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Business cycle convergence in EMU: A first look at the second moment*

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Abstract

We propose the analysis of the dynamics of the standard deviation of business cycles across euro area countries in order to evaluate the patterns of cyclical convergence in the European Monetary Union for the period 1960-2008. We identify significant business cycle divergence taking place in the mid-eighties, followed by a persistent convergence period spanning most of the nineties. This convergent episode finishes roughly with the birth of the European Monetary Union. We show that a hypothetical euro area including all the new members of the recent enlargement rounds does not imply a sizeable decrease in the optimality of the currency union. Finally, the European synchronization differential with respect to other developed economies seems to have been diluted within a global cycle since 2004.

Keywords: Business cycles, business cycle convergence, European Monetary Union.

JEL classification: E32, E63, F02.

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1 Introduction

The process of monetary integration in Europe has contributed to the development of the academic literature on European business cycle synchronization (see de Haan *et al.*, 2008, for a recent survey that summarizes the results of this branch of the literature). Different variables and filtering procedures have been used to measure the business cycle and diverse measures have been used to analyse the similarity among business cycles. The most widely used measure of business cycle coherence is the correlation coefficient between national cycles. Within this line of research, several findings of the literature can be emphasized. Firstly, there exists evidence of homogeneity of business cycles in the European Union (EU) (Agresti and Mojon, 2001, Christodoulakis *et al.*, 1995, Wynne and Koo, 2000) and certain authors claim that we can talk about a European business cycle almost in the same terms as we talk about a US business cycle (Agresti and Mojon, 2001, Wynne and Koo, 2000). Secondly, business cycle correlation in Europe is a relatively recent phenomenon. Artis and Zhang (1997 and 1999) point out that the emergence of a European cycle seems to coincide with the inception of the Exchange Rate Mechanism (ERM) and that it is a specific fact to the group of countries participating in ERM. However, Inklaar and De Haan (2001), using Artis and Zhang's (1997 and 1999) updated dataset but with different subsamples, found no evidence of a systematic relationship between business cycle homogeneity and monetary integration and pointed out that most cycles in ERM are better correlated during the period 1971-1979 than in the period 1979-1987. Finally, other authors find that the convergence period starts in the early nineties (Angeloni and Dedola, 1999, Massmann and Mitchell, 2003, Darvas and Szápari, 2005), although there is evidence of an increase in cyclical heterogeneity in Europe during the 2000-2002 recession (Fidrmuc and Korhonen, 2004). Moreover, the European business cycle seems to dilute within a global international business cycle in recent years (Artis, 2003, Pérez *et al.*, 2007).

While the first steps in the monetary integration process contributed to the development of business cycle synchronization literature, the EU enlargement and the no-opting out rule led to the development of a number of studies on the synchronization of the new member countries with the EU or the European Monetary Union (EMU) (see Fidrmuc and Korhonen, 2006, for a meta-analysis on business cycle correlation between the euro area and Central and Eastern European countries - CEECs). From this literature it can be highlighted that several new EMU members and candidate countries show a high level of synchronization with the EU-15 countries, especially Hungary, Poland and Slovenia (Artis *et al.*, 2004, Fidrmuc and Korhonen, 2004 and 2006, Darvas and Szápari, 2005). However, the level of homogeneity among the new members is lower than that of the EMU-12 group and the synchronization between the new members and the EMU is lower relative to the comovement of countries taking part in past enlargement rounds (Artis *et al.*, 2004). The synchronization of the group of new members seems to have decreased during the 2000-2002 recession as in the case of EMU economies (Fidrmuc and Korhonen, 2004).

Most of the existing empirical literature mentioned above uses correlation-based measures to assess the degree of business cycle synchronization. Several studies use alternative methodologies based on spectral analysis to approach this research question. Croux *et al.* (2001) define a cohesion measure in the frequency domain which generalizes bivariate dynamic correlations to more than two series. Frequency domain methods are also employed by Hughes Hallet and Richter (2006) and Koopman and Azevedo (2008) to measure the degree of convergence among European business cycles. Wavelet analysis methods such as those recently proposed by Rua (2010) and Aguiar-Conraria and Soares (2011) generalize the method to allow comovement both at the frequency level and over time. The results in Aguiar-Conraria and Soares (2011) confirm the existence of a core/periphery divide in terms of cyclical synchronization in EMU.

In this piece of research we analyse the dynamics of business cycle dispersion in Europe for the period 1960-2008 using novel methods. On the one hand, we use business cycle extraction methods that constitute an improvement upon those usually employed in the literature. On the other hand, we propose a new time-varying method to measure business cycle synchronization that allows for business cycle homogeneity to be quantified at a given point in time instead of over (relatively long) periods, as is the case with indicators based on cyclical correlations.[1] In particular, we extract the business cycle from quarterly GDP series for 36 countries, including members of EMU, new EU members and other OECD economies, using an unobserved components model in the spirit of Harvey (1989) and Harvey and Jaeger (1993) using Kalman (1961) filtering methods. As a measure of coherence, the time series of the cross-country standard deviation of business cycles is studied for different groups of economies, and significant changes in this measure are assessed using Carree and Klomp's (1997) convergence test. We also analyse the time series properties of our business cycle synchronization measure in order to characterize different systematic periods of convergence/divergence among the cycles of the groups considered applying the procedure proposed by Bai and Perron (1998 and 2003). To our knowledge, the dynamics of business cycle dispersion has not been exploited hitherto as an indicator of business cycle coherence. In this sense, our method allows for the first time to assess quantitatively research questions related to business cycle synchronization without the potential ambiguity of predefining correlation periods.

Our dispersion indicator is complemented with an index of coherence of the state of the cycles. We also compute an indicator of the "cost of inclusion" for the members of each group considered in our analysis. Such an indicator allows us to link the strand of the literature dealing with Optimum Currency Area (OCA) criteria with that focused on costs and benefits of currency area membership. Our approach allows us to answer the main questions highlighted by the literature concerning business cycle synchronization in Europe such as the determination of the level of synchronization among members of EMU, the existence of a core-periphery divide within the EMU, the impact of the recent enlargement and the characteristics of the cyclical comovement in EMU in comparison with the global economy.

Our results show a significant convergence period observed since the beginning of the nineties (thus confirming the results of Angeloni and Dedola, 1999, Massmann and Mitchell, 2003, and Darvas and Szápari, 2005) which seems to finish with the birth of EMU, in a period of macroeconomic convergence following the implementation of the Maastricht convergence criteria. The strong pattern of convergence in the group of EMU-12 countries during the nineties leads to a new synchronization regime since 1996 which is characterized by a higher level of business cycle coherence. New EU members experienced a period of significant cyclical convergence since the mid-nineties, both among themselves and with the EMU-12. After the crisis of 2001-2002 and in particular since 2004, the enlargement of the euro area has had little impact on the optimality of the European currency area from the point of view of business cycle synchronization. However, as in Artis (2003) and Pérez *et al.* (2007), we also find evidence that the European business cycle seems to dilute within a world-wide cycle from 2004 onwards. In recent years, new EU members are in similar or better levels of synchronization than some of the periphery countries.

[1]See Rua (2010) for a recent assessment of the importance of accounting for time dependence in the analysis business cycle cohesion.

The paper is structured as follows. In section two we present the business cycle extraction method and the basic characteristics of business cycle dispersion in EMU for the period under study. Section three presents the results of the convergence tests and identifies the different synchronization periods in the sample for EMU. Different alternative groupings are also considered and analysed. In section four, the cost of inclusion of the countries in the current EMU and a hypothetically enlarged EMU is assessed. Section five concludes.

2 Business cycles in EMU

In order to study the convergence of business cycles, an estimate of the cyclical component of the variable of interest (in our case, quarterly real GDP) needs to be obtained. For this purpose, following Harvey (1989) and Harvey and Jaeger (1993), we decompose the GDP series of each country under study into unobservable trend, cyclical and irregular components. Let y_{it} be the (logged) level of GDP corresponding to country i in period t then

$$y_{it} = \tau_{it} + \phi_{it} + \varepsilon_{it}^{y}, \;\; \varepsilon_{it}^{y} \sim \mathbf{NID}(0, \sigma_{\varepsilon^y}^2), \tag{1}$$

where τ_{it} is the trend component, ϕ_{it} is the cyclical component and ε_{it}^{y} is the (white noise) irregular component. The trend component, in its most general specification, will be assumed to be a random walk with a drift, where the drift follows a random walk as well, that is,

$$\begin{aligned} \tau_{it} &= \tau_{it-1} + \beta_{it-1} + \varepsilon_{it}^{\tau}, \;\; \varepsilon_{it}^{\tau} \sim \mathbf{NID}(0, \sigma_{\varepsilon^\tau}^2), & (2) \\ \beta_{it} &= \beta_{it-1} + \varepsilon_{it}^{\beta}, \;\; \varepsilon_{it}^{\beta} \sim \mathbf{NID}(0, \sigma_{\varepsilon^\beta}^2). & (3) \end{aligned}$$

This specification of the trend component nests several interesting cases. It should be noticed that if $\sigma_{\varepsilon^\tau}^2 > 0$ and $\sigma_{\varepsilon^\beta}^2 > 0$, this component induces an $\mathsf{I}(2)$ trend on y_{it}. On the other hand, if $\sigma_{\varepsilon^\tau}^2 > 0$ and $\sigma_{\varepsilon^\beta}^2 = 0$, τ_{it} is a random walk trend with drift. The case $\sigma_{\varepsilon^\tau}^2 = 0$ and $\sigma_{\varepsilon^\beta}^2 > 0$ defines a smoothly changing trend,[2] and $\sigma_{\varepsilon^\tau}^2 = 0$ and $\sigma_{\varepsilon^\beta}^2 = 0$ implies a deterministic linear trend.

The cyclical component is assumed to follow a damped stochastic sine-cosine wave, specified as

$$\begin{bmatrix} \phi_{it} \\ \phi_{it}^{*} \end{bmatrix} = \rho_i \begin{bmatrix} \cos \lambda_i & \sin \lambda_i \\ -\sin \lambda_i & \cos \lambda_i \end{bmatrix} \begin{bmatrix} \phi_{it-1} \\ \phi_{it-1}^{*} \end{bmatrix} + \begin{bmatrix} \theta_{it} \\ \theta_{it}^{*} \end{bmatrix}, \;\; \begin{bmatrix} \theta_{it} \\ \theta_{it}^{*} \end{bmatrix} \sim \mathbf{NID}(\mathbf{0}, \mathbf{\Sigma}_\theta), \tag{4}$$

for $\rho_i \in [0,1]$, $\lambda_i \in (0,\pi)$ and $\mathbf{\Sigma}_\theta = \text{diag}(\sigma_\theta^2, \sigma_\theta^2)$, so the disturbances of the cyclical component are assumed independent and of equal variance. It can be easily shown that the specification given by (4) implies that the cycle follows an ARMA(2,1) process, and that the constraints on the parameter space given above restrict the roots of the lag polynomial to lie on the region of the parameter space that leads to pseudo-cyclical behaviour in ϕ_{it}.

