Measuring Similarity of Business Cycles in the Euro Area and the U.S.

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Abstract
If business cycles in a currency union diverge considerably, the common monetary policy will not be optimal for all countries or regions in the union. We propose a new method to measure business cycle similarity that takes cycle phase and cycle amplitude into account. We find that the business cycles of several countries exhibit little similarity with the euro area reference cycle. However, for the euro area as a whole, differences between business cycles have gradually declined since the 1990s. Our results suggest that business cycles in the euro area exhibit more similarities than regional business cycles in the U.S..

Key words: business cycles, similarity, synchronicity, euro area, United States
JEL-classifications: E32, F02, F42

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1 Introduction

If business cycles in a currency union diverge considerably, the common monetary policy will not be optimal for all countries concerned ('one size does not fit all'). Whereas countries in the downward phase of the cycle would prefer an expansionary monetary policy, countries in the upward phase of the cycle would prefer a more restrictive policy stance. Moreover, even if cycle phases coincide perfectly, cross-country differences with respect to the amplitude of the cycle can hamper the implementation of a common monetary policy as well. Countries with large swings in their business cycle would prefer larger interest rate steps than countries with moderate business cycle amplitudes.

A large literature has examined the similarity of business cycles and the forces affecting changes therein. Studies on business cycle similarity between countries in the euro area yield contradicting results.[1] In their seminal paper, Frankel and Rose (1998) argue that high trade intensity between countries causes their business cycles to become more similar, thereby decreasing the cost of giving up monetary policy autonomy. Subsequent studies have confirmed this finding, and suggested other factors influencing business cycle similarities.[2]

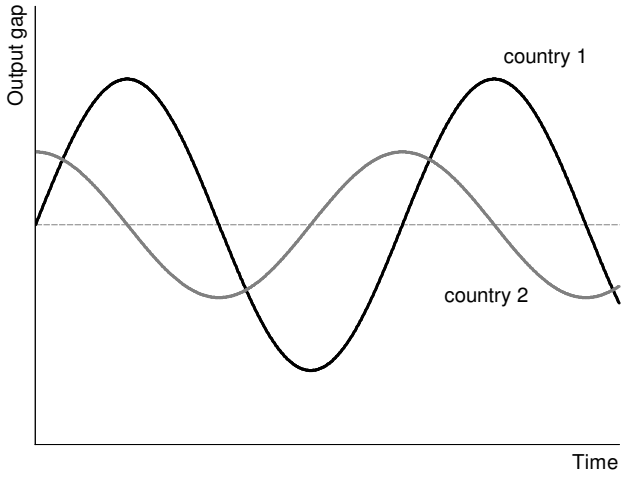
Most studies proxy business cycle similarity between two countries by using the correlation of deviations of real GDP levels from their trend value

[1] For instance, Massmann and Mitchell (2004) find some evidence for increasing business cycle synchronicity since the 1990s. Likewise, Altavilla (2004) and Artis, Krolzig and Toro (2004) find support for a common European cycle. However, using a variety of methods, Camacho, Perez-Quiros and Saiz (2006, 2008) find no evidence for an increase in synchronicity or for a European business cycle. See De Haan, Inklaar and Jong-A-Pin (2008) for a survey.

[2] See, for example, Kose, Prasad and Terrones (2003), Imbs (2004), Baxter and Kouparitsas (2005), and Inklaar, Jong-A-Pin and De Haan (2008).

over a particular time period. As we will argue in more detail in section 2, the correlation coefficient does not take into account that business cycles may differ because countries are in different phases of the cycle (cycles can lead or lag each other), or because countries' business cycles have different amplitudes (cycles can have different standard deviations).[3]

Figure 1: Cycles can differ due to imperfect phase coincidence and imperfect amplitude similarity



We analyse business cycle similarity from the perspective of a monetary policy maker.[4] We propose two simple measures to analyse business cycle similarities. Figure 1 illustrates the intuition of our approach. The figure shows the output gap of two countries that have a common monetary policy. The monetary policy maker is interested in the similarity between countries'

[3]Wynne and Koo (2000), Altavilla (2004), and Camacho et al. (2006) pay some attention to this issue, although they mainly examine differences between broad measures of cycle volatility rather than examining whether fluctuations that coincide have the same magnitude.

