Business cycle synchronisation with(in) the euro area: In search of a ‘euro effect’*

Bas van Aarle[a], Marcus Kappler[b], Atilim Seymen[b], Klaus Weyerstrass[c],

Abstract

This paper studies business cycle synchronisation and convergence in the euro area. A set of stylised facts concerning the characteristics of the business cycle and synchronisation in the euro area is derived. It is analysed whether convergence or divergence patterns between the euro area countries changed after the introduction of the euro. In addition, a closer look is taken at the degree of business cycle synchronisation between other countries and the euro area average. Furthermore, a cluster analysis identifies clusters of countries within the euro area and an OECD sample sharing common business cycles, and a dynamic correlation analysis is carried out to broaden the scope of business cycle synchronisation further. We enrich the study with a frequency domain analysis and use the concepts of coherence, dynamic correlation and phase. Our main results are that coherence and dynamic correlation among the euro area countries, the UK, Japan and the US are fairly high.

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[a] European Business School, Soehnleinstrasse 8, 65201 Wiesbaden, Germany
[b] Zentrum für Europäische Wirtschaftsforschung, L 7, 1, D-68161 Mannheim, Germany
[c] (Corresponding author) Institut für Höhere Studien, Stumpergasse 56, 1060 Wien, Austria. Tel. +43/1/59991-233; Fax: +43/1/59991-555; Email: klaus.weyerstrass@ihs.ac.at.

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1 Introduction

Synchronicity of business cycles is often regarded as an important prerequisite for the well-functioning of a currency union like the euro area. In absence of a certain degree of synchronicity monetary policy does not satisfy the needs of all and may even contribute to cyclical divergence. The degree of business cycle convergence in a monetary union is the result of a number of different factors, the most important including the degree of symmetry of the underlying macroeconomic shocks in the Member States, the degree of symmetry in transmission channels and symmetry in institutional features (including fiscal policy) between the Member States, as well as the level of economic integration between the member countries. All these aspects play a important roles in the Optimal Currency Area (OCA) theory that seeks to determine the costs and benefits from a common currency and which has received a great deal of attention in the discussion about the creation of the euro. The aim of this paper is to provide new evidence about the degree of business cycle synchronisation and convergence in the euro area and other European and non-European countries.

The business cycle is not observed and assumptions about its characteristics have to be made in order to estimate it. Several methods to disentangle the cycle and trend from observed data exist, and the view on the business cycle and synchronicity will partly depend on the methodological choice. A set of stylised facts concerning the characteristics of the business cycle and synchronisation in the euro area and beyond will be derived as a starting point. A further question is whether convergence or divergence patterns between the euro area countries changed after the introduction of the euro. In addition, we also take a closer look at the degree of business cycle synchronisation between other countries and the euro area average. A comparison between the degree of synchronisation in the euro area and that in the other major industrialised countries will help to assess the effects of globalisation on cyclical convergence. If convergence of the euro area and other countries increased (or decreased) to a similar extent, the dynamics of business cycle convergence in the euro area may well be seen as part of a more global process of convergence (or divergence) rather than something specific to the euro area. Next, with the aid of a cluster analysis groups of countries within the euro area and an OECD sample sharing common business cycles are identified.

Section 2 establishes the main stylised facts concerning business cycle synchronisation in the euro area. Section 3 analyses business cycle synchronisation between the euro area and non-euro area countries. A cluster analysis is undertaken in Section 4 to identify groups of countries in the euro area and in the OECD that form clusters in terms of business cycle synchronisation. Section 5 uses dynamic correlation analysis to further refine the temporal aspects of business cycle synchronisation. Section 6 concludes the paper by summarising the main findings.

2 Business cycle synchronisation: Methodology and stylised facts for the euro area

In this section a set of up-to-date stylised facts concerning business cycle characteristics in the euro area and beyond is provided.

2.1 Methods of estimating the business cycle

In order to decompose the trend and the cycle components of observed real output, we examine several parametric and non-parametric approaches that have been proposed by Massmann and Mitchell (2004). In addition, a full structural production function approach as employed by the OECD is considered. After a brief outline of each method, we illustrate the differences and similarities of the outcomes by giving a synopsis of the estimated cycles for the aggregate real GDP of the 12 countries forming the euro area until the end of 2006 (euro area 12). The subject of interest is whether the different methods produce similar assessments of fluctuations in the output gap, i.e. the deviation of actual GDP from the estimated long-run trend or whether the different methods imply fundamentally different views on the development of the business cycle over time. We apply the following methods:

Within the class of non-parametric methods, the commonly used are the "band-pass filters" of **Baxter-King (BK)** and **Christiano-Fitzgerald (CF)**, which eliminate the trend and irregular components of a time series while preserving business cycle components. Both procedures are based on variations of two-sided moving averages to the time series and differ only in terms of the estimation of the weights given to the lead and lag components. Both filter variants require a specification of a typical cycle length, which we set at 1.5 to 8 years. The band-pass filter of BK requires a specification of a finite-order moving average for extracting the high-frequency component. For our quarterly data we employ a symmetric moving average of 12 quarters. The **Hodrick-Prescott (HP)** filter obtains the trend components of a time series after selecting the degree of smoothness for the trend. Regarding the smoothing parameter λ, we use the standard value of 1600 for our quarterly data. Also considered is a symmetric **moving average (MA)** for estimating a smooth trend component of the underlying series. The estimate of the cycle is the difference between the observations and the MA, which in our study is set to 12 quarters. In addition, we calculate the **first order difference (D1)** and for the **year-on-year difference (DIF4)** of real GDP. Although these transformations do not rely on a sophisticated statistical framework to decompose trend and cycle, they offer quite intuitive interpretations. For instance, these are the transformations commonly referred to when new economic data are officially released and communicated by EUROSTAT.

The **linear regression model (TIM)** assumes that output fluctuates around a deterministic trend and that deviations from the trend are stationary and may be interpreted as the cyclical component. However, such an assumption is in contrast with the usual outcomes of unit root tests, which imply that GDP is an integrated or difference stationary process. An **unobserved components model (UC)** is also considered. The model assumes that output can be decomposed into a trend, a cycle and an irregular component. We use the same specification as Massmann and Mitchell (2004) who employ a smooth local linear trend model which goes back to Harvey (1993). In this model, the trend component is a second order random walk, while the cycle is specified as a trigonometric function. The cycle measure is the difference between the estimated trend and the actual output series. Model parameters are estimated via the Kalman filter recursion and numerical optimisation of the likelihood function. The unobservable trend component is obtained with the aid of the fixed interval Kalman smoother. The **production function approach (PFA)** of the OECD belongs to the class of multivariate methods for estimating the trend component of output and the output gap. The PFA combines data on potential labour input, the trend of total factor productivity and the capital stock with a production technology, typically of Cobb-Douglas type.[1] For the present paper, we use the quarterly output gap series of the OECD Economic Outlook.

2.2 Methods of measuring synchronicity and convergence

Contemporaneous unconditional Pearson correlations, either computed between the business cycles of individual countries and a reference country or computed as unconditional bilateral correlations, are often used to assess business cycle synchronisation. To check for convergence, these correlations are typically computed over different time periods using a fixed or rolling sample window. The first alternative allows examining whether a single country convergence to a reference series - the euro area aggregate in our case - while the bilateral correlations allow to examine the dispersion of business cycle similarities over a group of countries. In particular, the first and second moments help to assess whether convergence takes place: a rise in the mean of the correlations computed over consecutive periods coupled with a simultaneous decrease in the variance of the correlations is considered as evidence of increased synchronisation. In the case of rolling samples, the outcomes can be sensitive to the considered window length over which correlations are computed (Gayer, 2007). The window length should be wide enough to leave sufficient observations to compute precise correlation coefficients but short enough to study the time-varying pattern of business cycle correlations.[2]

2.3 Cycle measures for euro area GDP

We start the descriptive analysis with a synopsis of the different measures for the cycle of aggregate GDP of the euro area. Figure 1 shows the time series graphs of the cycles over the period from 1970Q1 to 2007Q3.[3] The shaded areas highlight the periods of recession that have been identified by the CEPR Business Cycle Dating Committee and which have been updated for the periods after 2003Q3 with the aid of the Harding and Pagan (2002) dating rule. Table 1 contains a set of summary statistics which characterise these measures that have been computed over the common sample from 1991Q1 to 2007Q3. The visual inspection clearly demonstrates the sensitivity of the business cycle to the measurement.

[1] Beffy et al. (2006) explain the PFA procedure of the OECD in detail.
[2] Gayer (2007) remarks that "if the window length is shorter than the mean length of the cycle, small phase shifts between otherwise identical cycles can lead to systematic, but artificial, drops in the association measure at the turning points of the cycles."
[3] For the computation of the symmetric Baxter-King (BK) filter and the symmetric moving average (MA), the sample has been extended to 2009q4 by inclusion of GDP projection from the OECD Economic Outlook. Note that the BK filter loses 12 quarters of observations at either side of the sample, while the MA filter reduces the sample by 6 quarters.