The model specified by (1)-(4) can be written in state space form in a straightforward manner and estimated using maximum likelihood methods via the Kalman (1961) filter and the prediction

[2] The Hodrick-Prescott trend (Hodrick and Prescott, 1997) appears as a special case of the decomposition of a series into a smooth trend and an irregular component for specific values of $\sigma_{\varepsilon^\beta}^2/\sigma_{\varepsilon^y}^2 = \lambda$, and $\sigma_{\varepsilon^\tau}^2 = 0$ and $\phi_t = 0$, where λ is the smoothing parameter of the Hodrick-Prescott filter, 1600 for quarterly data. When $\lambda \to \infty$, the Hodrick-Prescott filter approaches to linear detrending. Thus, the Hodrick-Prescott estimate of the cyclical component is then simply given by the smoothed irregular component (see Harvey, 1989, and Harvey and Jaeger, 1993).

error decomposition. Once the estimates of the parameters in (1)-(4) are obtained, the cyclical component can be recovered as the smoothed estimate of ϕ_{it}, $\hat{\phi}_{it}$, which is given by $\mathsf{E}(\phi_{it}|\{y_{it}\}_{t=1}^{T})$.

The unobserved components model given by (1)-(4) is estimated for the real quarterly GDP data corresponding to all EU countries (with the exception of Malta and Romania) and 11 OECD countries which will be used as a control group for assessing the European idiosyncrasy of the results.[3] Using such a structural unobserved components model presents several advantages respect to other common filtering techniques. Firstly, the model specified nests some other filters like the Hodrick-Prescott (1997) and linear detrending or first-differencing and thus offers more flexibility when extracting the components. Secondly, it implicitly specifies a band of frequencies which corresponds to the business cycle, removing the long-run and irregular information. Thirdly, it allows for a rationale underlying the signal-extracting procedure and makes parametric assumptions concerning the data generating process. The latter is of importance when tracking the business cycle especially for two reasons. Part of the economies considered in the sample, CEECs which joined the EU in the 2004 and 2007 enlargements, are transition economies which experienced a crisis of particular features during the nineties associated to a transition process where political constraints are of importance (Roland, 2002).[4] In addition, Aguiar and Gopinath (2007) conclude that shocks to trend growth rather than transitory fluctuations around the trend are the primary source of the volatility observed for real variables in emerging markets. The unobserved components model allows us to take account of sharp drops in GDP series occurred during some periods of time, for example, in the case of the Finnish great depression in the nineties (see Conesa *et al.*, 2007, for an analysis of this case).[5] The proposed model can deal with these features by allowing a flexible estimation of movements in the trend component.[6] Together with the estimation of cyclical components, we obtain the state of the cycle in terms of recessions (peak-to-trough period) and expansion periods (trough-to-peak period). This discretization was carried out using Canova's (1999) rule: a peak is defined at time t if $\hat{\phi}_{it} > \hat{\phi}_{it-1}$, $\hat{\phi}_{it-1} > \hat{\phi}_{it-2}$ and $\hat{\phi}_{it} > \hat{\phi}_{it+1}$ and a trough is defined at time t if $\hat{\phi}_{it} < \hat{\phi}_{it-1}$, $\hat{\phi}_{it-1} < \hat{\phi}_{it-2}$ and $\hat{\phi}_{it} < \hat{\phi}_{it+1}$, where $\hat{\phi}_{it}$ is the smoothed cycle at period t.[7]

The synchronization among groups of N countries can be analyzed using the time series of (a) the

[3]GDP series of Bulgaria, Estonia, Greece, Latvia, Slovenia and Switzerland were seasonally adjusted using TRAMO-SEATS (Gómez and Maravall, 1996). See the Data Appendix for the specification of countries, sample periods and sources.

[4]Campos and Coricelli (2002) characterized some stylized facts of transition economies during the nineties such as output fall, a dramatic decrease in the stock of physical capital, high geographic labor mobility, intense reorientation of trade towards the West, a change in the structure of the economy, a rapid collapse of institutions and a deterioration of social well-being (see also, Svejnar, 2002, and Foster and Stehrer, 2007, for characterizations of macroeconomic transitions during this period).

[5]Conesa *et al.* (2007) use the Finnish depression of the nineties as a case study for great depressions methodology developed by Kehoe and Prescott (2002 and 2007) recognizing that such a depression does not fulfill the Kehoe and Prescott criteria, but comes close to them.

[6]Figures presenting the smoothed cyclical components of the quarterly GDP series corresponding to each one of the countries considered can be found in the *Appendix*. Detailed results of the estimated models and series of state variables can be obtained from the authors upon request.

[7]Following the original definition of a business cycle by Burns and Mitchell (1946), we impose further restrictions to the identified phases in order to avoid too short expansion or recession periods: (a) a phase must last at least two quarters, (b) a full cycle must last at least six quarters and a maximum of 12 years. The method by Canova (1999) is related to the popular dating procedure put forward by Harding and Pagan (2002). Since Canova (1999) defines the rule based on the cyclical component of the series instead of the overall level of GDP and its growth rate (as in Harding and Pagan, 2002), we use the former. A recent proposal by Harding and Pagan (2006) can be seen as a generalization of Canova (1999).

cross-country (weighted) standard deviation of the smoothed cyclical component, on the one hand,

$$\hat{S}_t = \sqrt{\sum_{j=1}^{N} \omega_{jt}(\hat{\phi}_{jt} - \sum_{k=1}^{N} \omega_{kt}\hat{\phi}_{kt})^2 / (1 - \sum_{j=1}^{N} \omega_{jt}^2)}, \quad (5)$$

and (b) the series of a (weighted) indicator of comovement, defined as

$$C_t = |2(\bar{c}_t - 0.5)|, \quad (6)$$

where $\bar{c}_t = (\sum_j^N \omega_{jt}\hat{c}_{jt})$, with $\hat{c}_{jt}$ denoting the state of the cycle for country j at time t, which takes value one if the country is in expansion and zero if it is in recession. We use a weight ω_{jt} for each cycle, which may be based on the size of the country or assumed equal across economies. The indicator of comovement is based on the absolute value of $\bar{c}_t$, the (weighted) mean of all the states of the cycles at time t, after a change of scale and origin. The comovement indicator series ranges from 0 (complete asynchrony) to 1 (full synchronization).

Figure 1 plots the time series of the (unweighted) cross-country standard deviation of the cyclical component across the countries which composed EMU-12, together with the weighted standard deviation with weights based on country size (as proxied by total GDP), so as to weight down deviations from countries that amount to a small proportion of total production in the aggregate euro area. The Hodrick-Precott (1997) trends of both series have been included in order to isolate the noisy component and to make it easier to distinguish the stylized facts of the dynamics of dispersion. Figure 2 shows the weighted standard deviation series together with the comovement series for EMU-12.

The overall dynamics of the weighted and unweighted dispersion measures present similar dynamic patterns, although the difference in the level of the standard deviation since the beginning of the seventies indicates that countries of relatively small size quantitatively induce a certain degree of business cycle divergence in the euro area. We discuss our results based on the weighted measure. The sample starts with strong convergence in business cycles in the beginning of the sixties, which turns into a period of increasing divergence that culminates in the mid seventies. After a period of cyclical convergence from the middle of the seventies to the beginning of the eighties, a persistent business cycle divergence trend takes place in the second half of the eighties, which is reversed in the first years of the decade of the nineties. The convergent pattern in the nineties ends with a reversion in the trend towards divergence in business cycles, which is more pronounced since the fourth quarter of 2006. By the end of the sample (end 2008), the dispersion of business cycles in EMU-12 has risen approximately to the levels observed in the mid-nineties.[8]

By concentrating on the dispersion of the estimated business cycles, our measure captures cyclical differences in terms of phase as well as in terms of amplitude of the cycle. Depending on the aim of the analysis, it may be of interest to compare cycles without taking into account differences in their amplitude. This can be done, for instance, by using standardized business cycle measures which are normalized by dividing through the standard deviation of the country-specific cyclical component.[9]

[8]If we extract the business cycle using the Hodrick-Prescott or Baxter-King filters, which are often used in the empirical literature on optimum currency areas, our qualitative results are left unchanged (see the corresponding section in the *Appendix*).

[9]In the *Appendix* we present the comparison of our measure with that constructed on standardized cycles. The stylized facts of both measures are qualitatively very similar, which makes us conclude that the business cycle

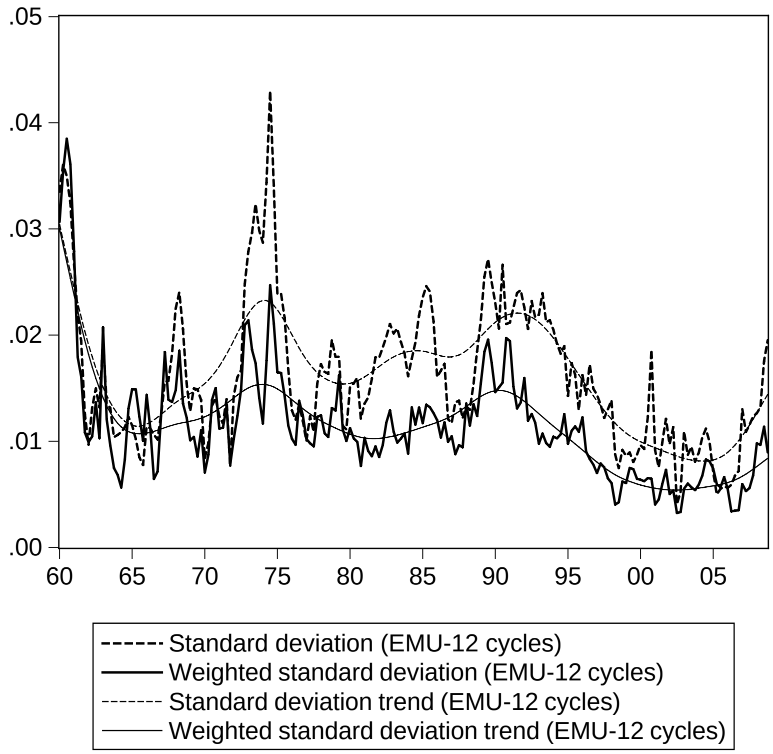

Figure 1: Dispersion of business cycles: EMU countries

Since our focus is on asymmetric shock transmission and this may take place when countries are in the same phase of the business cycle, thus leading to amplitude differences, we use the standard deviation of cyclical components (as opposed to that of standardized cyclical components) in our analysis. The comovement indicator series reveals a less clear pattern. However, some findings can be extracted from it. Some of the points of high coherence in the state of the business cycle coincide with the most relevant recessionary periods (mid seventies, beginning of the nineties, or beginning of the 2000s and the crisis period in 2008). Furthermore, there seems to be an increase of coherence in the phases of the cycles in EMU-12 since 1993, which is more evident since 2000.

In the following section we analyze the statistical significance of the changes in business cycle dispersion across EMU economies for different horizons, and assess the issue of the existence of a structural break in the dynamics of business cycle dispersion across EMU countries.

convergence patterns are not driven by the cyclical measure used.