[4]The similarity of business cycles can also been examined from a risk-sharing perspective. For instance, Kalemli-Ozcan, Sørensen and Yosha (2001) show that the opportunity cost of imperfect risk sharing between countries declines when their business cycles are more correlated or when cycles' standard deviations are more similar.

output gaps at time t, and the development of this similarity over time.[5] The bigger the output gap difference will be at time t, the more likely will it be that monetary policy is not optimal for both countries. However, if the output gap difference becomes smaller over time, 'one size will start to fit'. Differences between output gaps at any point in time are driven by whether or not countries are in the same business cycles phase (which we call cycle synchronicity), and by differences in business cycle amplitudes.

We apply our new measures to business cycles in the euro area for the period 1970-2006.[6] Our results show that the business cycle of several countries are quite different from the euro area reference cycle. However, for the euro area as a whole, differences between business cycles have gradually declined since the beginning of the 1990s, even though cycle synchronicity and similarity are currently not higher than during the 1970s. To assess our findings for the euro area, we also examine business cycles of U.S. states and regions. Our results suggest that business cycles in the U.S. are currently less similar than cycles in the euro area, even though the U.S. has been a monetary union for a much longer period of time and is generally believed to be more integrated than the euro area.

The remainder of the paper is organized as follows. Section 2 presents our synchronicity and similarity measures, while Section 3 describes the data used in the analysis. Section 4 presents the results, while the final section offers some concluding comments.

[5]To avoid confusing changes in cycle similarity with changes in the relative size of the economies under consideration, our measures of synchronicity and similarity do not distinguish between larger and smaller countries.

[6]Recently, Wälti (2008) has used our approach to examine factors driving business cycle synchronicity.

2 Method

Like most previous studies on business cycle similarity, we focus on deviations of real GDP from its trend value. These so-called output gaps play a central role in the monetary policy maker's reaction function, either because the policy maker explicitly aims at stabilising output fluctuations, or because the output gap is used as an indicator of future inflationary pressures.

2.1 Synchronicity

Our first measure, which we call output gap *synchronicity*, captures whether positive and negative output gaps coincide regardless of their amplitudes. Denoting the output gap of country i at time t by $g_i(t)$ and the reference output gap for the region at time t by $g_r(t)$, we can calculate synchronicity between the output gaps of the n countries in the sample and this reference as

$$\varphi(t) = \frac{1}{n} \sum_{i=1}^{n} \frac{g_i(t) g_r(t)}{|g_i(t) g_r(t)|}. \tag{1}$$

Since the term on the right of the summation sign equals 1 when $g_i(t)$ and $g_r(t)$ have the same sign while it equals -1 when their signs are opposite, $\varphi(t)$ lies between -1 and 1. When transformed to a [0,1] scale, the synchronicity measure indicates the fraction of countries with an output gap that has the same sign as the reference cycle in period t.

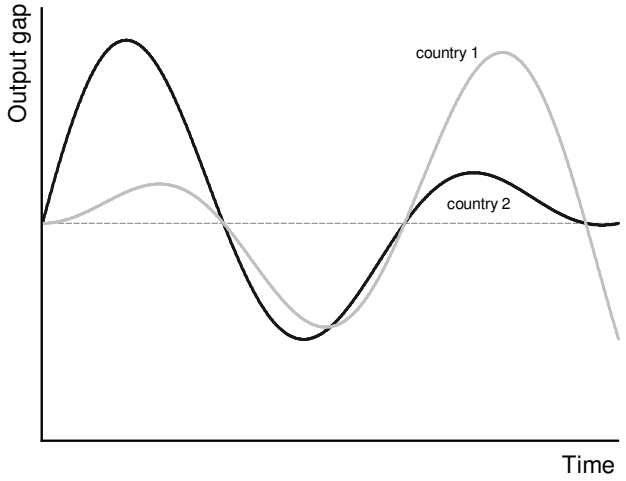
Likewise, we define synchronicity between an individual country i and the

reference cycle in period t as

$$\varphi_{ir}(t) = \frac{g_i(t)g_r(t)}{|g_i(t)g_r(t)|}. \tag{2}$$

When averaged over a time interval and transformed to a [0,1] scale, this measure shows the fraction of time that the output gap of country i has the same sign as the output gap of the reference cycle.[7] As a result, our measure is not only easy to interpret, but also provides a better quantification of cycle synchronicity than output gap correlations. Figure 2 illustrates this: although positive and negative output gaps coincide exactly, the heteroskedasticity of the time series causes the correlation between the output gaps to equal only 0.53. Our synchronicity measure yields a value of 1 for this time interval as it is invariant to the magnitude of cycle amplitudes.