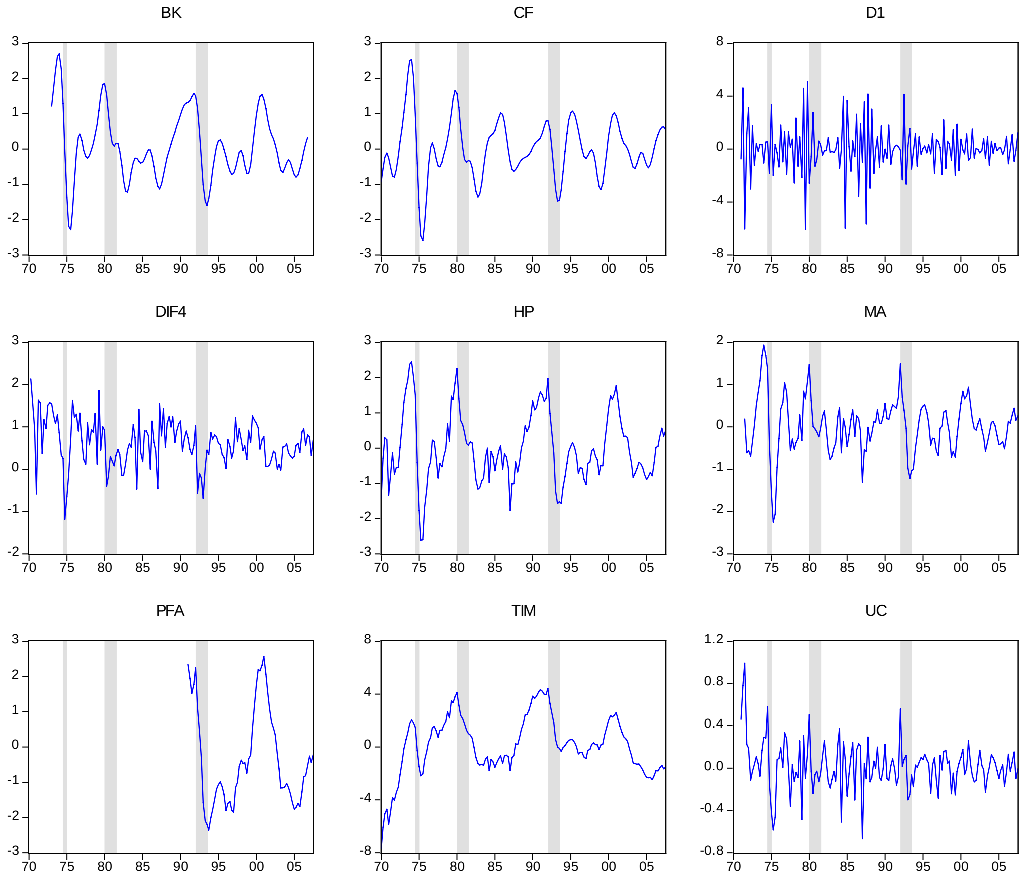


Figure 1: Cycle estimates for euro area GDP. BK=Baxter-King, CF=Christiano-Fitzgerald, D1=first differences, DIF4=year-on-year differences, HP=Hodrick-Prescott, MA=Moving average, PFA=Production function approach, TIM=linear regression model, UC=unobserved components model

The business cycles obtained with the band pass filters (BK and CF), the HP, the PFA, the MA and the TIM show similar patterns which are formally confirmed by the correlation coefficients (see Table 1). The first and fourth order differences (D1 and DIF4) of actual euro area GDP and the unobserved components model (UC) produce cycle patterns that are generally more volatile than the outcomes of the remaining methods.

Table 1: Summary statistics of euro area cycle measures

	BK	CF	D1	DIF4	HP	MAC	PFA	TIM	UC
Mean	-0.00	-0.00	0.01	0.49	-0.04	0.00	-0.36	0.33	0.00
Median	-0.21	-0.05	-0.00	0.53	-0.22	0.02	-0.84	0.15	0.02
Maximum	1.57	1.07	4.14	1.26	1.98	1.49	2.57	4.42	0.56
Minimum	-1.59	-1.47	-2.65	-0.69	-1.58	-1.22	-2.36	-2.48	-0.30
Std. Dev.	0.81	0.65	1.14	0.39	0.88	0.52	1.41	1.77	0.14
Skewness	0.48	-0.26	0.38	-0.52	0.57	0.01	0.70	0.60	0.43
Kurtosis	2.48	2.45	4.71	3.69	2.51	3.08	2.19	2.83	5.41
Jarque-Bera	3.22	1.55	9.29	4.11	4.09	0.02	6.96	3.91	17.44
Probability	0.20	0.46	0.01	0.13	0.13	0.99	0.03	0.14	0.00

Note: Sample period is from 1991Q1 to 2007Q3. See also notes to figure 1.

Table 2: Correlations of cycle measures

Correlation	BK	CF	D1	DIF4	HP	MAC	PFA	TIM	UC
BK	1.00								
CF	0.80	1.00							
D1	0.01	0.02	1.00						
DIF4	0.12	0.15	0.12	1.00					
HP	0.98	0.74	0.00	0.19	1.00				
MAC	0.89	0.84	-0.00	0.28	0.89	1.00			
PFA	0.92	0.54	-0.00	0.12	0.95	0.74	1.00		
TIM	0.78	0.44	-0.01	-0.01	0.79	0.63	0.82	1.00	
UC	0.39	0.45	-0.02	0.46	0.48	0.73	0.34	0.27	1.00
Probability	BK	CF	D1	DIF4	HP	MAC	PFA	TIM	UC
BK	-----								
CF	0.00	-----							
D1	0.92	0.89	-----						
DIF4	0.33	0.23	0.34	-----					
HP	0.00	0.00	0.97	0.13	-----				
MAC	0.00	0.00	0.99	0.03	0.00	-----			
PFA	0.00	0.00	1.00	0.33	0.00	0.00	-----		
TIM	0.00	0.00	0.96	0.93	0.00	0.00	0.00	-----	
UC	0.00	0.00	0.85	0.00	0.00	0.00	0.01	0.03	-----

Note: The *p*-values reported are for testing the hypothesis that a single correlation coefficient is equal to zero. Sample period is from 1991Q1 to 2007Q3. See also notes to Figure 1.

Overall, this exercise confirms the well documented fact that our picture of the business cycle mainly depends on it is measured (Massmann and Mitchell, 2004, Canova, 1998). This clearly advices not to focus the attention to just one measure of the business cycle when looking for convergence. Therefore, whenever sensible we look at several approaches to estimate the cycle to assess and test for synchronisation and convergence.

2.4 Stylised facts on business cycle synchronisation and convergence in the euro area

In this section, we provide an up-to-date view on synchronisation and convergence in the euro area. While the broadest view on the business cycle is certainly provided by real GDP, many studies focus on industrial production as a proxy due to monthly data availability. Some even argue to look at stationary business and consumer survey data to circumvent the problem associated with the identification of the cyclical component from trending statistical data (Gayer and Weiss, 2006). The variable we use in the first step is real GDP for the 12 Member States of the euro area.[4] In order to check the robustness of the results to alternative measurements of the cycle, the different approaches to separate cycles from trend as outlined in section 2.1 are considered.

A window length of 6 years has been chosen for computation of the correlations over a fixed rolling window. This length is approximately in line with the average duration of completed business cycle for the euro area since 1970 (cf. Figure 1). The averages of the correlations over the fixed rolling window (solid blue line) are shown in Figure 2 together with the average correlations for a fixed observation period with the same length (dotted red line). The rolling correlation refer to the *end points* of the windows, i.e. they compute the average correlation over the past window length. We focus on unweighted correlations and do not consider a weighting of correlation coefficients by country size since Gayer (2007) reports that the weighting of countries does not qualitatively alter findings.

Figure 2 shows that from all cycle measures a decrease in synchronisation appears for the recent past according to the rolling correlation measures. The dotted red lines which computes average correlations for three non-overlapping periods of equal length (1989Q1 to 1994Q4, 1995Q1 to 2000Q4 and 2001Q1 to 2007Q3) show for most cycle estimates that business cycle synchronisation is on a high level and steady over sub-periods. Exceptions are the correlations computed for the fourth differences of GDP. These show no degree of synchronisation at all and seriously question the use of such a measure for evaluating business cycles. The CF cycles imply a jump of synchronisation in the mid-nineties which is not observed for the other cycle measures. The drop in correlation that took place in 1997 coincides with the Asian emerging market crisis which had fairly diverse effects on the individual euro area countries (Gayer, 2007). The final stage of EMU with the introduction of the euro in January 1999 is accompanied by an increase in synchronisation. Also this well-known finding emerges clearly in Figure 2. Since 2003 a decrease in correlations can be observed which seems not to have stopped yet. None of the cycle measures considered points upwards at the end of the sample. The most recent sharp economic downturn originating from the mortgage sub-prime crisis in the US and hitting almost all industrialised countries and many emerging economies might have resulted in an increasing business cycle synchronisation. At present, however, it is too early find evidence for this notion in the data.

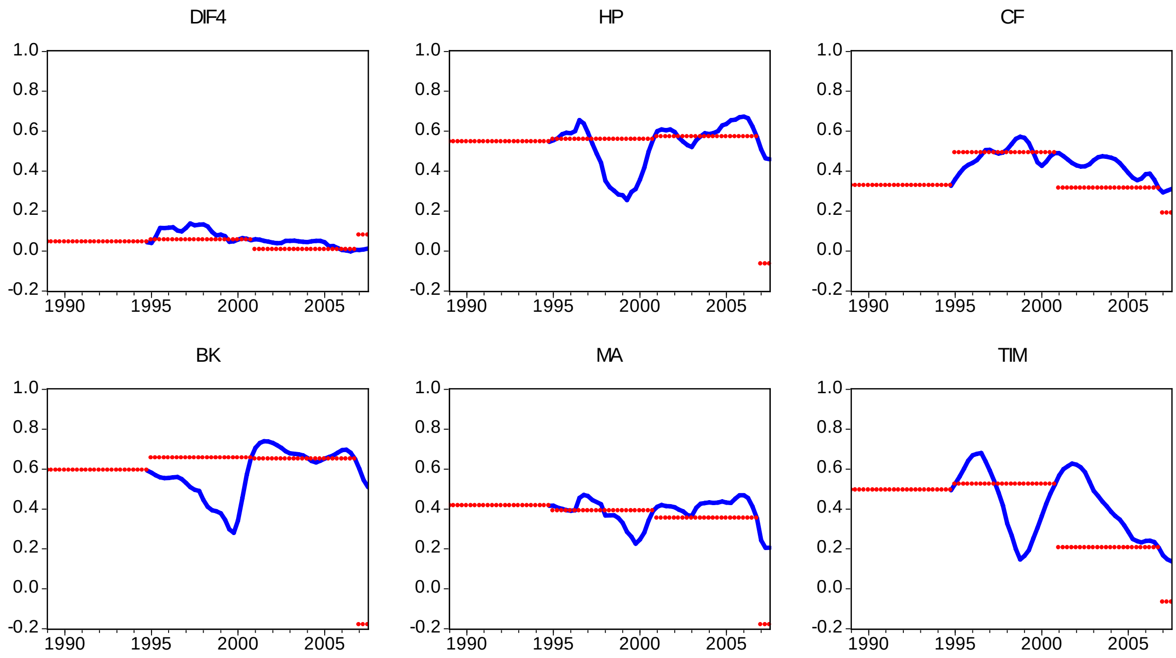


Figure 2: Mean of correlations in the euro area over a 6 year rolling window (blue) and a fixed period of 6 years (red). See also notes to figure 1.