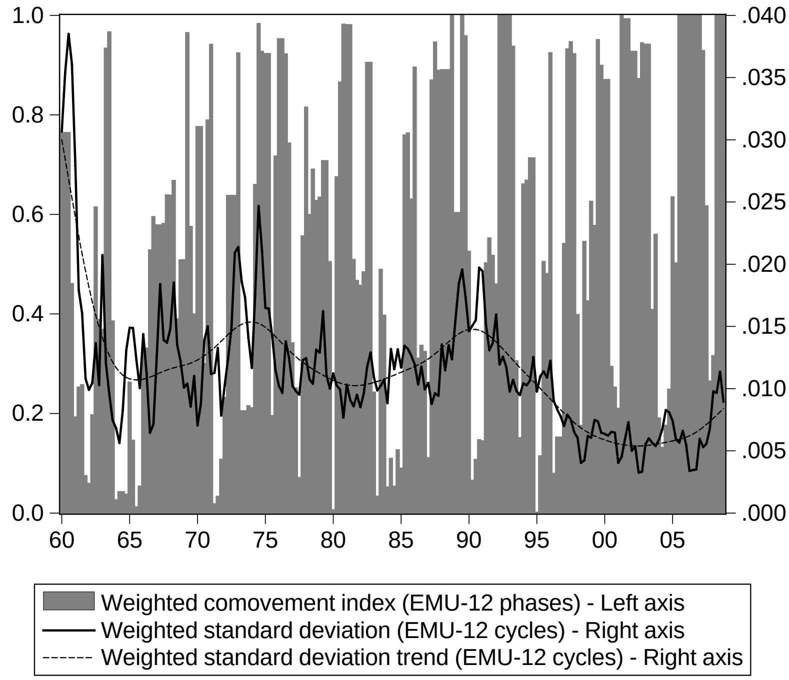

Figure 2: Dispersion and comovement of business cycles: EMU countries

3 Business cycle convergence and divergence patterns in the euro area

3.1 Testing for business cycle convergence/divergence

A first quantitative assessment of the patterns of convergence of business cycles across EMU economies can be carried out by studying the changes in our dispersion measure. The question that needs to be answered concerns whether the dynamics of the standard deviation of the cyclical component of GDP lead to statistically significant changes in the level of dispersion across cycles. Lichtenberg (1994) and Carree and Klomp (1997) tackle this issue in the framework of income convergence, defined as a reduction of the standard deviation of per-capita GDP across economic units. In order to test for the significance of changes in the standard deviation of EMU business cycles, we computed Carree and Klomp's (1997) T_2 test statistic, given by

$$T_{2,t,\tau} = (N - 2.5)\log[1 + 0.25(\hat{S}_t^2 - \hat{S}_{t+\tau}^2)^2/(\hat{S}_t^2\hat{S}_{t+\tau}^2 - \hat{S}_{t,t+\tau}^2)], \quad (7)$$

where $\hat{S}_t$ is the GDP-weighted cross-country standard deviation of $\hat{\phi}_{it}$ and $\hat{S}_{t,t+\tau}$ is the covariance between $\hat{\phi}_{it}$ and $\hat{\phi}_{it+\tau}$. Under the null hypothesis of no change in the standard deviation between period t and period $t+\tau$, T_2 is $\chi^2(1)$ distributed, and can thus be used to test for significant changes in dispersion.

$T_{2,t,\tau}$ was calculated for our sample using different potential convergence/divergence horizons ranging from one year ($\tau = 4$) to eight years ($\tau = 32$). Figure 3 presents the changes in the standard deviation of business cycles in EMU-12 that appeared significant at the 5% level for the horizons corresponding to two, four, six and eight years. That is, the variable which is plotted in Figure 3 is defined as

$$K_t = (\hat{S}_{t+\tau} - \hat{S}_t) I[T_{2,t,\tau} > \chi^2_{0.95}(1)], \tag{8}$$

where τ is alternatively equal to 8, 16, 24 and 32 quarters, $\chi^2_{0.95}(1)$ is the 95th percentile of the $\chi^2(1)$ distribution and $I[\cdot]$ is the indicator function, taking value one if the argument is true and zero otherwise.[10]

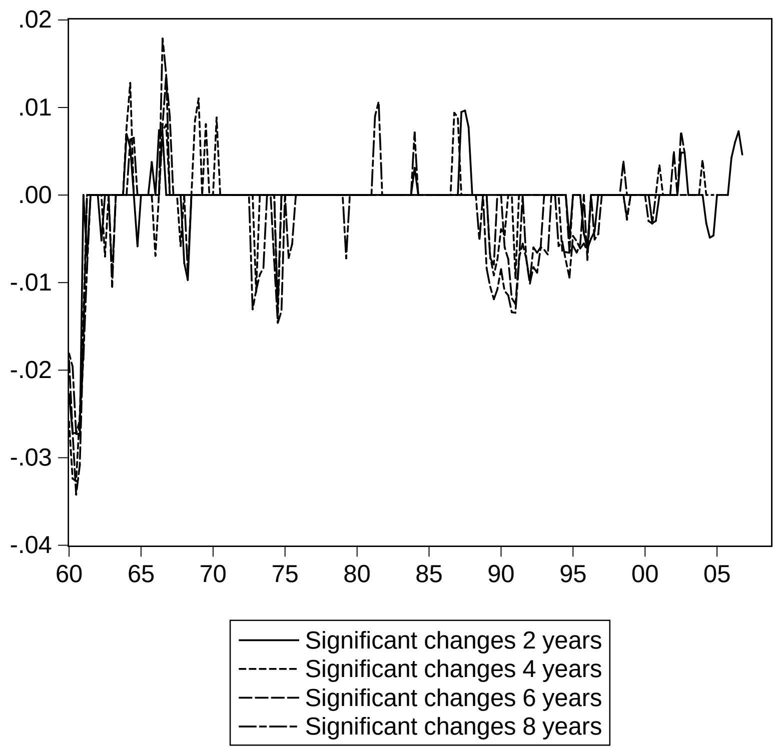

Figure 3: Significant dispersion changes: EMU

Figure 3 indicates that the medium run dynamics shown in Figure 1 actually led to statistically significant changes in the dispersion of business cycles in EMU for the period under study. In particular, a long period of sizeable and significant convergence took place in the nineties and finished with the inception of the monetary union in 1999, when a period of smooth divergence started. This last feature is common to the results reported by Hughes Hallett and Richter (2006) and can be considered as some evidence against the endogeneity of optimum currency area criteria (see Frankel and Rose, 1998), although it should be interpreted with care given the short size of the post-EMU sample.

[10] We also carried out the Carree and Klomp (1997) test using a 1% significance level. Results are robust to this stricter definition of convergence/divergence and are available from the authors upon request.

3.2 Synchronization regimes on the way to EMU

We can analyse the time series properties of our business cycle dispersion measure in order to identify systematic periods where different degrees of business cycle synchronization take place. Table 1 displays the results of Augmented Dickey-Fuller test (ADF, Dickey and Fuller, 1979) and KPSS (Kwiatkowski *et al.*, 1992) unit root tests for the dispersion series of EMU-12, the OECD control group and the Global-1 group including both the EMU-12 and OECD groups. Different unit root tests give contradicting results concerning the order of integration of the standard deviation of business cycles in EMU depending on the test statistic and the setting specified. A simple ADF test rejects the null hypothesis of a unit root at any sensible significance level, whereas the KPSS test rejects stationarity of the series under the null specification with intercept, but cannot reject stationarity under an specification with intercept and trend. We consider the series to be represented by an autoregressive process potentially subject to breaks in the intercept and the autoregressive parameter. This leads to the possible existence of different regimes of business cycle synchronization. Setting an autoregressive lag of one, which appears sufficient to account for the autocorrelation present in the data, the specification we consider for the weighted cross-country dispersion measure is the following,

$$\hat{S}_t = \sum_{j=1}^{R} (\alpha_{0,j} + \alpha_{1,j}\hat{S}_{t-1}) I(T_{j-1} \leq t < T_j) + \varepsilon_t, \tag{9}$$

where ε_t is a white noise disturbance, R is the number of regimes considered (therefore $R-1$ is the number of breaks in the parameters of the process), T_0 is the time index of the first observation and T_R is the time index of the last observation. We consider three specifications. A model with the structural change only in the intercept ($\alpha_{1,j} = \alpha_1$, $\forall j = 1, \ldots, R$), a specification with only the autoregressive parameter subject to structural change ($\alpha_{0,j} = \alpha_0$, $\forall j = 1, \ldots, R$), and a pure structural change model, where both parameters are allowed to present a break. Table 2 presents the results of the estimation of (2) for the cases of partial structural change models (with break in intercept and break in the autoregressive parameter, respectively), and pure structural change model, together with the sup-F test for the null of the model without breaks against each one of the models with breaks. In addition to this, we present the results of the unweighted and weighted double test (UDmax and WDmax, respectively), the sup-$F(\ell+1|\ell)$ test, and the number of breaks selected by the sequential procedure (Bai and Perron, 1998 and 2003), the Bayesian Information Criterion (BIC, Schwarz, 1978), and the modified BIC of Liu *et al.* (1997). The breaks were estimated in each case by choosing the values in the vector $\tau = (T_1 ... T_{R-1})$ that globally minimize the sum of squared residuals, allowing for a maximum of 4 regimes ($R = 4$, corresponding to 3 breaks). That is,

$$\{\hat{T}_1, \ldots, \hat{T}_{R-1}\} = \arg\min \sum_{t=0}^{T_R} \hat{\varepsilon}(\tau)_t^2, \tag{10}$$

where the search for the breaks is done after imposing a minimum of 15% of the full sample to be contained in each regime, in order to avoid spurious results caused by small subsample sizes. The significance levels of the sup-F tests are obtained in each case by simulating the critical values using the method proposed by Bai and Perron (1998 and 2003).

The results of the tests and the estimates of model (9) are shown in Table 2. Our results present evidence for the model with one break in all the specifications considered. Together with the mod-

	Setting with intercept		Setting with intercept and linear trend	
	ADF test stat.	KPSS test stat.	ADF test stat.	KPSS test stat.
EMU-12	-4.529***	0.988***	-4.905***	0.085
OECD	-3.586***	0.493**	-3.892**	0.155**
Global-1	-3.671***	0.768***	-4.476***	0.210**

Note: *, ** and *** stands for significance at the 10%, 5% or 1% level, respectively.

Table 1: Unit root test results for weighted standard deviation series

els estimated, we include the 95% and 90% confidence intervals for the break, the unconditional expectation and variance of the process implied by the model in each one of the regimes. The break is determined in the first quarter of 1996 for every model, and the structural change model with only the persistence parameter subject to break is the preferred one in terms of model selection criteria.[11] In the first regime (1960/1-1995/4) the process presents high persistence and convergence to a very low level of dispersion. The unconditional expectation of the process goes down from the first to the second regime, as well as the variance of the process. Figure 4 summarizes the results by plotting the unconditional expectation of the autoregressive process corresponding to each one of the regimes together with the original dispersion series. The shaded area in Figure 4 shows the 95% confidence interval corresponding to the estimated break.

