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WILL BUSINESS CYCLES IN THE EURO AREA CONVERGE? A CRITICAL SURVEY OF EMPIRICAL RESEARCH

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Abstract. This survey of business cycle synchronization in the European monetary union focuses on two issues: have business cycles become more similar, and which factors drive business cycle synchronization. We conclude that business cycles in the euro area have gone through periods of both convergence and divergence. Still, there is quite some evidence that during the 1990s business cycle synchronization in the euro area has increased. Higher trade intensity is found to lead to more synchronization, but the point estimates vary widely. The evidence for other factors affecting business cycle synchronization is very mixed.

Keywords. Business cycles; Synchronization of business cycles; EMU

1. Introduction

In their informal Ecofin meeting on 13 May 2005 the Finance Ministers of the countries in the euro area expressed their concerns about 'divergences of economic trends in the euro zone'. If business cycles in countries forming a monetary union diverge considerably, the common monetary policy will not be optimal for all countries concerned. Whereas countries in the downward phase of the cycle would prefer a more expansionary monetary policy, countries in the upward phase of the cycle would prefer a more restrictive policy stance. This 'one size does not fit all' problem may undermine the political support for the monetary union.[1] Evidence reported by Nitsch (2004) suggests that inflation differentials, which are clearly related to differences in business cycle positions, have led to the dissolution of currency unions in the past.

Will business cycles in the euro area become more similar over time, so that the 'one size does not fit all' problem will disappear? Two views have been put forward on this issue. In what we call the 'optimistic view', further economic and monetary integration will lead to less divergence. This view is quite popular among European policymakers. However, Krugman (1991) argues that in a further integrating Europe a similar concentration of industries may take place as in the US mainly because of economies of scale and scope.[2] Due to this concentration process, sector-specific

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shocks may become region-specific shocks, thereby increasing the likelihood of asymmetric shocks and diverging business cycles. So, the 'pessimistic view' holds that business cycles in the euro area may become more divergent in the future.

In the debate about business cycle synchronization in the euro area two related issues are being discussed. First, have business cycles in the euro area become more similar, and second, which factors drive business cycle synchronization? As to the first issue, the literature has not yet reached a consensus on whether business cycles of the countries in the euro area are converging. Differences between various studies may be explained in part by the use of different data. Other reasons, however, include the use of diverging methods of identifying business cycles and assessing convergence. Competing methods for the computation of a business cycle have been suggested. There is also no consensus on how convergence between business cycles should be gauged. Suggestions include looking for increased bivariate correlation of cyclical components, for decreased cyclical disparity or for evidence of an emerging common factor that drives individual countries' business cycles (Massmann and Mitchell, 2004).

As to the second issue, various factors have been put forward that may affect business cycle synchronization, ranging from trade relations (Frankel and Rose, 1998), specialization (Imbs, 2004), monetary integration (Fatás, 1997), financial relations (Imbs, 2006) and fiscal policy (Clark and van Wincoop, 2001). However, 'despite the theoretical and empirical analyses to date, it seems fair to say that there is no consensus on the important determinants of business-cycle comovement. The difficulty is that there are many potential candidate explanations' (Baxter and Kouparitsas, 2005, p. 114).

This paper surveys the empirical literature dealing with these issues, focusing on the current members of the monetary union in Europe.[3] This implies that papers on business cycle asymmetries among the G7 countries (like Kiani and Bidirkota, 2004) or on international business cycles (like Ambler *et al.*, 2004) are not discussed, unless they contain interesting results from the viewpoint of the present paper. Likewise, we do not review studies that focus on regional cycles in Europe (like Belke and Heine, 2004).

The remainder of the paper is organized as follows. Section 2 reviews methods to identify business cycles and business cycle synchronization. Section 3 assesses the degree of business cycle synchronization in the currency union in Europe. Section 4 discusses factors that drive business cycle synchronization. The final section offers some concluding comments.

2. Measuring Business Cycle Synchronization

Studies that examine synchronization of business cycles in the euro area often reach very different conclusions. Part of these differences can be related to the selection of variables used, diverging methodologies to construct business cycles and alternative ways to assess synchronization. We therefore start off by discussing the economic variables that have been considered, alternative ways to measure the cycle and different indicators of business cycle synchronization.