[4] Lack of data availability prevents us from considering the new euro area members Slovenia, Malta and Cyprus in this more long-term oriented exercise.

The overall picture of the development of mean correlations masks trends on the individual country level. Figure 3 shows the evolution of the correlations of the individual euro area countries vis-à-vis the euro area aggregate.

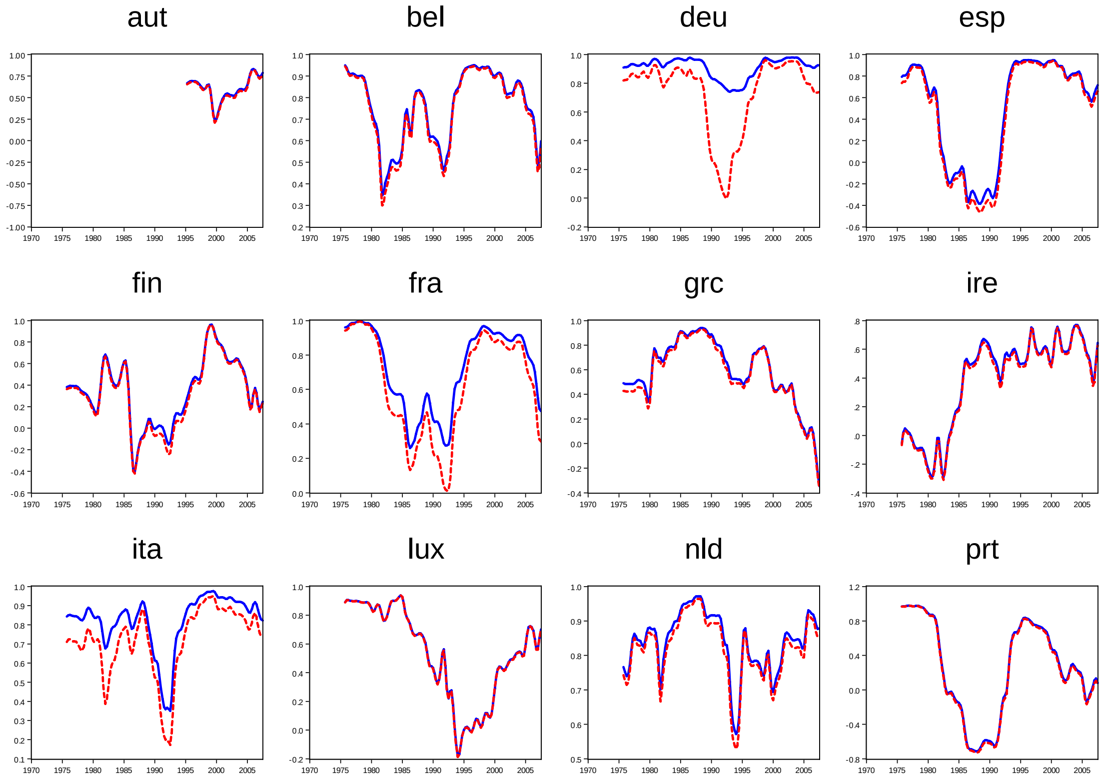


Figure 3: .Correlations of member countries vis-à-vis the euro aggregate
Notes: 6 years rolling window. CF filter based business cycles. ---: correlations against the total euro area cycle, ----: correlations against the aggregate euro area cycle which excludes the reference country. aut: Austria, bel: Belgium, deu: Germany, esp: Spain, fin: Finland, fra: France, grc: Greece, ire: Ireland, ita: Italy, lux: Luxembourg, nld: Netherlands, prt: Portugal.

These pictures basically confirm the results of previous studies showing that in particular Greece and Portugal have had business cycles that have uncoupled from the cycles shared by the larger European countries in recent years. For completeness, also correlations of a country with its respective “rest-of-the-euro area aggregate” are shown in Figure 3 to point out that only in the cases of Germany, France and Italy there could be small overestimations due to the large weights of these countries when taking the euro area aggregate to analyse business cycle synchronisation. This drawback has to be weighed against the complications of working with 12 (slightly) different (rest-of) euro area business cycles.

3 Business cycle synchronisation between the euro area and non-euro area countries

As discussed in the introduction, business cycle synchronisation and macroeconomic convergence in general are - amongst many other factors - key requirements for a well-functioning monetary union like the euro area. The working of the euro area is not only crucial for its member countries, but also for countries outside the euro area due to their economic linkages with the euro area. In fact, important questions could well be posed, such as: Has the introduction of the euro affected business cycle synchronisation within the euro area and between the euro area and non-euro area countries, both inside and outside the EU? What roles do global convergence and synchronisation play? In the literature on business cycle synchronisation, in particular the role of economic integration on business cycle convergence has been analysed, finding evidence of a positive relation, see in particular Frankel and Rose (1998), Imbs (2004), and Baxter and Kouparitsas (2005).

Here, we analyse business cycle synchronisation of other countries with the euro area. Within the group of the non-euro area countries we distinguish two sub-groups: (i) the group of EU countries that are currently not members of the euro area (NMS, Denmark, Sweden and the UK)[5] and (ii) the group of non-EU OECD countries. For the first group, an additional and important aspect is that entering the euro area at some point in time is a real option/obligation. The analysis of this group could be seen from the perspective of the OCA, where a sufficient degree of business cycle synchronisation is one of the criteria.

In this section, we analyse if there has been any change in business cycle synchronisation relating to the introduction of the euro. To do so, we compare business cycle synchronisation pre- and post EMU, analyse the cross-regime behaviour of business cycles and consider global business cycle convergence and its link with synchronisation in the euro area. We also take a brief look at business cycle volatility since it could also be related to business cycle synchronisation. The trend-cycle decomposition is achieved by taking (a) the HP filter and (b) year-to-to year growth rates. Note that in the case of the NMS the calculation of output gaps and other detrended variables is (even) more problematic than in the case of euro area countries: sample sizes are generally shorter, data less accurate, structural breaks omni-present and a long-run steady state of the economy not well defined. Despite such limitations, it is assumed that our data do approximate to a certain extent the true economic conditions. To obtain some degree of robustness in our results we include in the analysis both growth rates and de-trended variables based on the HP filter. In most cases both measures of the business cycle seem comparatively similar so that we indeed expect to obtain our results with some robustness.

One important aspect that we analyse first is whether business cycle volatility has changed. In recent studies, several authors have found that business cycle volatility has tended to decline since the mid 1990s. Evidence is found in particular for the US (where it has been dubbed the “Great Moderation” by Blanchard and Simon, 2001), but this decline in business cycle volatility seems to have also more global dimensions. Various explanations have emerged for this observed decline in business cycle volatility, ranging from higher trade and financial integration, lower exchange rate and terms-of-trade volatility, increasing consumption smoothing, better monetary and fiscal management, a “good-luck” factor in the sense of smaller and less frequent macroeconomic shocks, to more technical and institutional aspects such as more efficient inventory management and deregulation. Taken all together, these developments can be expected to explain the observed increased stability of business cycles in many countries and of the global economy as a whole. Overall, there is no clear consensus on the relative importance of each of such alternative explanations for the drop in business cycle volatility (neither in the case of the US nor of the euro area).

For the euro area an additional aspect may be taken into consideration, namely the possibility that the creation of the euro has contributed to a change in business cycle volatility. Obviously, that would be an important finding since it would mean that adopting the euro has led to a shift in busi-

[5] Slovenia entered the euro area on 1 January 2007, Cyprus and Malta on 1 January 2008, but for consistency and comparability we treat these three countries here as if they had not yet entered the euro area, so that the euro area in this section always refers to euro area-12.

ness cycle volatility in the euro area countries, apart from other factors that may play a role such as a global shift in business cycle volatility. Whether the introduction of the euro has had a negative, no, or positive effect on business cycle volatility is again an empirical question similar to the question on the effect of the euro on business cycle synchronisation. From a theoretical perspective there could be reasons to have both positive effects (positive effects on management of macro-economic policies, positive effects of higher integration) and negative effects (less coordination of monetary and fiscal policies from a national point of view, loss of exchange rates as shock absorber in the case of asymmetric shocks, the increased specialisation argument).