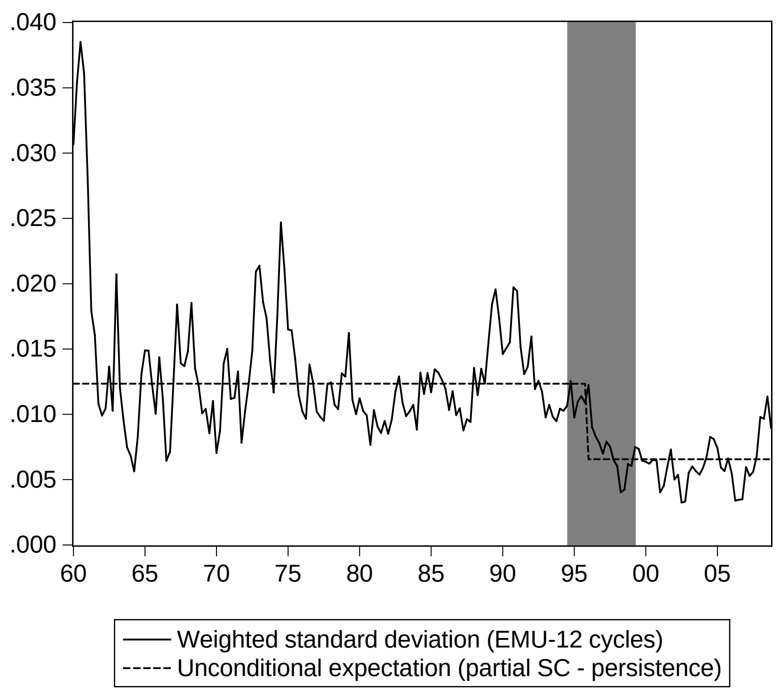

Figure 4: Business cycle dispersion regimes in EMU, $\mathbf{E}[S_t|\hat{T}_1, R_j, j = 1, 2]$ and 95% confidence interval

[11] The model with breaks (only) in the intercept and the model where all parameters are allowed to be subject to breaks offer similar conclusions.

	No-SC	Partial-SC (intercept)	Partial-SC (persistence)	Pure-SC
Breaks (SSR)				
R=2		(1996/1)	(1996/1)	(1996/1)
R=3		(1974/3,1996/1)	(1974/3,1996/1)	(1974/4,1988/4)
R=4		(1974/3,1987/4,1996/1)	(1974/3,1987/4,1996/1)	(1974/4,1988/2,1996/1)
Sup-F test (ℓ)				
Sup-F test (1)		11.0786**	13.9340***	15.5172***
Sup-F test (2)		4.8264	6.4010*	10.2270**
Sup-F test (3)		3.7096	5.0635	10.7876***
UDmax		11.0786**	13.9340***	15.5172***
WDmax		11.0786**	13.9340***	15.5172**
Sup-F test (ℓ+1/ℓ)				
Sup-F test (2/1)		0.8343	1.5049	2.6119
Sup-F test (3/2)		4.4118	5.3994	10.4191
No. breaks selected				
Sequential		1**	1***	1***
BIC		0	0	0
LWZ		0	0	0
$\hat{\alpha}_{0,1}$	0.0016*** (0.0004)	0.0026*** (0.0006)	0.0024*** (0.0005)	0.0026*** (0.0006)
$\hat{\alpha}_{1,1}$	0.8481*** (0.0336)	0.7906*** (0.0394)	0.8049*** (0.0370)	0.7931*** (0.0405)
break intercept	-	-0.0013*** (0.0005)	-	-0.0010 (0.0013)
break persistence	-	-	-0.1721*** (0.0663)	-0.0497 (0.1814)
Break		(1996/1)	(1996/1)	(1996/1)
95% Conf. Interval		(1994/3,2008/3)	(1994/3,1999/2)	(1994/4,2001/1)
90% Conf. Interval		(1995/2,2005/1)	(1995/1,1998/2)	(1995/2,1999/4)
Uncond. expect. ($R1$)	0.0107	0.0125	0.0123	0.0125
Uncond. expect. ($R2$)	-	0.0063	0.0066	0.0063
Variance ($R1$)	2.2943e-05	2.1131e-05	2.2507e-05	2.1354e-05
Variance ($R2$)	-	3.9863e-06	2.5575e-06	3.3215e-06
Q(1) test	0.3301	0.5307	0.5082	0.5344
Q(4) test	6.7083	8.1647*	8.0686*	8.1397*
JB test	55.3790***	65.2270***	61.3897***	64.4724***

Note: The dependent variable is the weighted standard deviation of business cycles across countries for EMU-12. *, ** and *** stands for significance at the 10%, 5%, and 1% level. "Q(z) test" is the Ljung-Box test statistic (Ljung and Box, 1978) for autocorrelation up to zth order. "JB test" is the Jarque Bera test statistic (Jarque and Bera, 1987) for residual normality. LWZ is the modified Schwarz criterion of Liu *et al.* (1997). The significance level of the sup-F tests were computed using the algorithm in Bai and Perron (1998 and 2003), using 1000 replications with Wiener processes of sample size 500.

Table 2: AR(1) models with structural changes for the weighted cross-country dispersion of business cycles: EMU-12

To sum up, two distinct regimes concerning the synchronization of business cycles can be found in the euro area for the period under study. A first period covers the sample from the start (1960/1) until the mid-nineties, and is followed by a second regime which spans until the end of the sample in 2008/4, characterized by a lower unconditional expectation and volatility in the dispersion series.

3.3 Is there an EMU business cycle?

Beyond the determination of the level of synchronization among the members of EMU, several issues highlighted by the literature can be addressed within the framework developed in this paper. In particular, the existence of a core-periphery divide within the EMU, the impact of the recent enlargement, and the characteristics of the cyclical comovement in EMU in comparison with the global economy can be easily assessed. The core-periphery debate in Europe had its climax during the beginning of the nineties, coinciding with the preparation period for the currency union after the signing of the Maastricht Treaty in 1992. The decision stipulated in the Copenhagen

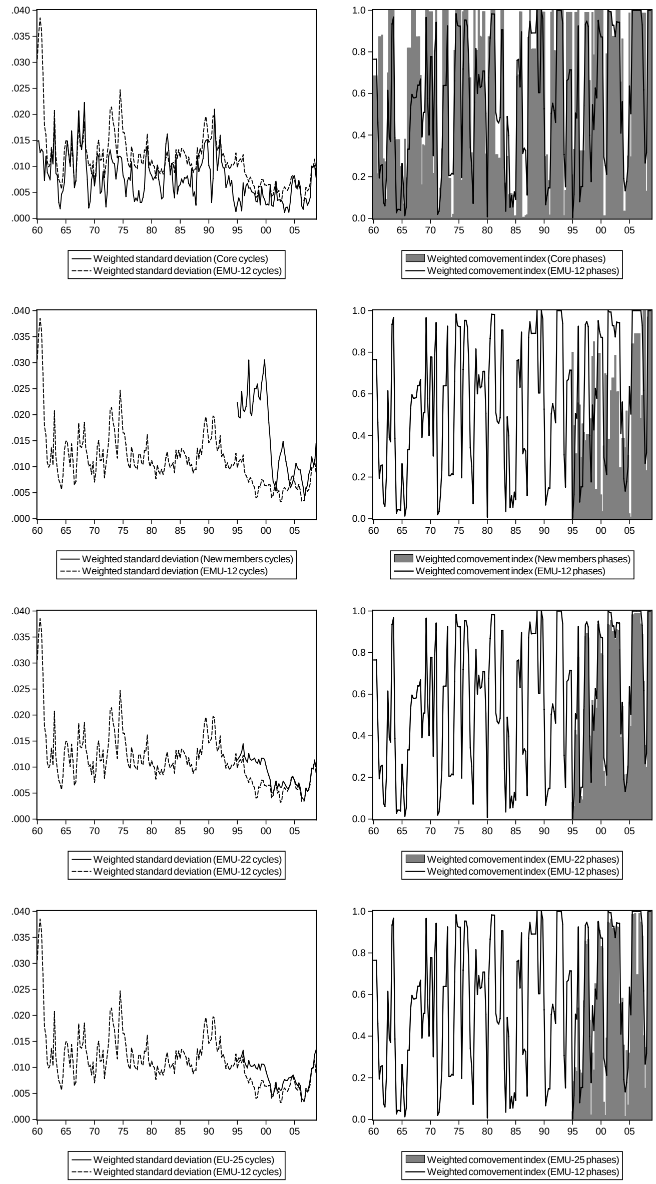

Figure 5: Business cycle dispersion: Core, Enlargement group, EMU-22, EU-25

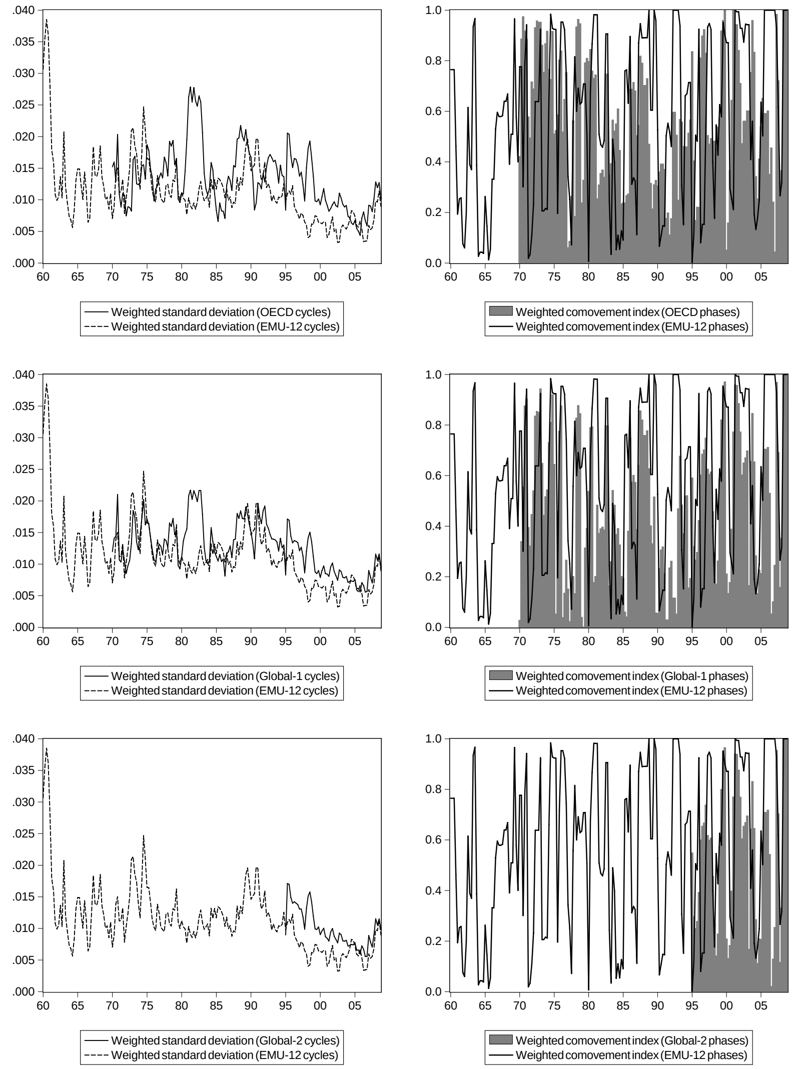

Figure 6: Business cycle dispersion: OECD, Global-1, Global-2

European Council in 2002 that all the new members resulting from the enlargements of 2004 and 2007 would go straight into the Stage Three of EMU without an opting-out clause intensified the debate. Some scholars had concluded that a currency union beyond the core of countries identified by Germany, Benelux and France would not fulfill the OCA criteria to the degree needed to avoid problems if asymmetric shocks are sizeable (see, for example, De Grauwe, 1993). Nevertheless, the comparison either with a core group or the periphery of countries of the EMU-12 has continued in the business cycle synchronization literature when assessing the costs and benefits of joining EMU for new EU members (see Fidrmuc and Korhonen, 2006, for a meta-analysis on business cycle correlation between the euro area and CEECs). From this literature it can be highlighted that several acceding countries showed highly synchronized with the EU-15 countries, especially Hungary, Poland and Slovenia (Artis *et al.*, 2004, Fidrmuc and Korhonen, 2004 and 2006, Darvas and Szápari, 2005). However, the homogeneity between new EU members and EMU is lower than during past enlargements (Artis *et al.*, 2004) and seems to have decreased during the 2000-2002 recession as in the case of countries within EMU (Fidrmuc and Korhonen, 2004). Finally, several authors have recently found evidence in favour of the existence of a world-wide trend towards business cycle synchronization since the end of the nineties and the beginning of the 2000s in which a hypothetical European business cycle would dilute (Artis, 2003, Pérez *et al.*, 2007).

