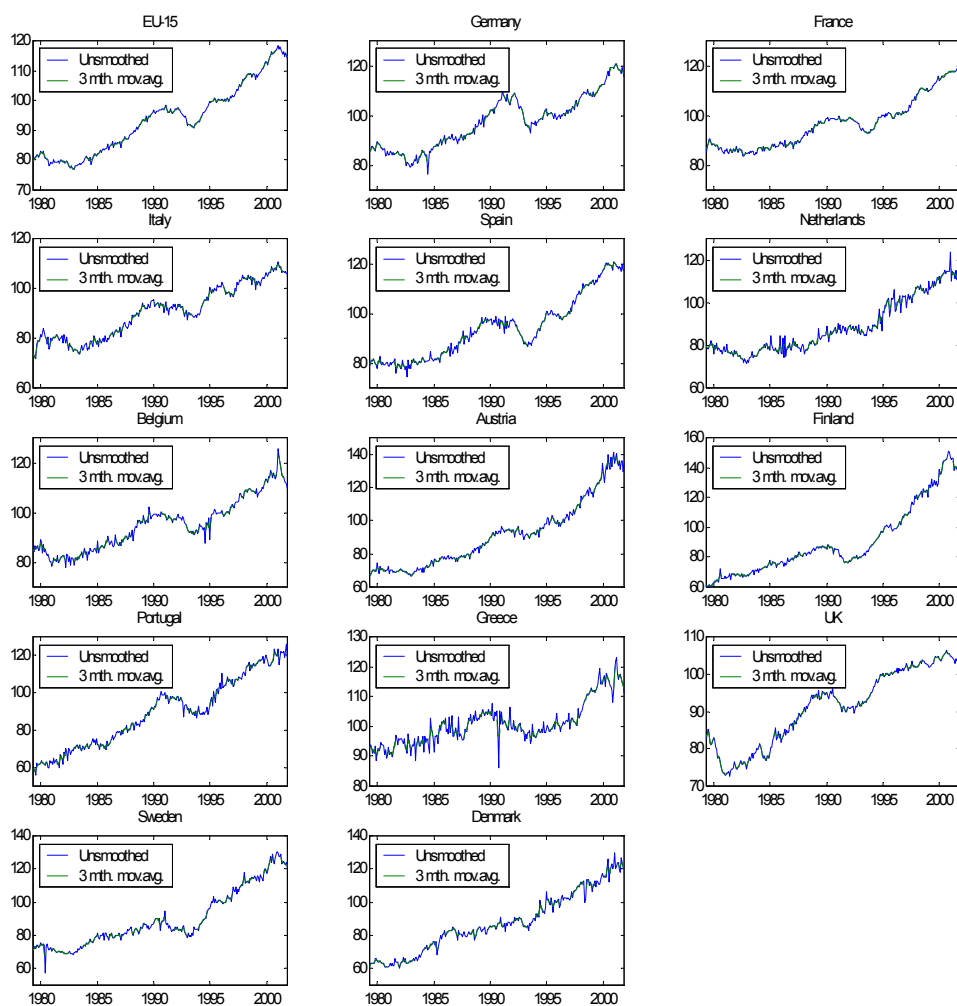
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
E15
DEU	0,5087	0,0132	0,6438	0,4245	0,7240	0,2405	0,2505	0,4513
FRA	0,2630	0,3055	0,4425	0,9097	0,5257	0,0842	0,9741	0,1439
ITA	0,1848	0,4018	0,1904	0,4604	0,7439	0,1801	0,1709	0,7979
ESP	0,3391	0,1762	0,8824	0,8845	0,7466	0,6817	0,2141	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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