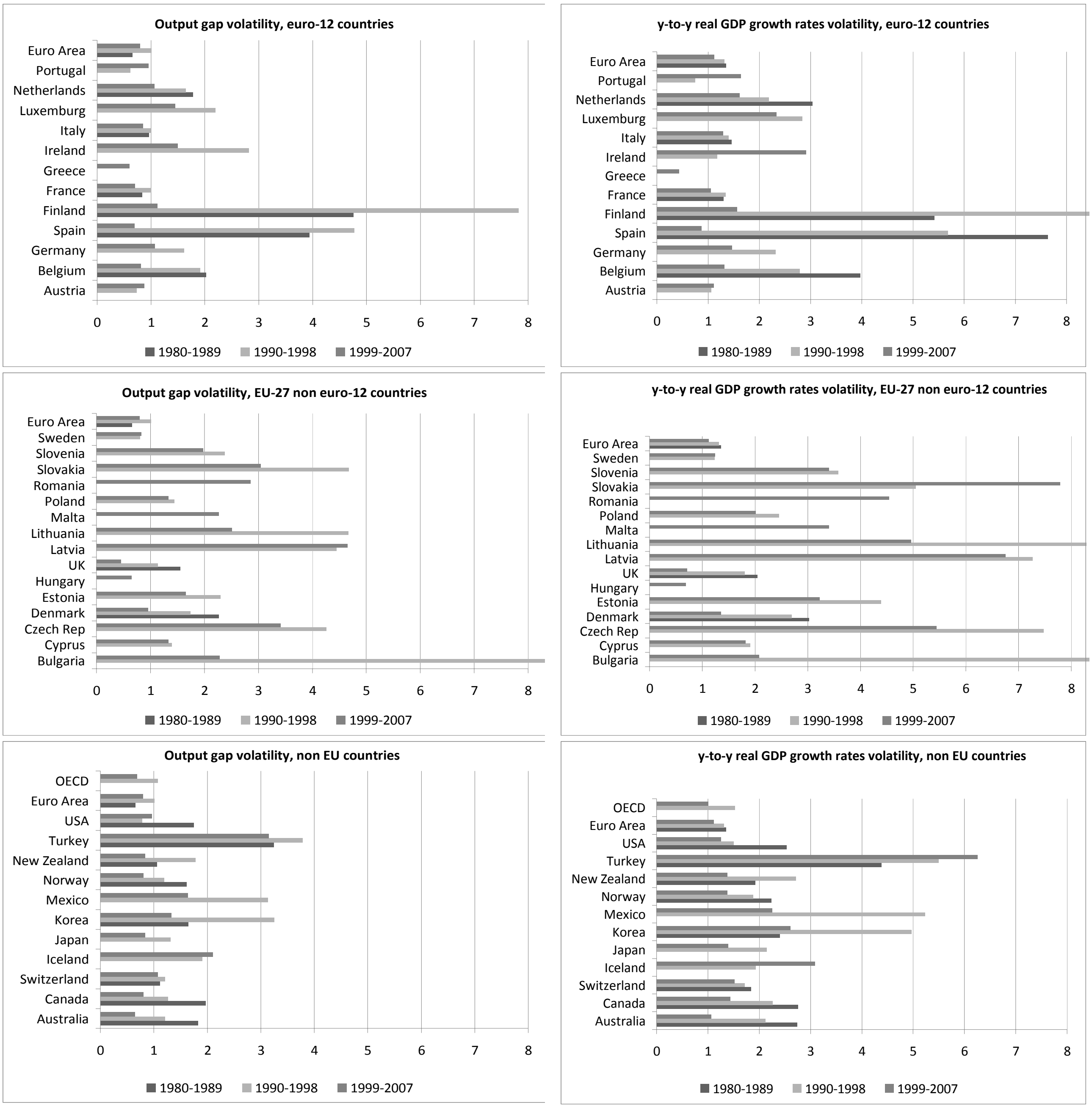
Figure 4 summarises the stylised facts about business cycle volatility. To proxy business cycle volatility we calculate both the standard deviation of the output gap (panel (a)) and real GDP growth rates (panel (b)).[6] For most countries, business cycle volatility is somewhat lower in the period 1999-2007 compared to the period 1990-1998 and to the period 1980-1989, where the earliest period is subject to data availability. Thus, there is indeed some tendency towards declining business cycle volatility and a possible effect of the introduction of the euro on business cycle volatility in the euro area. At the same time, also the volatility of many non-euro area countries and of the aggregate OECD business cycle displays a drop since 1990, pointing at a global dimension as well in this process of declining volatility. Compared to the US, the reduction in business cycle volatility is actually smaller in the euro area. In most cases the observed changes are not so large, exceptions being in particular Finland, most NMS, Korea and Mexico. The observed heterogeneity between euro area countries in the extent of the reduction of business cycle volatility is also noted by the European Commission (2007) in its analysis of business cycle volatility in the euro area. Results also vary somewhat depending on whether output gaps or real GDP growth rates are used, like in the case of Ireland, Latvia or Slovakia.

In most cases we are able to calculate pair-wise business cycle correlations for a considerably longer sample period and it is therefore interesting to explicitly distinguish between the period before and after the introduction of the euro and see if there are differences between both periods in terms of business cycle synchronisation. Figure 5 displays the business cycle correlations - measured again by correlations of output gaps and real GDP growth rates - distinguishing between 3 periods: (i) the EMS period 1980-1989, (ii) the pre-EMU period 1990-1998, and the (iii) the euro area period 1999-2007, and for the three different groups of countries. We also calculate the (unweighted) averages and the (unweighted) variances: an increase of synchronisation between groups of countries can be defined as an increase in the average business cycle correlation together with a decrease in the variance of business cycle correlations, so that business cycles on average are more similar and there is a reduction of heterogeneity between countries in their degree of business cycle synchronisation with the euro area economy. A number of stylised facts appear from these figures. Firstly, as also noted in other studies, the nineties - in particular the first halve - were a decade of business cycle divergence in the euro area[7], whereas business cycle convergence increased again in most cases during the second halve of the 1990s and afterwards. This is seen in the average and variance of correlations and in practically all cases also in the individual country cases. Both in the cases of correlations of output gaps and real GDP growth rates

[6] In their analysis of business cycle volatility in Germany, Buch et al. (2004) also use these two measures. Evidence is found for a small decline in volatility of the German business cycle since the early 1990s.

[7] The first halve of the 1990s was marked by a set of idiosyncratic shocks and developments, think of the German reunification shock and its aftermath, the crises in the EMS and the breaking up of communism in Eastern Europe, to name a few. In addition, lack of monetary and fiscal policy convergence and coordination is likely to have played a role in business cycle divergence during the first halve of the 1990s.

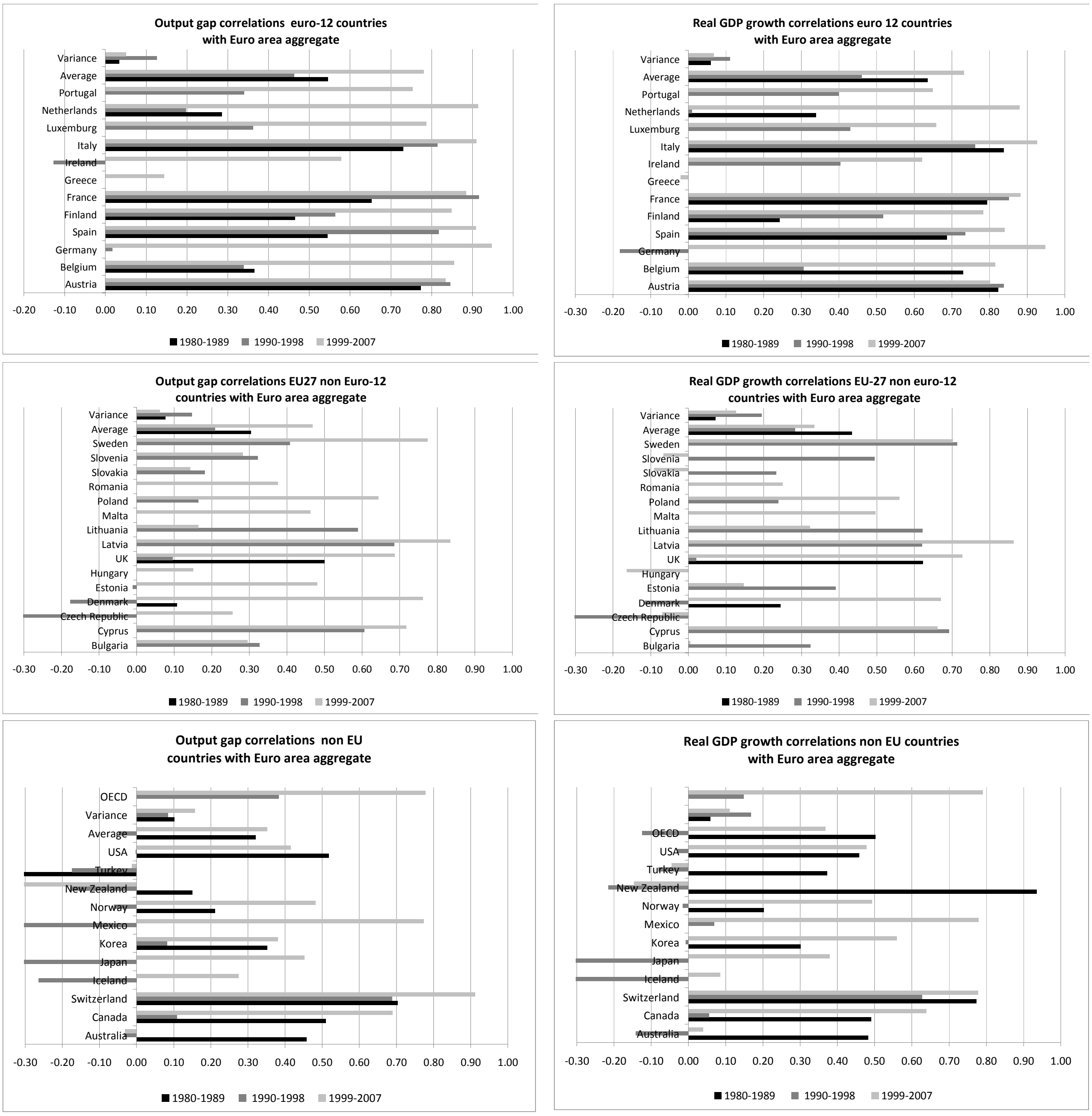
this outcome is found. In the 1999-2007 period business cycle synchronisation has reached again the previous level of around 0.7.



(a) output gaps (b) y-to-y real GDP growth rates

Figure 4: Business cycle volatility

Secondly, the business cycles of the EU countries not in the euro area-12 are on average clearly less synchronised with the euro area aggregate than most euro area-12 countries. Their synchronisation is currently comparable to that of the euro area Members States in the period before adopting the euro. However, most countries display the similar dynamics in that synchronisation was low and/or declining in the 1990s, but increased again since 1999. Exceptions are Slovenia, Slovakia, Lithuania and Bulgaria, which actually witnessed a small decline in business cycle synchronisation with the euro area. Also the case of Denmark, Sweden and the UK deserves attention: their business cycle synchronisation with the euro area reaches a high level, implying that from that point of view entering the euro area should not be considered as a dramatic decision.



(a) output gaps (b) y-to-y real GDP growth rates

Figure 5: Synchronisation with the euro area

Thirdly, we find evidence of increasing synchronisation with the euro area in the group of non-EU countries, although this group also clearly contains a cluster that is - not surprisingly - hardly synchronised with the euro area (Turkey, New Zealand, Iceland and Australia). Synchronisation between the euro area and the global cycle has increased considerably so that we can certainly speak of a “global convergence effect” that has affected the euro area in the recent period in the sense that global spillovers on the euro area economy have gained importance.