Figure 2: Imperfect correlation despite perfect coincidence of positive and negative output gaps

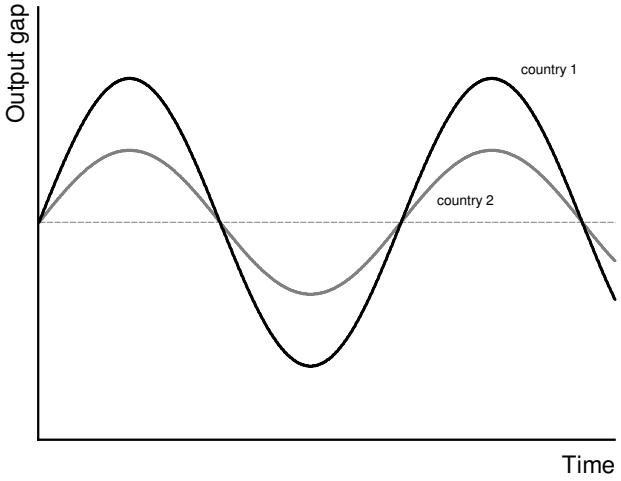


[7]The bivariate synchronicity measure thus closely resembles the concordance index that Harding and Pagan (2002, 2006) calculate for the classical business cycle.

2.2 Similarity

Output gap correlations also do not capture whether output gaps are similar in magnitude. The correlation between two series can be equal to one even when both series have different standard deviations. This is illustrated in Figure 3, where two cycles are shown that have very different amplitudes while the correlation between both still equals 1.

Figure 3: Perfect correlation despite imperfect similarity between output gaps' amplitudes



Therefore, we propose the following measure of output gap *similarity*:

$$\gamma(t) = 1 - \frac{\sum_{i=1}^{n} |g_i(t) - g_r(t)|}{\sum_{i=1}^{n} |g_i(t)|}, \tag{3}$$

where n again indicates the number of countries in the sample, and t denotes the time period. The output gap similarity measure $\gamma(t)$ evaluates the total distance between output gaps of the countries in the sample and the reference output gap, and scales this distance by the overall sum of the individual

output gaps to prevent the measure from being affected by an overall change in cyclical activity in the region. In a similar fashion, we define the output gap similarity between country i and the reference in period t as

$$\gamma_{ir}(t) = 1 - \frac{n\,|g_i(t) - g_r(t)|}{\sum_{i=1}^{n} |g_i(t)|}. \tag{4}$$

As is the case for the synchronicity measure, averaging output gap similarity between individual countries and the reference over all n countries in the sample yields output gap similarity for the region as a whole. Clearly, output gap similarity can be smaller than 1 for two reasons: i) cycles are not perfectly synchronous, and ii) cycles have different amplitudes.

2.3 Reference cycle

Having defined our synchronicity and output gap similarity measures, we need to specify the region's reference cycle. As Camacho et al. (2006, p. 1689) argue, this decision is complicated by the fact that we cannot ex ante "take as given that the European cycle exists and that it coincides either with the cycle of a leading European economy, or the cycle of a weighted average of several European economies, or the cycle of a common factor." We therefore adopt a statistical approach and select the cycle that maximises synchronicity in Eq. (1) and output gap similarity in Eq. (3) simultaneously. This implies that the reference gap $g_r(t)$ should be set to the median of all individual countries' output gaps observed at time t. After all, this minimises the numerator of Eq. (3) and thus maximises output gap similarity in the sample of countries (see Joag-Dev, 1989), while it simultaneously maximises

overall synchronicity, since the median output gap has by definition the same sign as the majority of the observed output gaps. Defining the reference cycle in this way ensures that synchronicity defined in Eq. (1) and output gap similarity defined in Eq. (3) always lie between 0 and 1. Synchronicity between the business cycle of an individual country and the reference cycle can lie between -1 and 1, while for output gap similarity the minimum and maximum values are $1 - n$ and 1.