The aim of this section is to analyse, on the one hand, whether the traditional core of EMU countries shows a higher degree of synchronization than the whole euro area. On the other hand, we also study whether the hypothetical inclusion of all the new EU members in the currency area induces relevant changes to the degree of optimality of EMU, and whether the cyclical comovement among EMU countries presents some differential features relative to the rest of the world.

Figure 5 presents the standard deviation series of the core EMU, the group of new EU members, a hypothetical EMU-22 including all the new members of the recent enlargements in 2004 and 2007 and the EU-25, together with the dispersion series for EMU-12 (first column of panels). Figure 5 also includes the respective coherence indices (second column of panels). Figure 6 shows the same information for the OECD control group, which includes developed countries that are not part of the European integration process and the three opt-out clause members (Denmark, United Kingdom and Sweden) and two global groups, one which includes all the countries but the enlargement group (Global-1), and a second one formed by all the countries considered in this piece of research (Global-2).

The core group shows similar dynamics to those of the EMU-12 group, but it presents in general a lower level in the dispersion series, reflecting higher synchronization. In some subperiods of increasing divergence, however, both dispersion series reach similar levels. In addition, the coherence measure presents higher values and more periods of full synchronization during the whole sample. The group of new EU members experienced strong cyclical convergence after 1995, and is since 2004 in a level of synchronization similar to that of the EMU-12. The behaviour of the dispersion series is much more volatile, however. This pattern is also consistent when looking at the coherence index.

With respect to the OECD group, the EMU-12 group has experienced a more synchronized behaviour since the beginning of the eighties. From the beginning of the nineties (1992) until 2004, the levels and dynamics of synchronization became roughly similar in both groups. The coherence index reveals also a somehow more synchronized behaviour in the phase of the cycle for EMU-12, but this is less clear than for the dispersion series. When considering a global economy group with these two groups of countries (Global-1) a similar conclusion is obtained, with EMU-12 showing a more synchronized behaviour. This is also evident when the EMU-12 is compared to a global group (Global-2) including all the countries here considered (the EMU-22 countries and the control group of OECD countries). The EMU-12 group shows a higher level of synchronization from the beginning of the comparison sample until 2004.

Structural break analysis was also carried out for the OECD and Global-1 groups (see Tables 3 and 4, respectively).[12] An AR(1) process with one break was able to model the dispersion measure for the OECD group well. After testing for parameter stability, a model with a break in persistence estimated in 1999/1 was chosen, a specification which performs slightly better than its competitors and makes the comparisons among groups easier. Concerning the Global-1 group, an AR(1) model with one break in the autoregressive coefficient estimated in 1998/4 was also selected. For both groups we find a decrease in the long-run unconditional expectation of the synchronization measure. The variances of the processes in Tables 3 and 4 show also a decrease from the first to the second regime. The results of Tables 3 and 4 in comparison to those of Table 2 show higher unconditional expectations in the OECD and the global group considered (Global-1) than in EMU-12. However, the (unconditional) variance of the dispersion measure in the OECD and Global-1 groups is lower than that of the EMU-12 group.

To sum up, the strong pattern of convergence in the EMU-12 during the nineties presents a new regime since 1996 which is characterized by more synchronization of business cycles and less volatility in our measure summarizing such comovement. The core group of EMU countries is characterized by a higher degree of cyclical synchronization. The new EU members experienced a strong convergence in cyclical patterns both within the group and with respect to the EMU-12. After the recession of 2001-2002 and in particular since 2004, the enlargement of the euro area does not appear to have a significant impact on the optimality of the European currency area from the point of view of business cycle synchronization. The EMU-12 group shows more synchronized business cycles than the group formed by other OECD countries or the global economy. However, from 2004 onwards, the European differential disappears and the European business cycle seems to dilute within a global business cycle.

In the analysis carried out hitherto, the measure of business cycle synchronization is based on the comparison of contemporaneous cyclical states. The existence of lead-lag relationships across business cycles in Europe has been emphasized in the OCA literature (see the contribution by Aguiar-Conraria and Soares, 2011, for a recent example). In order to assess the robustness of our analysis to the existence of such synchronization patterns, we repeated the analysis using leads and lags of up to four quarters for each country. In a first step, we repeated the EMU synchronization analysis allowing each country to be a leader (that is, including a lag of the corresponding series instead of the contemporary value) or a follower (that is, including a lead of the corresponding series instead of the contemporary value). The overall pattern of the dispersion series is unaffected by these changes and the general conclusion of our analysis (in terms of the overall dynamics of the cross-country dispersion measure and the regimes identified) are not affected by the potential existence of lead/lag relationships between the cycles considered.[13]

[12] Carree and Klomp's (1997) test was implemented for all the groups considered in our analysis. Results are not reported here because of reasons of space. They confirm the description of the dynamics above mentioned and are available from the authors upon request.

[13] Detailed results for this robustness exercise can be found in the *Appendix*.

	No-SC	Partial-SC (intercept)	Partial-SC (persistence)	Pure-SC
Breaks (SSR)				
R=2		(1999/1)	(1999/1)	(1999/1)
R=3		(1977/2,1999/1)	(1977/2,1999/1)	(1980/3,1999/1)
R=4		(1977/2,1983/1,1999/1)	(1977/2,1983/1,1999/1)	(1977/2,1983/1,1999/1)
Sup-F test (ℓ)				
Sup-F test (1)		128.9633***	96.9283***	129.2726***
Sup-F test (2)		65.9577***	55.5108***	66.5164***
Sup-F test (3)		49.4858***	40.8158***	51.2707***
UDmax		128.9633***	96.9283***	129.2726***
WDmax		128.9633***	96.9283***	129.2726***
Sup-F test (ℓ+1/ℓ)				
Sup-F test (2/1)		11.0582**	7.0869*	9.6346
Sup-F test (3/2)		12.8591**	15.5393***	11.2795
No. breaks selected				
Sequential		1*** or 3**	1***	1***
BIC		3	3	3
LWZ		1	1	1
	No-SC	*Partial-SC (intercept)*	*Partial-SC (persistence)*	*Pure-SC*
$\hat{\alpha}_{0,1}$	0.0021*** (0.0006)	0.0034*** (0.0008)	0.0032*** (0.0007)	0.0033*** (0.0008)
$\hat{\alpha}_{1,1}$	0.8438*** (0.0436)	0.7724*** (0.0502)	0.7888*** (0.0472)	0.7801*** (0.0527)
break intercept	-	-0.0015*** (0.0006)	-	-0.0007 (0.0018)
break persistence	-	-	-0.1523*** (0.0560)	-0.0880 (0.1789)
Break		(1999/1)	(1999/1)	(1999/1)
95% Conf. Interval		(1998/4,2000/4)	(1998/3,2000/3)	(1998/4,2000/4)
90% Conf. Interval		(1998/4,2000/2)	(1998/3,2000/2)	(1998/4,2000/2)
Uncond. expect. ($R1$)	0.0133	0.0151	0.0150	0.0151
Uncond. expect. ($R2$)	-	0.0084	0.0087	0.0085
Variance ($R1$)	2.4521e-05	2.1058e-05	2.2483e-05	2.1692e-05
Variance ($R2$)	-	4.1839e-06	1.4590e-05	6.6922e-06
Q(1) test	0.0705	0.3400	0.2192	0.2788
Q(4) test	0.7262	1.0853	1.0616	1.0957
JB test	53.7529***	36.7712***	40.4554***	38.5142***

Note: The dependent variable is the weighted standard deviation of business cycles across countries for the OECD group. *, ** and *** stands for significance at the 10%, 5%, and 1% level. "Q(z) test" is the Ljung-Box test statistic (Ljung and Box, 1978) for autocorrelation up to zth order. "JB test" is the Jarque Bera test statistic (Jarque and Bera, 1987) for residual normality. LWZ is the modified Schwarz criterion of Liu *et al.* (1997). The significance level of the sup-F tests were computed using the algorithm in Bai and Perron (1998 and 2003), using 1000 replications with Wiener processes of sample size 500.

Table 3: AR(1) models with structural changes for the weighted cross-country dispersion of business cycles: OECD

The stylized facts above described lead us to consider which factors may be the main drivers underlying the patterns of cyclical synchronization detected. Some determinants of business cycle synchronization have been highlighted by the literature.[14] In particular, there is strong empirical evidence on the relationship of cyclical synchronization with trade integration (De Haan *et al.*, 2008, Inklaar *et al.*, 2008), and with fiscal policy (Christodoulakis *et al.*, 1995, Fatas and Mihov, 2003a, Fatas and Mihov, 2003b, Darvas *et al.*, 2005, Böwer and Guillemineau, 2006, Akin, 2006).

Empirical research supports the existence of a positive relationship between trade intensity and

[14] Early on, McKinnon (1963) extended the criteria by considering optimality in terms of openness and size of the economy. Together with factor mobility, openness and size of the economy, a large number of OCA criteria have been suggested in the literature (see, for example, Tavlas, 1993, Mongelli, 2002, De Grauwe and Mongelli, 2005, De Haan *et al.*, 2008, or Dellas and Tavlas, 2009).