However, the values in Figure 5 are averages for three distinct periods and allow only in a relatively crude manner to detect whether the pattern of business cycle synchronisation is changing. It is possible to make the presence (or absence) of a “euro-effect” on business cycle synchronisation more specific by computing the correlations over successive intervals of four years (a four-year “rolling window”). We calculated four-year rolling window output gap correlations to have a better insight into the dynamics of business cycle synchronisation with the euro area. Figure 6 shows results for the group of EU-27 countries that are currently not members of the euro area.

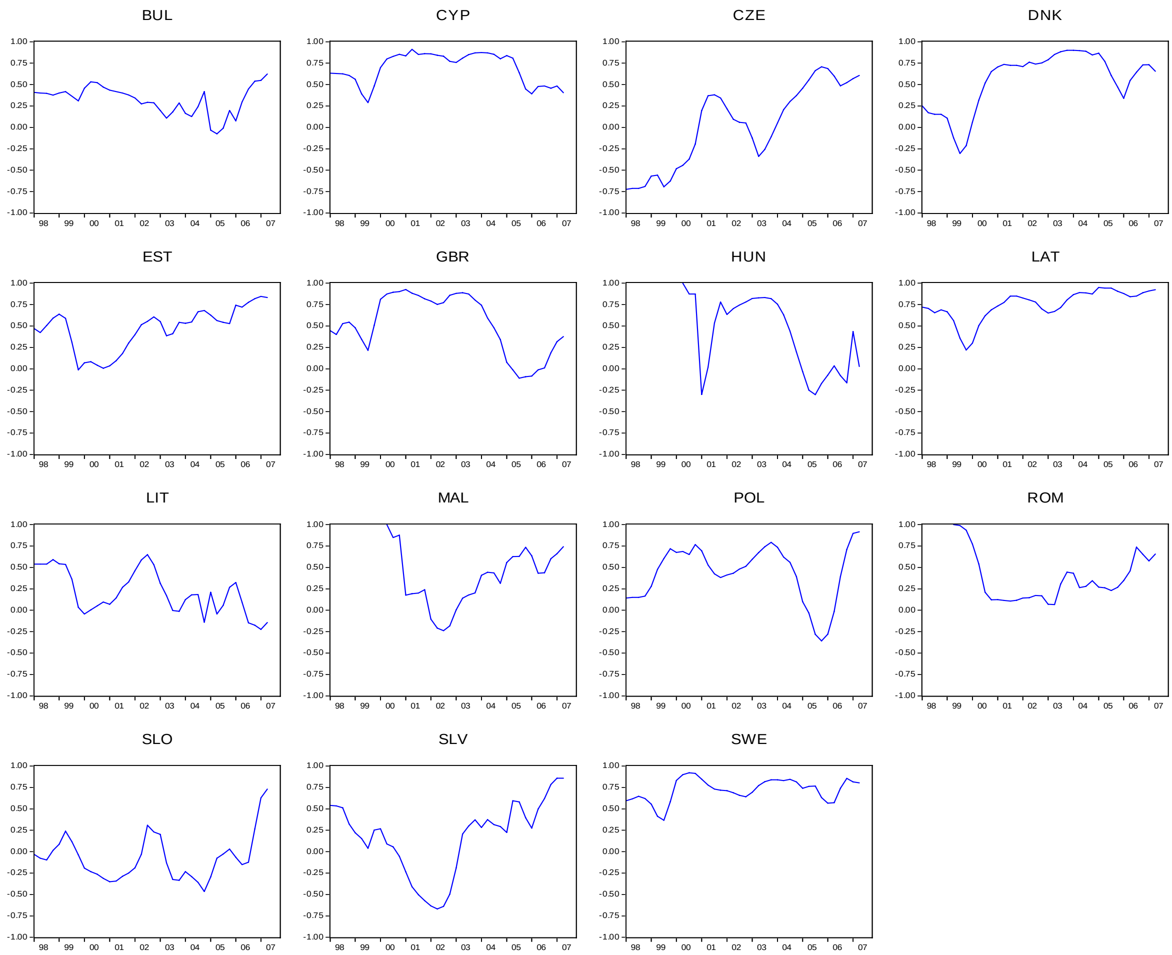


Figure 6: Output gap correlations of non euro-12 EU-27 countries vis-à-vis the euro aggregate over a 4 years rolling window (bul: Bulgaria, cyp: Cyprus, cze: Czech Republic, dnk: Denmark, est: Estonia, gbr: United Kingdom, hun: Hungary, lat: Latvia, lit: Lithuania, mal: Malta, pol: Poland, rom: Romania, slo: Slovakia, slv: Slovenia, swe: Sweden).

It is seen that several countries such as Cyprus, Latvia and Sweden maintained a high and steady degree of cyclical synchronisation with the euro area during the period from 1994Q1 to 2007Q3.[8] Others such as Lithuania, Hungary and the United Kingdom have de-coupled from the euro area movement in recent years. Since 1999, a steady increase in synchronisation with the euro area reference cycle is visual for the Czech Republic, for Slovenia and Slovakia, but also for Malta and Estonia. Figure 7 shows the time-varying cyclical correlations of the non-EU countries vis-à-vis the euro area aggregate. A high degree of co-movement with the euro area can be observed for Switzerland, whereas New Zealand, Turkey and Australia clearly have had cycles that were generally not much related to the cyclical movements observed in the euro area. Also the output gaps of the US and the euro area aggregate have become more dissimilar. Again, this observation might have changed in the wake of the recent economic downturn.

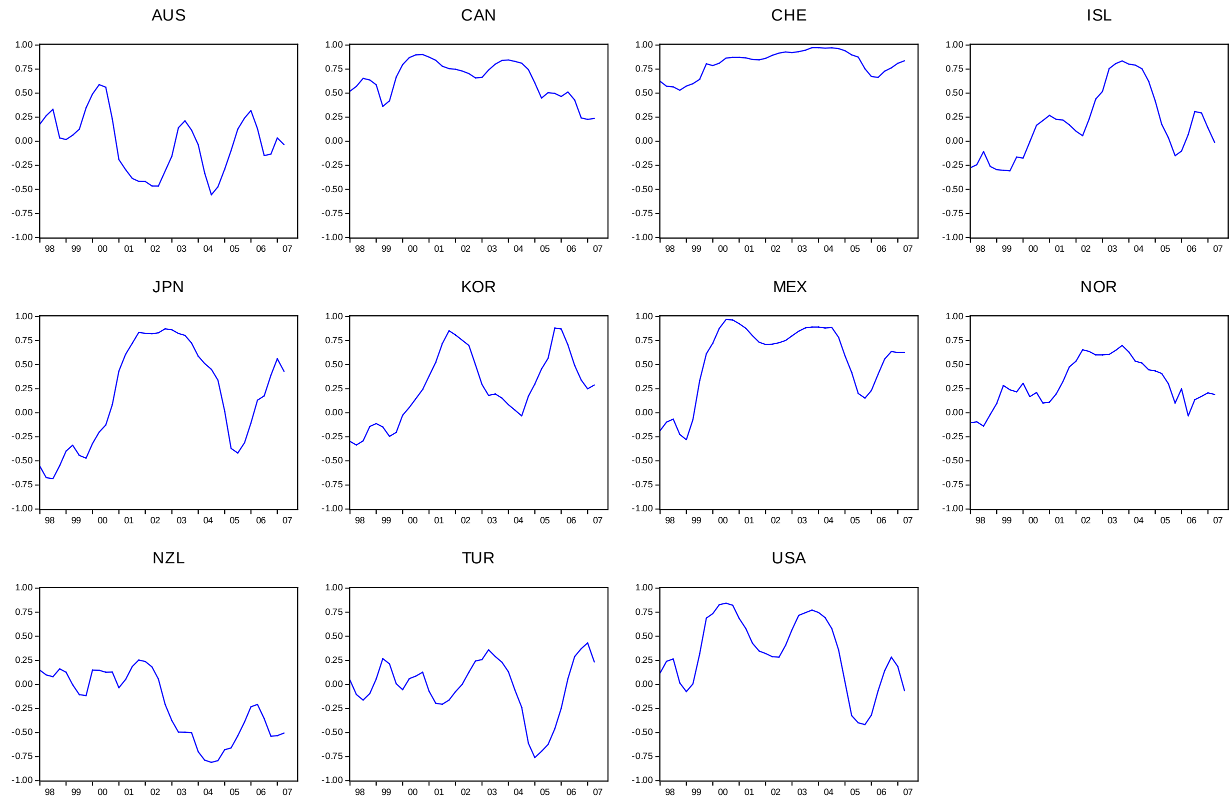


Figure 7: Output gap correlations of non EU countries vis-à-vis the euro aggregate over a 4 years rolling window (aus: Australia, can: Canada, che: Switzerland, isl: Iceland, jpn: Japan, kor: Korea, mex: Mexico, nor: Norway, nzl: New Zealand, tur: Turkey, usa: United States).

4 A cluster analysis

By means of a hierarchical cluster analysis, a set of variables is divided into groups (clusters) sharing similar characteristics. In terms of business cycle synchronisation, the variables are output gaps estimated with the asymmetric Christiano-Fitzgerald filter. For the cluster analysis, we opt to use the asymmetric Christiano-Fitzgerald band pass filter as the preferred method for separating the cycle from the trend mainly for two reasons. Firstly, it belongs to the class of time series filters which are most commonly used in studies of business cycle convergence and synchronisation and therefore facilitates the comparison of our results with the outcomes of other studies. Secondly, this filter allows extracting a precise business cycle frequency band (1.5 to 8 years) which seems most appropriate for examining synchronisation and convergence. Also the asymmetric CF filter suffers less from the familiar end-point problem which, for instance, characterizes the HP filter. For the determination of the clusters, the Ward method is applied (see, e.g., Graff, 2006).

The Ward method is based on the Euclidean distance, where the distance between two items, *x* and *y*, is the square root of the sum of the squared differences between the values of the items:

$$D(x,y) = \sqrt{\sum_i (x_i - y_i)^2}\,, \qquad (1)$$

[8] Note that in Figures 6 and 7, 16 quarters of observations “get lost” at the start of the sample.

with x_i and y_i defined as the output gaps of countries x and y in period i.

The idea of the Ward algorithm is to calculate for all possible clusters the variable means and the Euclidean distances. The clusters are then determined on the basis of the minimum increase of the Euclidean distance. The linkage function specifying the distance between two clusters is computed as the increase in the “error sum of squares” (*ESS*) after fusing two clusters into a single cluster. The Ward method seeks to choose the successive clustering steps so as to minimise the increase in the *ESS* at each step.