Our reference cycle is thus defined as the cycle that lies the closest to all individual countries' cycles in terms of synchronicity *and* output gap similarity. Conceptually, it highly resembles a principal component cycle, since this is the cycle that lies the closest to all individual countries' cycles in terms of correlation. However, in contrast to a principal component cycle, our proposed reference cycle maximises cycle similarity not only for the full sample period for which it is calculated, but also for all possible sub-samples. This advantage reflects the fact that the reference output gaps, as well as the synchronicity and similarity measures, are calculated on a per-observation basis without being affected by output gaps observed at earlier or later dates.

Using our preferred reference cycle, the multivariate synchronicity measure $\varphi(t)$ can be used to calculate the magnitude of the majority of countries with equally signed output gaps $(1 + \varphi(t))/2$. For example, when $\varphi(t) = 0.5$, we can calculate that $(100\% * (1 + 0.5)/2 =)75\%$ of the output gaps at time t are either all positive or all negative. Synchronicity between an individual country and the reference, $\varphi_{ir}(t)$, indicates whether or not the country has an output gap with the same sign as this majority. The multivariate output gap similarity measure $\gamma(t)$ indicates the share of cyclical fluctuations that

all countries have in common. Analogous to the coefficient of determination R^2, the output gap similarity measure can be read as $1 - \frac{\text{unexplained variation}}{\text{total variation}}$.[8] Similarity between an individual country and the reference now indicates whether, compared to the other countries in the sample, these two have a relatively large ($\gamma_{ir}(t) > \gamma(t)$) or a relatively small ($\gamma_{ir}(t) < \gamma(t)$) part of cyclical fluctuations in common.

3 Data

We apply the output gap synchronicity and cycle similarity measures to the euro area using time series on quarterly real GDP for eleven countries (Cyprus, Luxembourg, Malta, and Slovenia have been excluded from the sample for reasons of data availability) which cover the 1970.1–2006.4 period. Most statistics have been obtained from the online version of the IMF International Financial Statistics database. For some of the countries time series are not available since the beginning of our sample period. These countries include Belgium (1980.1), Ireland (1997.1), the Netherlands (1977.1), and Portugal (1977.1). Statistics for Greece for 1970.1–1999.4 and Italy for 1970.1–1979.4 have been obtained from Eurostat. We have removed the 1991.1 unification level-shift in German GDP by means of ratio splicing using the first annual overlap. Finally, we have removed seasonal fluctuations using the U.S. Census Bureau X-12-ARIMA procedure. To examine cycle similarity in the U.S., we use GDP statistics by state and region for 1997-2007 from

[8] This interpretation requires that we define 'unexplained variation' as $\sum |g_i - g_r|$ rather than as $\sum (g_i - g_r)^2$. We define 'total variation' as $\sum |g_i - 0|$ rather than as $\sum (g_i - \bar{g}_i)^2$, where $\bar{g}_i$ denotes the sample mean of g_i, which is equal to 0 for output gaps.

the Bureau of Economic Analysis (U.S. Department of Commerce). All data are available on request.

To calculate output gaps, it is common practice to use non-parametric filtering methods such as the high-pass filter developed by Hodrick and Prescott (1997) or the band-pass filters proposed by Baxter and King (1999) and Christiano and Fitzgerald (2003). We employ the Christiano-Fitzgerald filter and configure it to extract all cycles with duration of 8 years or less. The Christiano-Fitzgerald filter has the advantage that we do not lose observations at the beginning and end of the sample period.[9] We do not remove higher frequency fluctuations from the series since cross-country differences between fluctuations with shorter periodicities can also lead to regional asymmetries in for instance the impact of monetary policy. Through dividing the extracted cycles by their corresponding trend components, we obtain the output gaps used in the empirical analysis.

4 Empirical analysis

4.1 Euro area business cycle similarity since the 1970s

Figure 4 shows eight-year moving averages of output gap synchronicity and similarity for the euro area as a whole. Although both measures were defined independently from one another, they produce almost identical patterns for the euro area as a whole. Synchronicity as well as similarity between busi-

[9] In order to mitigate any end-point problems in applying the filter to the relatively short time series for U.S. GDP, we chain link our data for 1997–2007 to U.S. GDP statistics for 1977-1996 based on the SIC rather than NAICS industry classification.

ness cycles has increased continuously from 1990 onwards, although cycle similarity is currently only marginally higher than at the end of the 1970s.[10]