		Partial-SC (intercept)	*Partial-SC (persistence)*	*Pure-SC*
Breaks (SSR)				
R=2		(1998/3)	(1998/4)	(1998/3)
R=3		(1982/4,1998/3)	(1992/1,1998/4)	(1974/4,1998/4)
R=4		(1977/2,1983/1,1998/3)	(1977/1,1982/4,1998/4)	(1979/3,1992/1,1998/4)
Sup-F test (ℓ)				
Sup-F test (1)		18.4029***	20.6386***	22.8586***
Sup-F test (2)		9.3591***	11.0168***	15.7140***
Sup-F test (3)		7.7297***	9.0150***	12.2046***
UDmax		18.4029***	20.6386***	22.8586***
WDmax		18.4029***	20.6386***	22.8586***
Sup-F test (ℓ+1/ℓ)				
Sup-F test (2/1)		1.1243	2.3414	6.7042
Sup-F test (3/2)		1.7226	2.4158	4.5045
No. breaks selected				
Sequential		1***	1***	1***
BIC		1	1	0
LWZ		0	0	0
	No-SC	*Partial-SC (intercept)*	*Partial-SC (persistence)*	*Pure-SC*
$\hat{\alpha}_{0,1}$	0.0021*** (0.0006)	0.0042*** (0.0008)	0.0039*** (0.0008)	0.0043*** (0.0009)
$\hat{\alpha}_{1,1}$	0.8357*** (0.0448)	0.7080*** (0.0558)	0.7294*** (0.0518)	0.7020*** (0.0601)
break intercept	-	-0.0018*** (0.0005)	-	-0.0022 (0.0016)
break persistence	-	-	-0.1949*** (0.0528)	0.0456 (0.1659)
Break		(1998/3)	(1998/4)	(1998/3)
95% Conf. Interval		(1997/4,2003/1)	(1998/1,2000/3)	(1997/4,2002/2)
90% Conf. Interval		(1998/1,2001/4)	(1998/2,2000/1)	(1998/1,2001/2)
Uncond. expect. ($R1$)	0.0127	0.0144	0.0144	0.0144
Uncond. expect. ($R2$)	-	0.0083	0.0084	0.0082
Variance ($R1$)	1.6027e-05	1.1293e-05	1.1959e-05	1.1105e-05
Variance ($R2$)	-	2.5731e-06	1.6869e-06	2.8929e-06
Q(1) test	0.0316	0.1812	0.0916	0.2065
Q(4) test	1.9931	1.2093	0.9825	1.2471
JB test	46.1899***	31.3117***	36.9374***	30.2708***

Note: The dependent variable is the weighted standard deviation of business cycles across countries for the Global-1 group. *, ** and *** stands for significance at the 10%, 5%, and 1% level. "Q(z) test" is the Ljung-Box test statistic (Ljung and Box, 1978) for autocorrelation up to zth order. "JB test" is the Jarque Bera test statistic (Jarque and Bera, 1987) for residual normality. LWZ is the modified Schwarz criterion of Liu *et al.*, 1997. The significance level of the sup-F tests were computed using the algorithm in Bai and Perron (1998 and 2003), using 1000 replications with Wiener processes of sample size 500.

Table 4: AR(1) models with structural changes for the weighted cross-country dispersion of business cycles: Global-1 group

business cycle synchronization, while for the rest of OCA criteria the evidence is more mixed (see, De Haan *et al.*, 2008, for a survey). However, Mendoça *et al.* (2011) conclude that trade has a decreasing marginal effect on business cycle correlation, and Inklaar *et al.* (2008) find that for countries with highly synchronized cycles trade intensity effects decrease and other factors have as strong an effect as trade. From a cost-benefit perspective, Bayoumi (1994) highlights that the constitution of a currency area realizes welfare gains from lower transaction costs associated with trade within the union, and creates costs from the lower flexibility in the adjustment towards full employment, related to the importance of the union's production in consumption and the idiosyncrasy of shocks. Moreover, regions outside an existing currency area that are highly integrated with it may have an incentive to join the union to realize the gains from lower trade costs, since they are negatively affected by output costs experienced by the members of the monetary union. In this sense, the currency area would work as an attractor, showing some degree of irreversibility. Thus, trade integration plays a primary role in explaining business cycle synchronization, though other factors may be relevant as well—specifically, fiscal policy.

The last period of strong business cycle convergence since the beginning of the nineties, which seems to finish with the birth of EMU, runs in parallel to the macroeconomic convergence initiated by the Maastricht Treaty, and particularly coincides with the period of widespread fiscal consolidation and convergence among European countries following the lines stated in the Treaty. It is in this period when a stronger European differential with respect to other advanced economies in terms of cyclical synchronization is found. Fatás and Mihov (2003a and 2003b) document a deeper convergence in the conduct of fiscal policy among EMU countries in this period, associated with a reduction in the use of discretionary fiscal measures across euro area countries. To the extent that the observed differences in business cycle in Europe are due mostly to differences in variables that are under control of the government (Christodoulakis *et al.*, 1995), the process of fiscal coordination would be behind this trend in business cycle synchronization. This result may be indicative on the importance of similarity in idyosincratic fiscal shocks as a determinant of cyclical convergence, and highlights the relevance of fiscal policy as a source of asymmetric shocks in the context of OCA theory.

4 The cost of inclusion in a monetary union

Up to this point, the method used has proved to be an efficient instrument for the automatic determination of business cycle synchronization regimes given a group of countries. The cost-benefit balance of being part of a currency union for a single country is also of capital importance for policy-makers. We analyse this issue from the point of view of the potential distortion in terms of synchronization implied by the inclusion of a country in the group of economies forming the currency area.

A measure based on business cycle synchronization, such as ours, only assesses one of the many factors which play a role in the decision of joining a monetary union, and emphasizes aspects related to the costs of giving up independent monetary policy instruments. However, it should be noted that there are also potential gains from belonging a monetary union that can be realized. Joining a currency union may improve the optimality of monetary policy as a consequence of the gains in commitment technology (Giavazzi and Pagano, 1988), and increased credibility of central bank's commitment when private sector's beliefs reflect imperfect information about the monetary policy enforced by the authority (Ravenna, 2012). As a result, there would exist an incentive to join a currency area, and to maintain the agreement, enhancing the sustainability of monetary unions.

From a theoretical point of view, the parallel divergence patterns in business cycles and fiscal stance following the birth of EMU can be seen as a result of the interplay between monetary policy in a currency union and national fiscal policies. There is theoretical support for an optimal policy mix of a common monetary authority to stabilize inflation in the union as a whole, and coordinated national fiscal policies with a role for country-specific stabilization of domestic output gap and inflation differentials (Galí and Monacelli, 2008), or only domestic output gap (Pappa and Vassilatos, 2007). Nevertheless, there are problems associated with a mix of common monetary policy and national fiscal policies. Within a monetary union, a country experiencing large deficits and high debt-to-GDP ratios may create negative spillover effects for the rest of the currency area, increasing the interest rate of the monetary union and thus, the load of financing government debts in other members of the currency area (De Grauwe, 2007). Besides, Onorante (2004) shows that fiscal activism is always increased by entry in a monetary union, because the potential costs of running higher deficits (in terms of higher interest rates) for a country in the monetary union are lower than if monetary policy was independent, falling part of the costs entailed by the increase of interest rates on other member countries. In addition to this, Galí and Monacelli (2008) highlight that a common monetary policy targeting inflation of the union as a whole is only optimal when national fiscal policies are neutral at the union's level, in the sense that they are not creating inflationary strains on the union.

Therefore, the design of an optimal policy agreement and the determination of role of fiscal policies in a currency area acquires meaning. Fiscal constraints may help avoid the free-riding problems arising from the interaction between national fiscal policies and a common monetary policy (Uhlig, 2002), or help coordinate national fiscal policies to avoid inflationary pressures on the union (Galí and Monacelli, 2008). In absence of broad fiscal coordination, as agreements concerning common policy goals and strategies (Von Hagen and Mundschenk, 2001), deviations from the optimal level of cyclical comovement would appear as a result of asymmetric shocks coming from national fiscal policies, and the central bank may find it optimal to deviate from strict inflation targeting.

The incidence of asymmetric shocks or asymmetric transmission mechanisms to symmetric shocks, which is the factor we focus on here, is the characteristic which is identified as the crucial measure for assessing optimality of currency areas by Mundell (1961) in his seminal contribution (see Dellas and Tavlas, 2009, for a revision of the developments of OCA theory). In spite of the fact that all the benefits of membership for the individual countries joining the currency area are not captured by the indicator proposed here, the importance of cyclical homogeneity for the conduct of common monetary policy in the monetary union is evident. This is the case if we assess the problem from the point of view of the monetary authorities in the established currency union, for which indicators based on comparing cyclical synchronization contain information about the potential problems of accepting a new country in the monetary union in two dimensions. On the one hand, if the business cycle of the potential member country is not in synchronization with existing members, monetary policy decisions based on the cyclical development of the full monetary union (as is the case if interest rate setting in the currency area can be approximated by a Taylor rule) will be less optimal for the "older" member countries. On the other hand, we may assume that the monetary policy authority in the currency union is formed by representatives from each one of the economies of the monetary union and that they act in the benefit of their own country. For simplicity, assume that the rule for monetary policy decisions in the central bank of the monetary union is of the "one country - one vote" type. In this case, a variable based on synchronization of cycles is helpful to measure the tensions that would arise in terms of achieving a common interest rate decision. Thus, in this sense, the extra costs for reaching agreement in the monetary authority that would be implied by the inclusion of the country in the currency area would also be mirrored by our indicator (see for instance Aksoy *et al.*, 2002, for a model in this spirit).

We propose to analyse the cost of inclusion of a country j in the group Ω by using the simple indicator

$$\text{coi}_{t,j}|\Omega = \frac{\hat{S}_t|\Omega_{-j} - \hat{S}_t|\Omega}{\hat{S}_t|\Omega}, \tag{11}$$

where $\hat{S}_t|\Omega_{-j}$ is the (weighted) cross-country standard deviation of business cycles corresponding to the group Ω excluding country j and $\hat{S}_t|\Omega$ is the (weighted) cross-country standard deviation of smoothed cycles for the group Ω including country j, both evaluated at time t. The indicator is defined as a rate of change in dispersion, taking negative values when the standard deviation of the group increases as the country is included (that is, when the country induces cyclical divergence in the group), and positive values when the inclusion of the country induces a decrease in the dispersion (that is, when it induces cyclical convergence in the group). Using this measure of the cost of inclusion of a country is thus possible to obtain a quantification of the impact that each country has in the degree of synchronization of a (potential) currency union at a given period in time. Figures 7 and 8 show the cost-of-inclusion of each member for the EMU-12 and the hypothetical enlarged EMU-22 considered in the section above, using the weighted dispersion measure.[15]

Figure 7 displays the cost-of-inclusion of the members of EMU-12. On one side, Austria, Belgium, France, Germany, Finland, Italy, and, since the nineties, Spain, appear as countries that imply some benefit in terms of cyclical synchronization within this group. In very specific periods, some of these countries entail a cost for synchronization in the euro area. This is the case for the end of the eighties and the beginning of the nineties in the case of Finland, a period which coincides with the collapse of the Soviet Union and with the Finnish great depression, and during the recession of 2001-02 or around 2004-05. On the other side, the cost of inclusion for Greece, Ireland, Luxembourg and Portugal appears positive. When looking at the hypothetically enlarged EMU-22 in Figure 8, the results show that the inclusion of the majority of the new EU countries implies a larger degree of synchronization. Only Poland during the nineties, Ireland, Germany, and Spain at the end of the sample experience some cost of inclusion in specific periods. The rest of the countries evidence benefits from forming part of the EMU in most of the period considered (1995-2008). As for the case of the overall synchronization measure presented in the previous sections, the results concerning the relative cost of inclusion across European economies are robust to redefining the synchronization measures based on potential lead/lag relationships among cyclical components.[16]

5 Conclusions

In this paper we propose a new method to quantify the degree of cyclical synchronization within groups of countries which is based on the cross-country dispersion of business cycles. We use the method to analyse the dynamics of business cycle dispersion in EMU for the period 1960-2008. We extract business cycles from GDP data using an unobserved components model and assess the significance of changes in the cross-country standard deviation of cycles and the coherence of cyclical phases across EMU countries. Our results show a significant period of convergence in busi-

[15] In the empirical literature that assesses optimality based on correlation measures, most authors compare individual countries to weighted averages of other countries (by, for example, computing the correlation between the business cycle of a country and that of the euro area, which is by construction a weighted average). Here we follow a comparable approach by concentrating on the GDP-weighted dispersion. Our method, however, allows to treat all countries equally by comparing the unweighted dispersion measure of the group with and without the economy of interest. This would imply that small countries are treated in a similar fashion as large countries in the comparison and would be in line with the intuition put forward above concerning the difficulties in the agreeing on monetary policy decisions in a currency union. As an example, in the *Appendix* we include the results based on the unweighted measure for the EMU-22 group. The results here presented are robust for both weighted and unweighted measurements. Further details can be obtained from the authors upon request.