The *ESS* of a set X of N_X values is the sum of squares of the deviations from the mean value. Hence, the *ESS* is given by the following expression:

$$ESS(X) = \sum_{i=1}^{N_X} \left| x_i - \frac{1}{N_X} \sum_{j=1}^{N_X} x_j \right|^2 \qquad (2)$$

Mathematically, the linkage function, i.e. the distance between clusters X and Y, is described by the following expression:

$$D(X,Y)) = ESS(XY) - \left[ESS(X) + ESS(Y) \right], \qquad (3)$$

where XY is the combined cluster originating from fusing clusters X and Y. In contrast to other clustering methods which focus on the distance between the clusters, the Ward algorithm maximises the homogeneity within the groups. This algorithm seems to be best suited in the context of business cycle synchronisation. The idea behind the identification of clusters of similar business cycle characteristics is to find groups of countries sharing common business cycles rather than focussing on the differences of the business cycle characteristics between countries in different clusters.

Empirical results

The cluster analysis is in the first instance performed for the 12 countries forming the euro area until the end of 2006 (EUR12). If the euro area countries are analysed in a larger context such as the OECD, the resulting cluster patterns may be different, since in the larger sample some euro area countries may experience a higher synchronisation with some countries outside the euro area than with other euro area Member State. Hence, in addition to the analysis for the euro area, a separate cluster analysis is performed for 30 OECD countries. The clustering is based on the quarterly output gaps estimated over the period 1970Q1 (where available; in some cases, the data series start at later points in time) until 2007Q3.

At the lowest level of aggregation, one cluster of two countries and one group of three countries are formed, while the remaining countries do not pertain to any cluster. The first group of countries with similar business cycles is formed by the Netherlands and Austria. At the next stage, this group is joined by Germany. The second cluster is made up by Belgium, France and Spain, joined by Italy at the second stage. At the first stage, Greece and Portugal do not belong to any cluster. It is only at the second stage that these two countries merge to a separate cluster. Finally, three countries do not pertain to any cluster at this stage. These are Ireland, Luxembourg and Finland. At the next stage, the Netherlands, Austria and Germany remain in a separate cluster. A second group is made up of Belgium, France, Spain, Italy, Greece and Portugal. Only after these two clusters have merged to one in the next step, Ireland joins this group, and Luxembourg and Finland join this single group successively at the last stages. Table 3 summarises the findings of the cluster analysis for the 12 euro area countries.

Table 3: Business cycle clusters of euro area (12 countries)

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Netherlands, Austria	Netherlands, Austria, Germany	Netherlands, Austria, Germany	Netherlands, Austria, Germany, Belgium, France, Spain, Italy, Greece, Portugal, Ireland	Netherlands, Austria, Germany, Belgium, France, Spain, Italy, Greece, Portugal, Ireland, Luxembourg	Netherlands, Austria, Germany, Belgium, France, Spain, Italy, Greece, Portugal, Ireland, Luxembourg, Finland
Germany					
Belgium, France, Spain	Belgium, France, Spain, Italy	Belgium, France, Spain, Italy, Greece, Portugal			
Italy					
Greece	Greece, Portugal				
Portugal					
Ireland	Ireland	Ireland			
Luxembourg	Luxembourg	Luxembourg	Luxembourg		
Finland	Finland	Finland	Finland	Finland	

Based on these results, a reasonable representation of the business cycles of the 12 euro area countries in the sample implies three clusters and three individual countries. The first cluster comprises the Netherlands, Austria and Germany. The second group consists of Belgium, France, Spain and Italy. Greece and Portugal form the third cluster, while Ireland, Luxembourg and Finland are quite different from the other countries.

Table 4: Correlations between output gaps of EUR12 countries

	Austria	Germany	Netherl.	Belgium	France	Italy	Spain	Greece	Protugal	Ireland	Finland	Luxemb.
Austria	**1.00**											
Germany	**0.68**	**1.00**										
Netherlands	**0.83**	**0.74**	**1.00**									
Belgium	0.45	0.55	0.61	**1.00**								
France	0.34	0.30	0.49	**0.83**	**1.00**							
Italy	0.20	0.52	0.44	**0.79**	**0.79**	**1.00**						
Spain	0.49	0.66	0.48	**0.75**	**0.65**	**0.66**	**1.00**					
Greece	0.25	0.40	0.21	0.24	0.19	0.41	0.42	**1.00**				
Protugal	-0.03	0.29	0.02	0.38	0.41	0.56	0.53	**0.51**	**1.00**			
Ireland	0.32	0.44	0.43	0.61	0.41	0.43	0.50	-0.14	0.16	**1.00**		
Finland	-0.30	-0.13	-0.03	0.47	0.60	0.54	0.32	-0.14	0.13	**0.39**	**1.00**	
Luxembourg	0.51	0.25	0.49	0.29	0.24	0.07	0.14	0.17	-0.24	**-0.14**	**-0.05**	**1.00**

Notes: Output gaps have been calculated by applying the full-sample Christiano-Fitzgerald filter to quarterly GDP. Sample period is from 1970Q1 to 2007Q3.

The output gaps have been calculated by applying the full-sample Christiano-Fitzgerald filter to quarterly real GDP over the period 1970Q1 to 2007Q3. Hence, Table 4 shows the input data for the above cluster analysis. The three clusters identified in the previous analysis are highlighted in different colours and by the boxes. As expected, the business cycle synchronisation is highest within the clusters. The table also reveals the observation that, on average, the business cycles of Ireland, Luxembourg and Finland are only loosely correlated to the cyclical variations of the other euro area countries.

In the following, the clusters will be related to factors that may be important determinants of business cycle synchronisation, such as geographical proximity, trade linkages, fiscal policy and institutional similarities. Annual bilateral trade figures are taken from the IMF Direction of Trade database. Fiscal policy indicators (the overall and the cyclically adjusted primary budget balances in relation to GDP) were taken from the database of the OECD Economic Outlook. Institutional indicators may be found in the database of the Fraser Institute and in the dataset provided by

Nickell (2006). The Fraser Institute publishes a Freedom of the World index for more than 120 countries (see Gwartney and Lawson, 2007). The overall index consists of several sub-indices such as a labour market regulation index, a business regulation indicator and an overall regulation index. Data are provided for the period from 1970 to 2005, but for the period from 1970 to 2000 data are only available in five-year intervals. Annual data are only published from 2000 onwards. For the present analysis, the missing data within the five-year periods have been constructed by linear interpolation. For some indicators and countries, the dataset starts at later points in time. As an example, the business regulation indicator is available only from 1995 onwards. Nickell (2006) provides a set of OECD indicators for labour market institutions for 20 OECD countries (from the euro area 12, Greece and Luxembourg are missing in this dataset). The dataset contains annual data for the period from 1960 to 2004, but for some indicators and countries the time period is shorter.

Regarding the institutional framework, Table 5 depicts the values of important labour market institutions that might be related to business cycle synchronisation. Countries of the first cluster identified above are market in red, and countries belonging to the second cluster are written in blue. Of the two countries belonging to the third cluster (written in green), only for Portugal data on labour market institutions are published in the Nickell database where the data were taken from. Similarly, only for two out of the three individual countries not belonging to any cluster (in black), data are available.

Table 5: Labour market institutions in euro area countries

	Austria	Netherlands	Germany	Spain	France	Italy	Belgium	Portugal	Ireland	Finland
Union density	36.1	22.6	23.9	13.9	9.7	34.6	55.7	23.5	36.9	77.0
Barg. centralisation	3.0	3.0	3.0	3.0	2.0	2.0	3.0	4.0	4.0	5.0
Barg. coordination	4.0	4.0	4.0	3.0	2.0	4.0	4.5	4.0	4.0	5.0
Replacement rate	31.7	52.7	29.1	36.5	41.2	34.0	39.9	41.5	35.8	35.0
Tax rate	15.8	9.7	15.5	21.3	26.9	26.8	19.8	16.8	7.3	22.8

Trade union density, i.e. the share of employees that are trade union members, is quite heterogeneous within the clusters. This applies in particular to the second cluster, where the corresponding values vary between 9.7 in France and 55.7 in Belgium. Centralisation of the wage bargaining process is significantly more homogeneous within the clusters, and the borderlines between the clusters are more clearly visible. The same applies to wage bargaining coordination. However, both bargaining coordination and centralisation exhibit much less cross-country differences than the other labour market institutions. Regarding the benefit replacement rate, in the first cluster the Netherlands stand out with a significantly higher value than the other countries. On the other hand, Austria and Germany in the first cluster, as well as the countries belonging to the second cluster are characterised by relatively similar benefit replacement rates. Finally, cross-country differences in the employment tax rate fit to the clustering of countries.

An important source of business cycle synchronisation is the bilateral trade intensity. Following, e.g., Böwer and Guillemineau (2006), for each pair of countries the bilateral trade intensity is defined as the sum of bilateral exports and imports, divided by the sum of total exports and imports of both countries. Looking at the first cluster of countries, Austria and Germany as well as Germany and the Netherlands show high bilateral trade intensities, while Austria and the Netherlands do not trade as much with each other. In the second cluster, all countries exhibit high bilateral trade intensities, the only exception being the pair Belgium-Spain. In this case, the geographical distance is also relatively high. On the other hand, the trade linkages of Belgium are highest with Germany and the Netherlands, countries that are in a different cluster. The countries of the third cluster, Greece and Portugal, show a high bilateral trade intensity. However, due to the geographical proximity, Spain is Portugal's most important trading partner.