Figure 4: Cycle synchronicity and similarity in the euro area as a whole

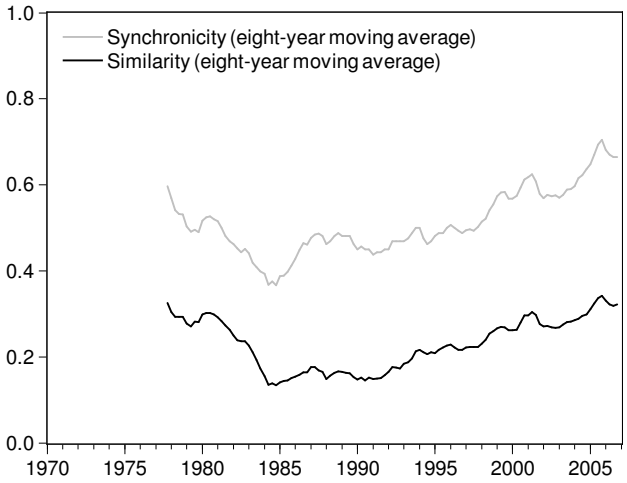


Figure 5 shows eight-year moving averages of output gap synchronicity and similarity of individual countries' business cycles vis-à-vis the euro area's reference cycle. The figure shows that both synchronicity and similarity fluctuate substantially over time and differ between countries. More recently, especially Spain, Greece, and the Netherlands have become more synchronous with the reference, while for these countries output gap similarity has increased too. During the last part of the period, Belgium experienced a clear decline in synchronicity, while Germany experienced a clear decline in similarity. For France, output gap synchronicity and similarity both decreased moderately during this period. The strong temporary decrease in similarity experienced by Finland at the end of the 1980s reflects the deep recession

[10]These findings do not change when we include only countries in the analyses for which a complete time series with GDP statistics is available (results are available on request).

that hit the country due to the Nordic banking crisis and the collapse of the Soviet Union.

Figure 5 also shows that developments in output gap synchronicity and similarity differ substantially across countries. This finding is confirmed by the correlation between the eight-year moving averages for synchronicity and similarity, which on average equals 0.21. Since the main difference between both measures is that output gap similarity takes into account cycles' amplitudes while output gap synchronicity does not, this result suggests that changes in similarity are mainly caused by changes in the similarity of cycles' amplitudes rather than by changes in the coincidence of cycles' phases (see Mink et al. 2007 for further evidence).

We have performed a simulation analysis to examine whether the observed output gap synchronicity and similarity outcomes allow us to reject the null hypothesis that business cycles of euro area countries fluctuate independently from each other. To this end, we randomly draw output gaps from a uniform distribution, which is symmetric around zero, $U(-x, x)$. Since the moving window used in the analysis consists of thirty-two quarters, we generate sequences with a length of 32 observations and calculate output gap synchronicity and similarity for 10,000 simulations.

Table 1 lists the lower and upper 2.5%-critical values that we obtain for sample sizes between two and eleven countries. Note that these critical values are not affected by the choice of parameter x, since the synchronicity measures do not take cycles' amplitudes into account, while multiplying all output gaps by a constant does not affect the similarity measures either.

Using the critical values, we cannot reject the null hypothesis of cycle

Figure 5: Cycle synchronicity and similarity between individual countries and the euro area