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2.1 *Data*

The two most important variables used are quarterly data on GDP and monthly data on industrial production (IP). In addition, GDP is sometimes decomposed into expenditure categories such as consumption and investment. Annual data are usually avoided to capture more of the high-frequency fluctuations.[4]

From the perspective of this paper, studies of business cycle synchronization should focus on the broadest possible output variable, i.e. GDP.[5] Unfortunately quarterly real GDP data are not available for many countries on a long-term basis. IP data have the advantage that they are available for many countries at a monthly frequency. However, the conceptual reasoning behind using IP is less convincing. First, manufacturing activity represents less than 20% of aggregate output in the euro zone so *a priori* it would not seem to be representative of total output.[6] Second, manufacturing output is much more volatile than aggregate output.[7]

2.2 *Measuring Business Cycles*

A first distinction that has to be made is between classical business cycles and deviation (or growth) cycles. Burns and Mitchell (1946) define (classical) business cycles in terms of absolute expansions and contractions of economic activity. Most recent business cycle studies, however, look at deviation cycles, i.e. the deviation of economic activity from a 'trend'. This also holds true for most studies surveyed here. A practical reason why most researchers focus on deviation cycles is that most (parametric) measures used to describe the cycle need stationary series as input. Furthermore, since most economies are growing over time classical recessions occur much less frequently than growth cycle recessions.

The studies surveyed in this paper use a variety of filtering techniques to decompose output into trend and cycle.[8] The most straightforward filtering technique is calculating first differences.[9] Usually, this is enough to render the series of interest stationary. However, as Baxter and King (1999) point out, first differencing does remove a trend from a series, but potentially at the cost of a shift in the peaks and troughs of the differenced series and a larger volatility. The phase shift may not be too important when comparing cycles across countries since this phase shift is the same for both countries. However, the larger weight on higher frequencies in the series emphasizes the irregular 'noise' over the cyclical movements.

Most studies under review apply non-parametric filters such as the Hodrick–Prescott (1997) filter, the Baxter–King (1999) and the Christiano–Fitzgerald (2003) band-pass filters, and the phase average trend (PAT, Boschan and Ebanks, 1978).[10] Probably the most widely used filter is the Hodrick–Prescott (HP) filter. This filter estimates the trend component by minimizing deviations from trend, subject to a predetermined smoothness of the resulting trend. The HP filter can be interpreted as a high-pass filter that removes fluctuations with a frequency of more than 32 quarters or eight years and puts those fluctuations in the trend.[11]

Baxter and King (1999) argue that the combination of such a high-pass filter on the one hand and a low-pass filter (which removes high frequencies) on the

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other is better since the HP filter still leaves much of the high-frequency noise as part of the cycle. If such a so-called band-pass (BP) filter is applied, the resulting cyclical component does not contain any fluctuations with high or low frequencies beyond predetermined cut-off points. Both Baxter and King (1999) and Christiano and Fitzgerald (2003) derive an approximate BP filter, using somewhat different assumptions. Although different in details, in both cases the weights for the two-sided filter are estimated using frequency domain arguments.

Finally, the PAT is closely related to the method used to calculate business cycle turning points. The PAT filter, originally proposed by Boschan and Ebanks (1978), starts off by estimating a 25-quarter moving average. The turning points of the deviations from this trend are dated using the Bry and Boschan (1971) algorithm, which generates classical cycle turning points that closely approximate those selected by the NBER Business Cycle Dating Committee. Finally, the trend is estimated by connecting the mean values between each cyclical peak. Zarnowitz and Ozyildirim (2002) show that the PAT filter gives similar turning points as other filters such as the HP and the Baxter–King BP filter. Only few studies summarized in this paper apply this filter.