Differences in the cyclical position of the euro area countries may also be related to diverging fiscal policies. If fiscal policy divergence is a reaction to asymmetric shocks, then differences in fiscal policies may lead to more business cycle synchronisation. If, on the other hand, fiscal policy is itself a source of business cycle shocks, then diverging fiscal policies are associated with more heterogeneous business cycles (see, e.g., Darvas et al., 2005). The fear that diverging fiscal policies might reduce the business cycle coherence in the euro area was one of the reasons for including the deficit criterion both in the Maastricht Treaty and in the Stability and Growth Pact (SGP). Different measures may be considered as fiscal policy indicators. One obvious candidate is the overall budget balance in relation to GDP. This indicator was taken for the Maastricht Treaty and the SGP. However, the overall budget balance is to a considerable degree endogenous to the business cycle, since automatic stabilisers induce a rising deficit in a cyclical downturn and an improvement in an upturn. Furthermore, the overall budget balance contains the interest payments on outstanding public debt. This expenditure item does not reflect the current fiscal policy stance. Hence, the primary budget balance, i.e. the budget balance adjusted for interest payments, is better suited as an indicator for discretionary fiscal policies. Based on these considerations, both the overall budget balance and the cyclically adjusted primary balance, each in relation to nominal GDP, are taken into account.

Over the period from 1980 to 2007, the countries of the first cluster, i.e. the Netherlands, Austria and Germany, had quite large overall budget deficits. In the period from 1999 to 2007, the average budget deficit ratio of Germany had only marginally improved, while the deficit ratios of the Netherlands and of Austria had improved considerably. Hence, since the introduction of the euro the fiscal positions of these three countries have exhibited some divergences. Also based on the cyclically adjusted primary budget balance (CAPB), the fiscal policy stance of Austria and the Netherlands has been very similar since the introduction of the euro, while the CAPB of Germany was about one percentage point smaller. On the other hand, before 1999, the fiscal policies of Austria and Germany were more similar with each other and more distinct from that of the Netherlands. Based on the overall budget balance, in the second cluster, Belgium and Spain on the one hand and Italy and France on the other hand show similarities, but there are substantial differences between these two sub-groups. While Belgium and Spain had almost balanced budgets since 1999, France and Italy ran quite large deficits. However, over the period from 1980 to 1998, all four countries, and in particular Belgium and Italy experienced high budget deficits, and the deficits of all four countries were considerably larger than those of the countries in the first cluster. Looking at the CAPB over the period since 1999, a somewhat different picture emerges. This indicator would show Spain and Italy having moderate surpluses, while Belgium having a larger surplus and France a smaller one. Before 1999, Spain, Italy and France exhibited similar fiscal policy stances with moderate deficits, while Belgium stands out with a surplus. The two countries of the third cluster, Portugal and Greece, ran high budget deficits both before and after the introduction of the common currency. However, based on the cyclically adjusted primary balance, the fiscal policy stance of both countries has been almost balanced. Hence, while the overall budget balance differentiates this cluster significantly from the other countries, the differences of the CAPB are much smaller. Among the three remaining countries, Ireland and Luxembourg show more similar fiscal policies than Finland. Summarising these results, the overall budget balances are more similar within each cluster than between the clusters. However, when measuring the fiscal policy stance by the cyclically adjusted primary budget balance, the differentiation between the clusters is less clear-cut.

The extent of business cycle synchronisation between the countries might also be influenced by the industry structure. In particular, the share of manufacturing in total value added may be important, since industry is the sector that is most open to international competition and thus vulnerable to the international transmission of economic fluctuations and to external shocks (see, e.g., Artis and Claeys, 2007). In the first cluster, the average share of manufacturing amounts to 18.7 percent, slightly above the value of 16.6 percent recorded for the second cluster. In the third cluster (Greece and Portugal), the importance of manufacturing is considerably lower (13.2 percent). Finally, among the three countries not belonging to any cluster, the share of manufacturing varies between 7.9 percent in Luxembourg and about 23 percent in Finland and Ireland. However, within the first two clusters, there is also a significant variation. This applies in particular to the first cluster, where the share of manufacturing ranges from 13.3 percent in the Netherlands to 22.6 percent in Germany. Hence, in some cases there is more variation within than between the clusters. Thus, the importance of manufacturing appears to explain only a small portion of business cycle synchronisation.

Regarding geographical proximity, in the first cluster Austria and Germany as well as Germany and the Netherlands share common borders, but this does not pertain to the pair Netherlands-Austria which nevertheless exhibits a high degree of business cycle synchronisation. Moreover, some countries sharing a common border are found in different clusters. Among others, examples are Belgium and the Netherlands or Spain and Portugal. In the second cluster, Belgium and France, France and Spain as well as France and Italy have common borders. The third cluster groups two countries (Portugal and Greece) which are in geographical terms quite distant from each other.

To summarise this section, the results of the cluster analysis in comparison with possible factors driving business cycle synchronisation indicate that bilateral trade intensity and common borders are more important determinants of business cycle synchronisation than regulation, fiscal policies, or the industry structure.

As mentioned above, extending the analysis to a larger sample of countries may affect the existing clusters, since some countries may show more business cycle similarities with countries outside the euro area than within this country-bloc. Hence, the cluster analysis was also performed for 30 OECD countries. The results can be found in Table 6.

Table 6: Business cycle clusters of 30 OECD countries

<table>
<tr><th>Stage 1</th><th>Stage 2</th><th>Stage 3</th><th>Stage 4</th><th>Stage 5</th><th>Stage 6</th></tr>
<tr><td>Netherlands, Austria, Belgium, France, Spain, Hungary, Germany, Italy, Switzerland, Norway</td><td rowspan="4">Netherlands, Austria, Belgium, France, Spain, Hungary, Germany, Italy, Switzerland, Norway, Greece, Portugal, Finland, Sweden, Australia, New Zealand, Poland, UK</td><td rowspan="5">Netherlands, Austria, Belgium, France, Spain, Hungary, Germany, Italy, Switzerland, Norway, Greece, Portugal, Finland, Sweden, Australia, New Zealand, Poland, UK, Slovakia</td><td rowspan="7">Netherlands, Austria, Belgium, France, Spain, Hungary, Germany, Italy, Switzerland, Norway, Greece, Portugal, Finland, Sweden, Australia, New Zealand, Poland, UK, Slovakia, Ireland, Japan, Czech Republic</td><td rowspan="11">Netherlands, Austria, Belgium, France, Spain, Hungary, Germany, Italy, Switzerland, Norway, Greece, Portugal, Finland, Sweden, Australia, New Zealand, Poland, UK, Slovakia, Ireland, Japan, Czech Republic, Korea, Luxembourg, Denmark, US, Canada, Iceland, Mexico</td><td rowspan="12">Netherlands, Austria, Belgium, France, Spain, Hungary, Germany, Italy, Switzerland, Norway, Greece, Portugal, Finland, Sweden, Australia, New Zealand, Poland, UK, Slovakia, Ireland, Japan, Czech Republic, Korea, Luxembourg, Denmark, US, Canada, Iceland, Mexico, Turkey</td></tr>
<tr><td>Greece, Portugal</td></tr>
<tr><td>Finland, Sweden</td></tr>
<tr><td>Australia, New Zealand, Poland, UK</td></tr>
<tr><td>Slovakia</td><td>Slovakia</td></tr>
<tr><td>Ireland, Japan</td><td rowspan="2">Ireland, Japan, Czech Republic</td><td rowspan="2">Ireland, Japan, Czech Republic</td></tr>
<tr><td>Czech Republic</td></tr>
<tr><td>Korea</td><td>Korea</td><td>Korea</td><td>Korea</td></tr>
<tr><td>Luxembourg, Denmark, US, Canada</td><td>Luxembourg, Denmark, US, Canada</td><td rowspan="2">Luxembourg, Denmark, US, Canada, Iceland</td><td rowspan="3">Luxembourg, Denmark, US, Canada, Iceland, Mexico</td></tr>
<tr><td>Iceland</td><td>Iceland</td></tr>
<tr><td>Mexico</td><td>Mexico</td><td>Mexico</td></tr>
<tr><td>Turkey</td><td>Turkey</td><td>Turkey</td><td>Turkey</td><td>Turkey</td></tr>
</table>

5 Coherence, phase effects and dynamic correlations of international business cycles

The previous sections analysed the euro area business cycle properties in the time domain and looked for changes in static correlations computed over different sub-periods to study the change in co-movement over time. In this section, we apply concepts that are defined in the frequency domain in which time series are described as being constituted of an infinite number of components with different periods and amplitudes. The aim of such a decomposition is to determine how important cycles of different frequencies are in accounting for the behaviour of a variable. Components that are not repeated over time have zero frequencies (or infinite periods) and noisy components correspond to very high frequencies (or short periods). In between lie the business cycle frequencies that account for all other movements in the series. In contrast to the analysis in the time domain, we are able to conduct a frequency-by-frequency analysis once the series has been transformed in its spectral representation. In particular, this allows us to concentrate on the most dominant frequencies of our cycle measures and leave aside components with frequencies that account only for a minor fraction of business cycle movements. Static cross-correlations are defined over the complete frequency range and thus do not allow us to focus on the most important cyclical components. For instance, when two series are correlated at low frequencies (the long-run swings in the series) but to a lesser extent at higher frequencies (the short-run swings) then the estimated static correlation will be a mixture of these correlations, hiding interesting dynamic relationships. A further advantage of analyses in the frequency domain is that it offers simple and intuitive statistics that reveal lead and lag relations between two cycle series for which the time domain counterparts are not that easily defined.

We use the concepts of *coherence* and *dynamic correlation* to determine the correlation between components of individual countries' cycles and a reference cycle over the range of the most dominant frequencies. Coherence is the frequency domain analogue of the cross-correlation function in the time domain and ranges from 0 to 1. However, this measure disregards the phase effect between different cycle series, i.e. this measure is completely independent of the position of two series in time. It determines only whether or not two series have the same pattern, independent of the position in time. Dynamic correlation, introduced by Croux et al. (2001), is a measure of the correlation between the components that takes the phase shift between those components into account. It is also computed frequency-by-frequency or over a frequency band and ranges between -1 and 1. Dynamic correlation reduces to static correlation if the complete frequency range is considered. A third measure that is of interest is the *phase effect*, which represents the shift in time between the components of two series for each frequency (or over a frequency band). The phase effect tells us the relative cyclical position of a countries' cycle when compared to a reference cycle. Thus, it allows us to assess the lead and lag relationship between cycles. The concepts of coherence, dynamic correlation and phase effect are closely related: if the phase effect is small in a range of frequencies, the absolute value of dynamic correlation and the value of coherence will be almost identical. In contrast, if the phase effect is pronounced, important differences between coherence and dynamic correlation will result. Taken together, these measures can provide us with important information regarding in-phase correlation, overall dynamic correlation and lead/lag relationships between the cycles of the euro area countries.