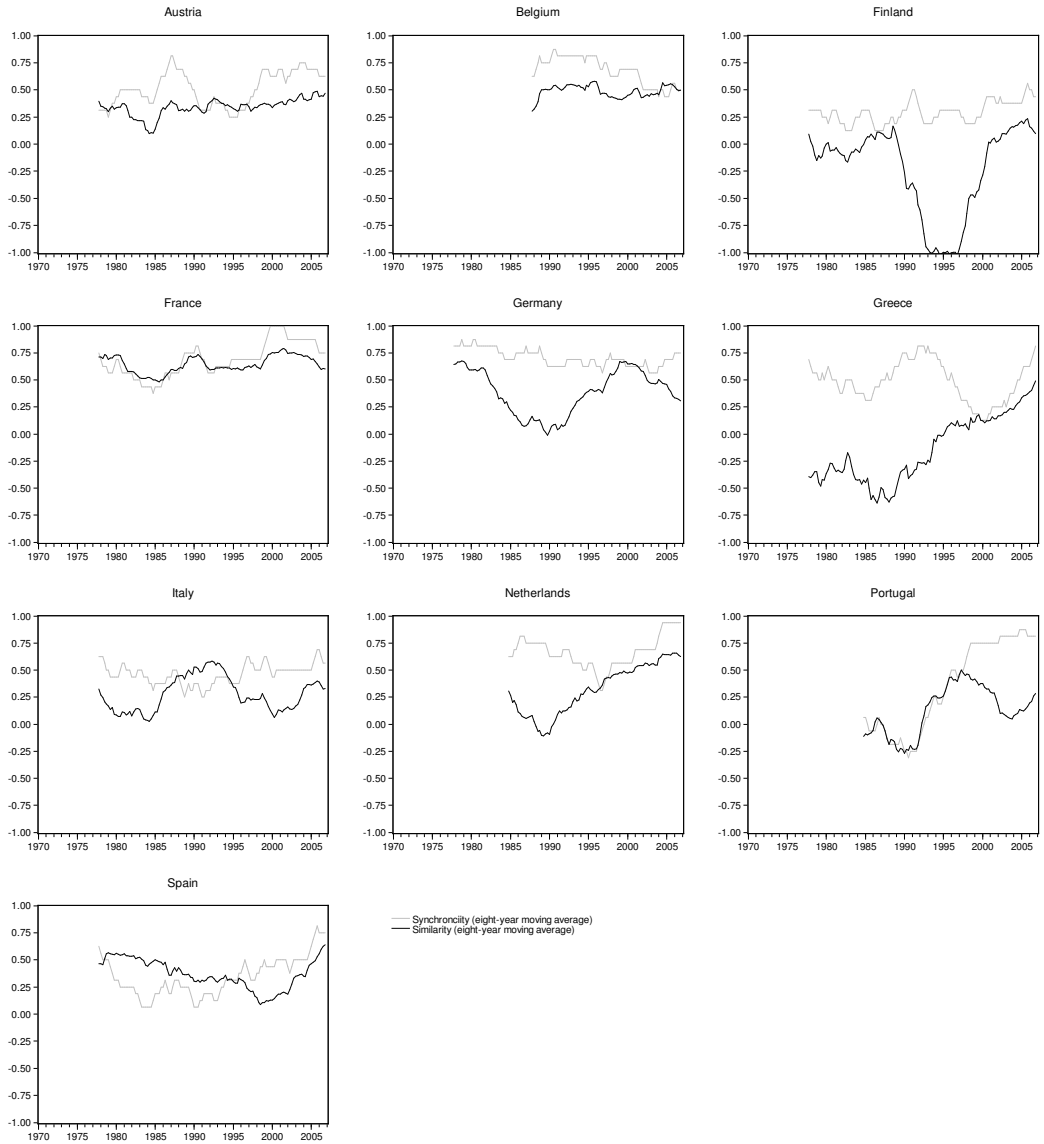


Table 1: Critical values for output gap synchronicity and similarity under business cycle independence

	Synchronicity				Similarity			
n	φ_{ir}^{-}	φ_{ir}^{+}	φ^{-}	φ^{+}	γ_{ir}^{-}	γ_{ir}^{+}	γ^{-}	γ^{+}
2	-	-	0.31	0.69	-	-	0.38	0.59
3	0.19	0.75	0.40	0.60	0.24	0.65	0.39	0.53
4	0.06	0.69	0.27	0.48	0.10	0.48	0.23	0.37
5	0.06	0.69	0.30	0.46	0.05	0.50	0.23	0.34
6	0.00	0.63	0.22	0.41	0.00	0.41	0.16	0.26
7	0.00	0.63	0.24	0.38	-0.03	0.42	0.16	0.25
8	-0.06	0.63	0.20	0.35	-0.06	0.37	0.12	0.20
9	-0.06	0.63	0.21	0.34	-0.08	0.38	0.12	0.19
10	-0.06	0.56	0.18	0.32	-0.09	0.34	0.09	0.16
11	-0.13	0.56	0.19	0.31	-0.11	0.35	0.09	0.16

Notes: φ_{ir} and φ are the output gap synchronicity measures defined in Eqs. (2) and (1); γ_{ir} and γ are the output gap similarity measures defined in Eqs. (4) and (3); the superscripts + and − denote the upper (97.5%) and lower (2.5%) confidence levels.

independence in many cases. However, for the euro area as a whole we find that output gap synchronicity is always significant, while output gap similarity is always significant except for the 1980s.