[16] The Appendix presents the results of the lead/lag synchronization analysis for the cost of inclusion estimate in more detail. The results remain unchanged when using either weighted or unweighted measurements. Further details can be obtained by the authors upon request.

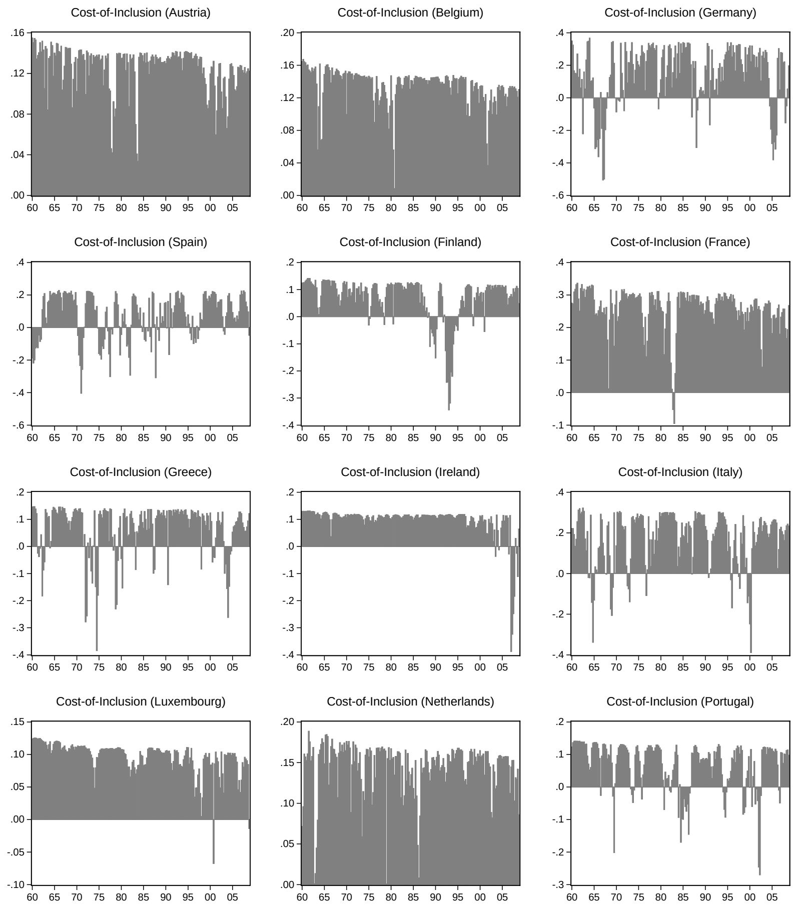

Figure 7: Cost of inclusion of a country: EMU-12 (based on the weighted dispersion measure)

ness cycles spanning the end of the seventies and the first years of the eighties, which is followed by a period of business cycle divergence. A significant convergence period is observed since the beginning of the nineties and finishes with the birth of EMU, when a smooth divergence period starts. Nevertheless, there exists some evidence for a regime characterized by higher comovements in business cycles and less volatility in cyclical synchronization starting in the mid of the nineties.

We also assess the features of business cycles in EMU relative to different relevant groups in order to give an answer to the most relevant questions highlighted by the empirical literature on the optimality of EMU as a currency area. These refer to the existence of a core-periphery divide, the impact of the enlargement of the euro area and the dilution of the EMU cycle within a world-wide business cycle. The core group of the EMU shows stronger synchronization than EMU-12 as a whole. The new members of the EU have experienced a process of convergence both within the group and with respect to the EMU-12, therefore their inclusion in the euro area does not introduce a significant decrease in the degree of optimality of EMU since 2004. Also, EMU-12 has shown a differential cyclical comovement with respect to the rest of the world during the period of macroeconomic convergence linked to the Maastricht Treaty. However, this European differential

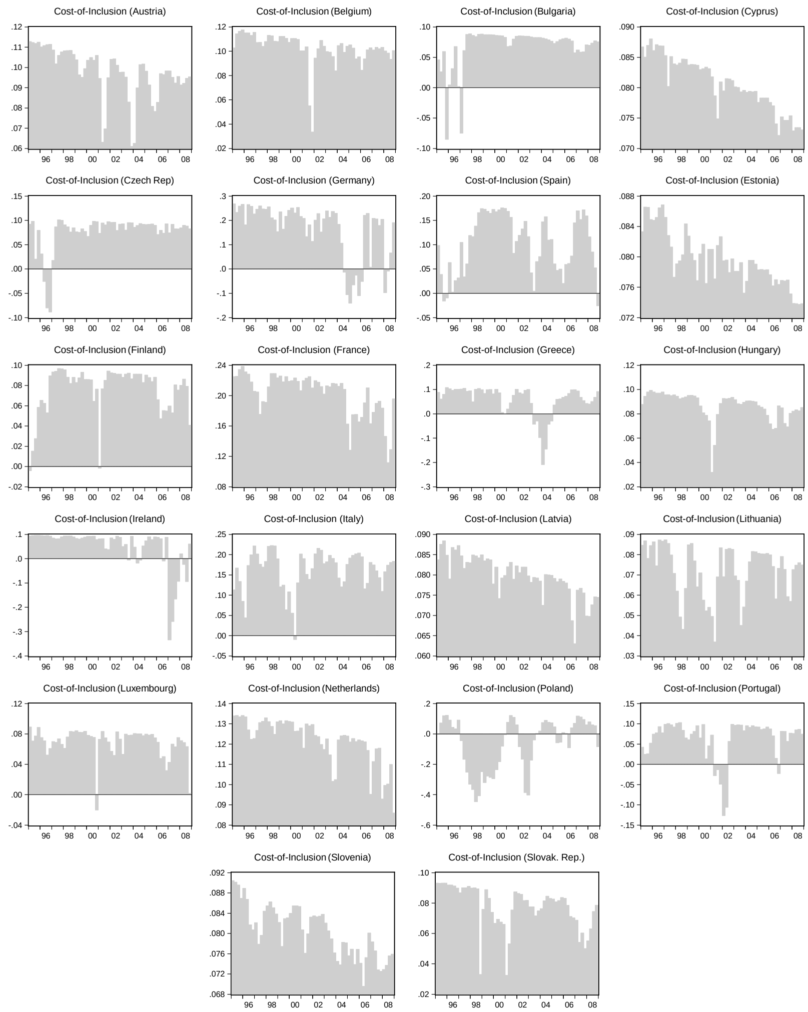

Figure 8: Cost of inclusion of a country: EMU-22 (based on the weighted dispersion measure)

has dissipated since 2004 in a world-wide business cycle. Finally, we evaluate the role of each country forming the EMU-12 and an enlarged EMU including all the members from recent 2004 and 2007 enlargements. Some of the new members of the EU do not imply a significant cost in terms of business cycle synchronization when joining EMU and exhibit levels of cost/benefit similar to the old members of EMU.

Against the background of the recent European crisis, it is relevant to consider the optimality of a currency area and its sustainability in order to assess to which extent monetary unions are susceptible of breaking up. The answer to this issue will depend on the gains in monetary policy implementation in a fixed exchange rate system, the existence of significant divergences in terms of OCA criteria, and cost-benefit analysis from pegging the exchange rate. Business cycle synchronization is used to summarize the information contained by the different OCA criteria. Some determinants of business cycle synchronization (and thus of the optimality of currency unions) have been highlighted by the literature. In particular, there is strong empirical evidence on a positive relationship of cyclical synchronization with trade integration, though trade intensity effects decrease with income synchronization (De Haan *et al.*, 2008, Inklaar *et al.*, 2008). There is also a direct relationship between cyclical comovements and with fiscal policy, the latter appearing as one of the main sources of asymmetric shocks in the context of OCA theory (Christodoulakis *et al.*, 1995, Fatas and Mihov, 2003a, Fatas and Mihov, 2003b, Darvas *et al.*, 2005, Böwer and Guillemineau, 2006, Akin, 2006).

When no gains in monetary policy implementation are realized and sizeable divergences exist, the cost from membership in the union may offset the benefits, making the currency area less optimal or even precluding countries from monetary integration. Perverse free-riding incentives originated by the interplay of a common monetary policy and national fiscal policies may create problems for the optimal policy mix. Furthermore, strengthening of coordination emerges as a necessary condition for currency areas well-functioning and sustainability.

Our analysis of business cycle synchronization emphasizes the role of cyclical homogeneity for the conduct of the common monetary policy in a currency area. Although cyclical comovement is the proxy for optimality of a monetary union most widely used by the literature, it does not encompass all the information concerning the cost-benefit analysis of joining a currency area. Notwithstanding, the method put forward in this contribution can be used to assess the effect of the determinants of the optimality of currency areas. In particular, unveiling the determinants of our cost-of-inclusion variable could shed light on the driving forces of business cycle synchronization in an econometric framework which would be more efficient than correlation-based models.

References

AGUIAR, M. and G. GOPINATH (2007): Emerging market business cycles: The cycle is the trend, *Journal of Political Economy*, 15. 69-102.

AGUIAR-CONRARIA, L. and M.J. SOARES (2011): Business cycle synchronization and the Euro: A wavelet analysis, *Journal of Macroeconomics*, 33. 477489.

AGRESTI, A.M. and B. MOJON (2001): Some stylised facts on the euro area business cycle, *ECB Working Paper* No. 95, December.

AKIN, C. (2006): Multiple determinants of business cycle synchronization. Paper presented at the 2006 Annual Meeting of the Canadian Economic Association, Montreal, May.

AKSOY, Y., DE GRAUWE, P. and H. DEWACHTER (2002): Do asymmetries matter for European monetary policy?, *European Economic Review* 46. 443-469.

ANGELONI, I. and L. DEDOLA (1999): From the ERM to the Euro: New evidence on economic and policy convergence among EU countries. *ECB Working Paper* No. 4, May.

ARTIS, M. (2003): Is there a European business cycle? *CESifo Working Paper* No. 4, May.

ARTIS, M., MARCELLINO, M. and T. PROIETTI (2004): Characterising the business cycle for Accession countries, *IGIER Working Paper*, No. 261.

ARTIS, M. J. and W. ZHANG (1997): International business cycles and the ERM: Is there a European business cycle?, *International Journal of Finance and Economics*, 2. 1-16.

ARTIS, M. J. and W. ZHANG (1999): Further evidence on the international business cycle and the ERM: is there a European business cycle?, *Oxford Economic Papers*, 51. 120-132.

BAI, J. and P. PERRON (1998): Estimating and Testing Linear Models with Multiple Structural Changes, *Econometrica*, 66. 47-78.