We present results for individual countries' cycles vis-à-vis the euro area cycle. Frequency domain analyses rely on large enough observation periods in order to obtain precise estimates of the population spectrum. Therefore, our results are most reliable for the estimations that exploit the entire sample period from 1970Q1 to 2007Q3.[9]

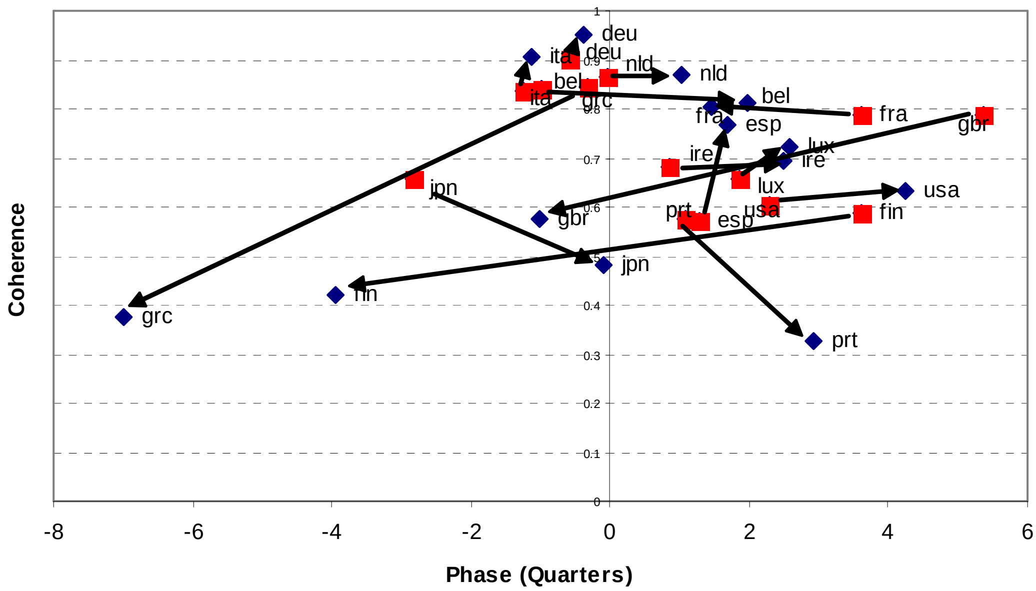
Since we are not interested in the values of coherence, dynamic correlation and phase effects at every frequency, following Azevedo (2002), we compute the means of these measures over frequency bands that encompass the most dominant ones, those that represent the major fluctuations in the cycles. Again, cycles are extracted with the aid of the Christiano-Fitzgerald (CF) bandpass filter. We estimate coherence, phase, and dynamic correlations for two sub-periods in order to unveil changes in these synchronisation measures over time. We use the same sample split as in section 2 to check whether the introduction of the euro in the year 1999 had any effect on convergence. A visualisation of the changes in the estimated coherence and phase effects between the two sample periods is presented in Figure 8. If the common currency had have a positive effect on business cycle synchronisation we would expect an increase in mean coherences and a decrease in the absolute value of mean phases for the euro area countries between the first and the second sub-period, the latter ranging from 1999Q1 to 2007Q3. That is, in Figure 8 we would expect to see arrows that point upwards and towards the ordinate with large arrows indicating a stronger increase in synchronisation than small arrows. We observe such a pattern for Italy, Germany and France, for which small increases in coherences and decreases in phase shifts between the two periods are found. However, these countries already displayed a high degree of business cycle synchronisation before the introduction of the euro. Interestingly, France decreased its phase

[9] We exclude Austria in this analysis due to a lack of consistent GDP data for the periods before 1989Q1.

lead against the euro area cycle from 3.6 quarters in the pre-euro era to 1.4 quarters in the euro era, bringing it closer to the aggregate cycle. The Spanish cycle considerably increased its synchronisation with the euro area cycle in terms of coherence, while the phase displacement against the euro area cycle slightly rose. Noteworthy is also the phase shift of Belgium between the two sample periods. While being very much in accordance with the aggregate cycle during the first period, the Belgium cycle changed in the period after 1999 and seems to have been leading the euro area cycle by approximately two quarters since then. This finding is very much in line with a widely-held view in the financial markets that the movement of the Belgian industrial confidence indicator might precede the euro area business cycles and for which Vanhaelen et al. (2000) provide analytical support that Belgium is also leading the euro area regarding GDP cycles. In particular, Vanhaelen et al. (2000) find that the leading nature is more pronounced for the sub-period beginning with the first quarter of 1993, which is a result that perfectly fits into our picture.

The most conspicuous results in Figure 8 are surely the large changes in coherence and phase that we observe for Greece, Finland and Portugal. All three countries loose in coherence against the euro area cycle and show large changes in phase shifts, with Finland becoming a lagger of the euro area cycle in the later period while Greece increases its negative phase shift and Portugal increases its positive phase shift. Again, it has to be noted that the phase effect may be estimated poorly and may not be very meaningful given the low estimated coherence for these countries. However, a de-coupling of the Greek, Finnish and Portuguese business cycles from the euro area cycle in the recent period is a feature that we also find in the time-varying correlation estimates recorded in Section 2.

Among the non-euro area countries, the changes in coherence and phase for Japan, the United Kingdom and the US stand out. According to the coherence estimates in the two periods, the US cycle's shape became slightly more similar to the euro area cycle, while the Japanese cycle clearly moved away from the euro area. For the same reasons as mentioned above, we do not want to attach too much importance to the phase estimate for Japan's cycle for the period from 1999Q1 to 2007Q3 in view of the low coherence estimate. However, these findings are in line with the observation that this period was characterised by a quite flat development of GDP in Japan without much business cycle fluctuations. This long phase of low GDP growth in Japan was mainly the result of structural problems, in particular in the Banking system. Due to the higher coherence in the recent sample period, we put more confidence into the US phase estimate and conclude from Figure 8 that the leading nature of US economic activity against the euro area economy is now even more pronounced than it was from the eighties to the end of the nineties. More precisely, the phase lead of the US cycle is estimated at 4.3 quarters for the latter sample period in comparison with an estimate of 2.3 quarters for the first period. A large adaptation of the United Kingdom's cycle to the euro area cycle took place in terms of phase, while the coherence against the euro area decreased. The marked convergence in terms of phase dominates the comparably lower divergence in terms of coherence in the computation of the dynamic correlation measure which is why we observe an increase in mean dynamic correlation of 0.46 for the United Kingdom between the two considered sub-periods.



Note: Sample: 1980Q1-1998Q4 (■) and 1999Q1-2007Q3 (◆)

Figure 8: Countries vis-à-vis the euro area: changes in mean coherence and mean phase effect

Table 7 provides the numerical data shown in Figure 8 and additionally records dynamic correlation estimates.

Table 7: Countries vis-à-vis the euro area, estimates for different sample periods

	1980Q1 – 1998Q4			1999Q1 – 2007Q3		
	Phase	Coherence	Dynamic Correlation	Phase	Coherence	Dynamic Correlation
bel	-0.99	0.84	0.85	1.96	0.81	0.76
deu	-0.58	0.90	0.86	-0.38	0.95	0.95
esp	1.28	0.57	0.45	1.70	0.77	0.71
fin	3.62	0.59	0.31	-3.96	0.42	0.30
fra	3.62	0.79	0.56	1.44	0.81	0.76
grc	-0.33	0.84	0.81	-6.98	0.38	0.10
ire	0.84	0.68	0.67	2.48	0.70	0.62
ita	-1.24	0.84	0.84	-1.13	0.91	0.87
lux	1.85	0.66	0.53	2.58	0.72	0.59
nld	-0.04	0.86	0.86	1.02	0.87	0.84
prt	1.08	0.58	0.09	2.91	0.33	0.01
uk	5.35	0.79	0.11	-1.00	0.58	0.56
jpn	-2.84	0.66	0.61	-0.08	0.48	0.48
usa	2.30	0.60	0.46	4.26	0.63	0.37

6 Conclusions

For almost a decade now, the euro has been the common currency of an increasing number of EU countries, and it established a record in terms of stability and credibility. A high enough degree of business cycle synchronisation is necessary for a well-functioning common currency area. The degree of synchronisation of business cycles among the Member States of the euro area is in most cases relatively high, but synchronisation has a dynamic rather than a static feature as it is driven by a large number of factors. Episodes of de-coupling and re-coupling of business cycle co-movements alter frequently, but a clear upward or downward trend is barely observable in the average degree of business cycle synchronisation in the euro area during the period 1990-2007. This paper showed that the euro area, on the one hand, displays a high level of business cycle co-movement of the euro area Member States. On the other hand, the hypothesis that the introduction of the common currency in 1999 has increased the business cycle synchronisation cannot be confirmed. The literature indeed provides conflicting results with regard to the effects of the introduction of the euro on synchronisation. The overall conclusion from our exercises is that on average business cycle convergence in the euro area has not changed substantially since the introduction of the euro. This result seems fairly robust to the measurement of the cycle and to different sample periods. Thus, a clear - positive or negative - “euro effect” on synchronisation does not appear in the latest available data. In most cases, euro area countries have displayed a drop in business cycle volatility during the recent years. Such a drop could possibly be linked to adopting the euro but may equally well reflect other factors such as the global decline of business cycle volatility.

The stylised facts also confirm the results of previous studies which showed that country-specific cycles were rather diverge - reflecting the heterogeneity of countries - and that in particular Greece and Portugal have had business cycles, which have uncoupled from the cycles shared by the larger European countries in recent years. Of the EU-27 non euro area countries, Denmark, Sweden and the UK exhibit similar business cycle co-movements with the euro area reference cycle as the euro-12 countries, while the NMS score on average considerably lower, raising doubts about the efficiency of rapid accession to the euro area for some of them.

Based on the results of a hierarchical cluster analysis, a reasonable representation of the business cycles of the 12 euro area countries in the sample implies three clusters sharing similar cycles, and three individual countries. The first cluster comprises the Netherlands, Austria and Germany. The second group consists of Belgium, France, Spain and Italy. Greece and Portugal form the third cluster, while Ireland, Luxembourg and Finland are quite different from the other countries.

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