4.2 Comparing the Euro Area and the U.S., 1999–2006

In this section we compare business cycle similarities in the euro area and the U.S.. The U.S. is often used as a benchmark for the euro area as it has been a monetary union for a long time. Table 2 reports output gap synchronicity and similarity for the countries in the euro area vis-à-vis the euro area reference cycle for 1999-2006. On average, $(100\% \times (1 + 0.66)/2 =)$ 83% of the countries in the euro area experience output gaps with the same

Table 2: Output gap synchronicity and similarity in the euro area, 1999–2006

Country	Synchronicity	Similarity
Austria	0.63^{+}	0.47^{+}
Belgium	0.50	0.50^{+}
Finland	0.44	0.10
France	0.75^{+}	0.60^{+}
Germany	0.75^{+}	0.31
Greece	0.81^{+}	0.49^{+}
Ireland	0.38	-0.79^{-}
Italy	0.56	0.33
Netherlands	0.94^{+}	0.62^{+}
Portugal	0.81^{+}	0.28
Spain	0.75^{+}	0.64^{+}
euro area	0.66^{+}	0.32^{+}

Notes: The superscript $^{+}$ indicates that synchronicity or similarity is significantly higher than would be expected under the null hypothesis of independence based on the critical values reported in the bottom row of Tables 1, while the superscript $^{-}$ indicates that synchronicity or similarity is significantly lower.

sign as the reference. However, the output gap similarity statistics suggest that cycles in the region have only about 32% of their variability in common. Even though output gap synchronicity is reasonably high, the output gap similarity measure shows that when cycle amplitudes are taken into account most business cycle fluctuations in the area turn out to be idiosyncratic. The Netherlands, Spain, and France have business cycles which are very similar to the rest of the area according to both measures, while especially Ireland and Finland deviate quite substantially from the reference.

Our next step is to compare cycle similarity in the euro area with cycle similarity in the United States. Table 3 reports cycle synchronicity and sim-

ilarity statistics for U.S. regions and states (both are calculated on the basis of annual GDP statistics). Even though the U.S. is considered more economically integrated than the euro area, differences between business cycles in the U.S. are larger than differences between business cycles in the euro area (output gap synchronicity and similarity for the euro area as a whole calculated on the basis of annual GDP statistics equal 0.59 and 0.28, respectively). This finding differs markedly from the results of Croux et al. (2001), who conclude that differences between business cycles in the U.S. are smaller than differences between business cycles in the euro area. The most likely explanation for this difference is that Croux et al. (2001) compare cycles in euro area GDP with cycles in U.S. personal income. Cycles in personal income, however, are also affected by taxes and social security arrangements, which causes them to become relatively similar across states and regions. We therefore also calculate output gap synchronicity and similarity using U.S. personal income. Indeed, these figures turn out to be much higher than those based on GDP statistics, since synchronicity and similarity equal 0.70 and 0.38 for U.S. states and 0.84 and 0.58 for U.S. regions, respectively. So our results suggest that if the US is considered the benchmark, upward potential for euro area business cycle similarity is fairly limited.

Table 3: Output gap synchronicity and similarity in the U.S. (states and regions), 1999–2006