BAI, J. and P. PERRON (2003): Computation and analysis of multiple structural change models, *Journal of Applied Econometrics*, 18. 1-22.

BAXTER, M. and M.A. KOUPARITSAS (2005): Determinants of business cycle comovement: A robust analysis, *Journal of Monetary Economics*, 52. 113-157.

BÖWER, U. and C. GUILLEMINEAU (2006): Determinants of business cycle synchronisation across euro area countries. *ECB Working Paper* No. 587, February.

BURNS, A.F. and W.C. MITCHELL (1946): *Measuring Business Cycles*. New York, New York: National Bureau of Economic Research, 1946.

CAMPOS, N.F. and F. CORICELLI (2002): Growth in transition: What we know, what we don't, and what we should, *Journal of Economic Perspectives*, XL (September). 793-836.

CANOVA, F. (1999): Does Detrending Matter for the Determination of the Reference Cycle and the Selection of Turning Points?, *Economic Journal*, 109. 126-150.

CARREE, M. and L. KLOMP (1997): Testing the convergence hypothesis: A comment, *Review of Economics and Statistics*, 79. 683-686.

CHRISTODOULAKIS, N., DIMELIS, S. and K. TRYPHON (1995): Comparisons of business cycles in the EC: Idiosyncracies and regularities, *Economica*, 62. 1-27.

CONESA, J.C., KEHOE, T.J. and K.J. RUHL (2007): Modeling great depressions: The depression in Finland in the 1990s, *Federal Reserve Bank of Minneapolis Quarterly Review*, 31. 16-44.

CROUX, C., FORNI, M. and L. REICHLIN (2001); A measurement of comovement for economic variables: Theory and empirics, *Review of Economics and Statistics*, 83. 232241.

DARVAS, Z., ROSE, A.K. and G. SZÁPARY (2005): Fiscal Divergence and Business Cycle Synchronization: Irresponsibility is Idiosyncratic, *NBER Working Paper* No. 11580.

DARVAS, Z. and G. SZÁPARI (2005): Business Cycle Sychronization in the Enlarged EU, *CEPR Discussion Paper* No. 5179.

DE HAAN, J., INKLAAR, R. and R. JONG-A-PIN (2008): Will business cycles in the euro area converge? A critical survey of empirical research, *Journal of Economic Surveys*, 22. 234-273.

DE GRAUWE, P. (1993): The political economy of monetary union in Europe, *The World Economy*, 16. 653-661.

sharing a single currency closer together?, *ECB Working Paper* No. 468, April.

DELLAS, H. and G.S. TAVLAS (2009): An optimum-currency-area odyssey, *Journal of International Money and Finance*, 28. 1117-1137.

DICKEY, A.D. and W.A. FULLER (1979): Distribution of the estimators for autorregresive time series with a unit root, *Journal of the American Statistical Association*, 74. 427-431.

45. 987-997.

FATÁS, A. and I. MIHOV (2003a): Fiscal Policy and EMU: Challenges of the Early Years, in BUTI, M. and A. SAPIR, (Ed.), *EMU and Economic Policy in Europe*. Edwar Elgar, Cheltenham (UK).

FATÁS, A. and I. MIHOV (2003b): On Restricting Fiscal Policy in EMU. *Oxford Review of Economic Policy*, 19. 112-131.

FIDRMUC, J. and I. KORHONEN (2004): The Euro goes East. Implications of the 2000-2002 economic slowdown for synchronization of business cycles between the euro area and CEECs, *Comparative Economic Studies*, 46. 45 62.

FIDRMUC, J. and I. KORHONEN (2006): Meta-analysis of the business cycle correlation between the euro area and the CEECs, *Jornal of Comparative Economics*, 34. 518 537.

FOSTER, N. and R. STEHRER (2007): Modeling transformation in CEECs using smooth transitions, *Journal of Comparative Economics*, 35. 57-86.

FRANKEL, J.A. and A.K. ROSE (1998): The endogeneity of the optimum currency area criteria, *The Economic Journal*, 108. 1009-1025.

GÓMEZ, V. and A. MARAVALL (1996): Programs TRAMO and SEATS. Instructions for the User (with some updates). Working Paper No. 9628, Research Department, Bank of Spain.

HARDING, D. and A. PAGAN (2002): Dissecting the cycle: a methodological investigation, *Journal of Monetary Economics*, 49. 365-381.

HARDING, D. and A. PAGAN (2006): The Econometric Analysis of Constructed Binary Time Series, Department of Economics - Working Papers Series 963, The University of Melbourne.

HARVEY, A.C. (1989): *Forecasting, Structural Time Series and the Kalman Filter*. Cambridge: Cambridge University Press.

HARVEY, A.C. and A. JAEGER (1993): Detrending, stylized facts and the business cycle, *Journal of Applied Econometrics*, 8. 231-247.

HODRICK, R.J. and E.C. PRESCOTT (1997): Postwar US business cycles: An empirical investigation, *Journal of Money, Credit and Banking*, 29. 1-16.

HUGHES HALLET, A. and C. RICHTER (2006): Measuring the degree of convergence among European business cycles, *Computational Economics*, 27. 229259.

INKLAAR, R. and J. DE HAAN (2001): Is there really a European business cycle? A comment, *Oxford Economic Papers*, 53. 215-220.

INKLAAR, R., JONG-A-PIN, R. and J. DE HAAN (2008): Trade and business cycle synchronization in OECD countries - A re-examination, *European Economic Review*, 52. 646-666.

JARQUE, C.M. and A.K. BERA (1987): A test for normality of observations and regression residuals, *International Statistical Review*, 55. 163172.

KALMAN, R.E. (1961): A New Approach to Linear Filtering and Prediction Problems, Transactions of the *ASME - Journal of Basic Engineering*, 82 (Series D). 35-45.

KALEMLI-OZCAN, S., PAPAIOANNOU, E. and J.L. PEYDRÓ-ALCALDE (2009): Financial integration and business cycle synchronization, *CEPR Discussion Paper* No. 7292.

KEHOE, T.J. and E.C. PRESCOTT (2002): Great depressions of the twentieth century, *Review of Economic Dynamics*, 5. 118.

KEHOE, T.J. and E.C. PRESCOTT (2007): *Great depressions of the twentieth century*, Federal Reserve Bank of Minneapolis, Minneapolis (US).

KOOPMAN, S.J. and J.V.E. AZEVEDO (2008): Measuring synchronization and convergence of business cycles for the Euro area, UK and US, *Oxford Bulletin of Economics and Statistics*, 70. 23-51.

KWIATKOWSKI, D., PHILLIPS, P.C.B., SCHMIDT, P. and Y. SHIN (1992): Testing the null hypothesis of stationary against the alternative of a unit root, *Journal of Econometrics*, 54. 159-178.

LICHTENBERG, F.R. (1994): Testing the convergence hypothesis, *Review of Economics and Statistics*, 76. 576-579.

LIU, J., WU, S. and J.V. ZIDEK (1997): On segmented multivariate regressions, *Statistica Sinica*, 7. 497-525.

LJUNG, G.M. and G.E.P. BOX (1978): On a measure of a lack of fit in time series models, *Biometrika*, 65. 297303.

MASSMANN, M. and J. MITCHELL (2003): Reconsidering the evidence: are Eurozone business cycles converging? *NIESR Discussion Paper* No. 210, March.

McKINNON, R.I. (1963): Optimum Currency Areas, *American Economic Review*, 53. 717-725.

MUNDELL, R.A. (1961): A theory of optimum currency areas, *American Economic Review*, 51. 657-665.

MONGELLI, F.P. (2002): "New" views on the optimum currency area theory: What is EMU telling us?, *ECB Working Paper* No. 138, April.

ONORANTE, L. (2004): Fiscal convergence before entering EMU, in LIEBSCHER, K., CHRISTL, J., MOOSLECHNER, P. and D. RITZBERGER-GRUENWALD (Ed.): *The economic potential of a larger Europe*, Edward Elgar, Cheltenham (UK).

PÉREZ, P.J., OSBORN, D.R. and M. SENSIER (2007): Business cycle affiliation in the context of European integration, *Applied Economics*, 39. 199-214.

RUA, A. (2010): Measuring comovement in the timefrequency space, *Journal of Macroeconomics*, 32. 685691

ROLAND, G. (2002): The political economy of transition, *Journal of Economic Perspectives*, 16. 29-50.

SCHWARZ, G. (1978): Estimating the dimension of a model, *Annals of Statistics*, 6. 461-464.

SVEJNAR, J. (2002): Transition economies: Performance and challenges, *Journal of Economic Perspectives*, 16. 3-28.

TAVLAS, G.S. (1993): The 'new' theory of optimum currency areas, *The World Economy*, 16. 663-685.

WYNNE, M.A. and J. KOO (2000): Business cycles under Monetary Union: A comparison of the EU and US, *Economica*, 67. 347-374.

Appendix: Data sources

Country	Sample period	Source
Australia	1960q1-2008q4	OECD
Austria	1960q1-2008q4	OECD
Belgium	1960q1-2008q4	OECD
Bulgaria	1994q1-2008q4	Eurostat
Canada	1960q1-2008q4	OECD
Cyprus	1995q1-2008q4	Eurostat
Czech Republic	1990q1-2008q4	OECD
Denmark	1966q1-2008q4	OECD
Estonia	1993q1-2008q4	Eurostat
Finland	1960q1-2008q4	OECD
France	1960q1-2008q4	OECD
Germany	1960q1-2008q4	OECD
Greece	1960q1-2008q4	OECD
Hungary	1991q1-2008q4	OECD
Iceland	1960q1-2008q4	OECD
Ireland	1960q1-2008q4	OECD
Italy	1960q1-2008q4	OECD
Japan	1960q1-2008q4	OECD
Latvia	1990q1-2008q4	Eurostat
Lithuania	1995q1-2008q4	Eurostat
Luxembourg	1960q1-2008q4	OECD
Mexico	1960q1-2008q4	OECD
New Zealand	1960q1-2008q4	OECD
Netherlands	1960q1-2008q4	OECD
Norway	1960q1-2008q4	OECD
Poland	1965q1-2008q4	OECD
Portugal	1960q1-2008q4	OECD
Republic of Korea	1970q1-2008q4	OECD
Slovenia	1992q1-2008q4	Eurostat
Slovak Republic	1993q1-2008q4	Eurostat
Spain	1960q1-2008q4	OECD
Sweden	1960q1-2008q4	OECD
Switzerland	1965q1-2008q4	OECD
Turkey	1960q1-2008q4	OECD
United Kingdom	1960q1-2008q4	OECD
USA	1960q1-2008q4	OECD

Table A1: Dataset: Samples and Sources

Weights for averaged indicators where computed by using annual data on real GDP (source: Penn World Table) in international dollars with reference in 1996 (Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, August 2009) for the period 1950-2007 updated up to 2008 using the GDP raw data described above and used for the extraction of business cycles. For each country, weights were calculated relative to the group considered. Two schemes of weights were used. The first one, a time-varying scheme in which for each year the weight was calculated and therefore a series of (annual) weights was used when computing the indicators. The second one is a scheme based on the mean weight for the whole sample period. This last weighting scheme was used when calculating the standard deviation series in the Carree and Klomp (1997) test. Our results are robust to the use of both weighting patterns.