Region/State	Synchronicity	Similarity	Region/State	Synchronicity	Similarity
Far West	0.50	-0.10	Rocky Mountains	0.75	0.09
California	0.50	-0.21	Colorado	0.25	-0.25
Nevada	0.50	-0.61	Idaho	0.25	-0.95
Oregon	0.75	-0.38	Montana	0.25	0.58
Washington	0.50	-0.17	Utah	0.25	0.8
Great Lakes	-0.25	0.11	Wyoming	-0.25	-0.61
Michigan	-0.25	-0.02	Southeast	0.75	0.54
Ohio	0.50	0.22	Alabama	0.75	0.38
Indiana	0.25	-0.19	Arkansas	0.75	0.34
Illinois	0.75	0.60	Florida	0.25	-0.18
Wisconsin	1.00	0.75	Georgia	0.25	0.29
Mideast	0.75	0.44	Kentucky	0.00	-0.07
Delaware	0.25	-0.47	Louisiana	0.75	-0.06
Maryland	-0.25	0.47	Mississippi	0.75	0.25
New Jersey	0.50	0.38	North Carolina	0.25	-0.19
New York	0.25	0.00	South Carolina	0.25	0.38
Pennsylvania	0.00	0.46	Tennessee	1.00	0.41
New England	0.50	0.19	Virginia	0.25	0.20
Connecticut	0.00	0.14	West Virginia	0.00	0.42
Maine	0.25	0.18	Southwest	0.00	0.59
Massachusetts	0.25	0.15	Arizona	0.25	-0.61
New Hampshire	0.50	0.37	New Mexico	0.75	-0.06
Rhode Island	0.50	0.11	Oklahoma	0.00	0.40
Vermont	0.00	0.50	Texas	0.50	0.45
Plains	-0.25	0.09	U.S. regions	0.47	0.24
Iowa	0.75	0.27	U.S. states	0.32	0.10
Kansas	0.00	0.33			
Minnesota	0.50	0.44			
Missouri	0.00	0.30			
Nebraska	0.50	0.32			
North Dakota	-0.50	-0.45			
South Dakota	0.00	-0.11			

4.3 Differences with correlation analysis

Our results differ substantially from those of various previous studies (see the survey of De Haan et al., 2008). In this part of the analysis we examine whether these differences are caused by the use of our new output gap synchronicity and similarity measures instead of business cycle correlations.

Table 4: Correlation between business cycle similarity patterns

Country	$\text{cor}(\rho, \varphi)$	$\text{cor}(\rho, \gamma)$
Austria	0.40	0.27
Belgium	0.01	0.45
Finland	0.72	0.12
France	0.70	0.77
Germany	0.71	0.37
Greece	0.54	-0.78
Italy	0.77	-0.55
Netherlands	0.93	0.16
Portugal	0.92	0.89
Spain	0.73	-0.18
Average	0.64	0.15

Notes: ρ, φ, and γ denote the eight-year moving averages of business cycle correlation, output gap synchronicity and similarity between a country's cycle and the reference.

Table 4 shows the correlation of eight-year moving averages of output gap synchronicity and similarity between individual countries and the reference on the one hand, and eight-year moving averages of cycle correlation with the reference on the other. The first column of the table shows that cycle correlation and output gap synchronicity can be quite different. The correlation between both eight-year moving averages ranges from 0.01 (Belgium) to 0.77 (Italy), with an average of 0.64. Differences between cycle correlation and

output gap similarity patterns are even larger, with a correlation between -0.78 (Greece) and 0.77 (France), while the average is only 0.15.

For the period 1999–2006, we also calculate countries' correlation with the euro area reference. Average cycle correlation for the region as a whole equals 0.54, which is in between the reported statistics for average output gap synchronicity and similarity in the bottom row of Table 2. For the cross-section of countries the correlation between cycle correlation and output gap synchronicity levels only amounts to 0.35, while the correlation between cycle correlation and output gap similarity levels equals 0.48. These results show that there are substantial differences between the results obtained from calculating cycle correlations and those obtained from calculating output gap synchronicity and similarity.

5 Conclusions and policy implications

Diverging business cycles in a currency union might undermine support for the monetary union. We add to the literature examining the similarity between business cycle fluctuations of countries in the euro area by proposing new measures of output gap synchronicity and similarity. The synchronicity measure signals whether countries' cycle phases coincide, while the similarity measure quantifies whether cycle phases coincide *and* whether cycles have similar amplitudes. As a particular advantage, the measures can be applied to a group of countries without defining a reference cycle in advance.

In our empirical analysis, we find that for the euro area as a whole output gap synchronicity and similarity have gradually increased since the 1990s.

However, business cycles of several individual countries still exhibit little similarity with the euro area reference cycle. In fact, synchronicity and similarity between business cycles of individual countries and the reference cycle fluctuate over time, and often are not higher than would be expected under business cycle independence. Nonetheless, business cycles in the euro area turn out to be more synchronous and more similar than business cycles in the U.S..

Our findings may have some implications for monetary policy. The result that cycle similarity in the euro area as a whole has increased since the beginning of the 1990s is convenient for European central bankers, even if they are only interested in maintaining price stability. On the other hand, our results also suggest that business cycles in the euro area are more similar than those in the U.S. so that further European economic integration may not necessarily increase cycle similarity.

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