To what extent does the selection of a particular way to model the business cycle affect conclusions on business cycle synchronization? Unfortunately, only few studies check how sensitive their results are in this respect. Artis and Zhang (1997) and Calderon *et al.* (2002) conclude that the choice of a particular filtering method is not crucial for their conclusions. Likewise, Massmann and Mitchell (2004, p. 303), who consider the largest number of business cycle measures, conclude that 'our examination of convergence between euro area business cycles indicates that there are substantive similarities across alternative measures of the business cycle'. This finding is remarkable since Canova (1998) concluded that different filtering methods lead to diverging conclusions regarding the business cycle for the United States. However, these findings are not mutually exclusive, since Canova compares the outcomes of applying different filters to output of one country, while Massmann and Mitchell and others compare the results using different filters across countries. So although the various filters may 'extract different types of information' (Canova 1998, p. 475), the findings are similar when comparing this information across countries.

In summary, studies that use standard filters such as the HP, Baxter–King and Christiano–Fitzgerald filters are likely to yield similar results. These three filters also perform reasonably well in isolating fluctuations in the data of certain frequencies, which after all is the most important goal of filtering. Using first differences is likely to lead to larger problems, as it puts too much weight on high-frequency fluctuations.[12]

2.3 *Measuring Synchronization: Measures*

Given a certain measure of the business cycle one has to determine to what extent these cycles move together across countries. Most studies use simple (Pearson) correlation coefficients of the cyclical part of GDP for this purpose but other

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measures have been suggested in the literature as well, like the dynamic correlation measure of Croux *et al.* (2001), the phase-adjusted correlations of Koopman and Azevedo (2003) and the concordance index of Harding and Pagan (2002).[13]

The dynamic correlation measure of Croux *et al.* (2001) is defined as the co-spectrum between two series over the product of the spectra of each series. The authors define this measure over a certain frequency band, i.e. fluctuations in the series with a certain period. They show that for time series with an infinite number of observations, the dynamic correlation between two series over a frequency band is equal to the regular correlation between two band-passed series. For finite time series this equality does not hold in general as both the BP filter and the dynamic correlation are estimated imperfectly. Croux *et al.* (2001) suggest that for more than two series, one should look at the cohesion of these series, defined as the (weighted) average of the binary dynamic correlation coefficients. This measure seems to provide a useful summary statistic on the degree of co-movement within a group of countries by avoiding the problem of choosing a base country.[14]

Koopman and Azevedo (2003) estimate an unobserved components model that accounts for time-varying phase differences as well as a time-varying relation between cycles. Their method refines standard contemporaneous correlations between cyclical components (determined using a BP filter) in two ways. First, they separate the contemporaneous correlation into a part due to differences in the position on the cycle of two countries (phase shift) and a 'phase-shift' adjusted correlation. Second, they allow for time variation in both the phase shift and the phase-shift adjusted correlation. Although this last innovation seems valuable, they can only implement their method by imposing a monotone time function. In other words, the correlation can either go up or down over the sample period. While this provides useful information, visual inspection of their cyclical component series suggests that periods of stronger and weaker correlation alternate.

The concordance index proposed by Harding and Pagan (2002) is a non-parametric co-movement measure that uses a binary indicator variable of recessions and expansions. This index measures the percentage of the time where the two series are in the same phase of the business cycle. The index is in some ways more flexible than the correlation coefficient since any method for distinguishing between recessions and expansions can be chosen. So while calculating the correlation between series of GDP, levels will generally not be very informative due to the strong trend in those series, classical recessions can be dated from these level series and the concordance index can be calculated. A drawback, however, is that analysing a binary variable throws away potentially useful information. Still, it would seem that the concordance index can be a useful complement to correlation measures between detrended series as well as providing a useful measure to analyse classical cycles.

Artis *et al.* (2002) provide a related perspective by looking at diffusion indices, which measure the share of countries that are in a recession if, say, the euro area as a whole is in recession. Such indices can also be modified to measure, for instance, the share of countries with above-trend growth. While the concordance index seems useful to summarize bilateral co-movement of two series, diffusion

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indices can provide insight in the co-movement within an aggregate at each point in time.

Most co-movement measures are judged by their characteristics and not so much by economic reasoning. An exception is the work by Kalemli-Ozcan *et al.* (2001), who argue that a natural measure of asymmetry quantifies the potential loss of welfare due to asymmetric GDP fluctuations in the absence of risk-sharing mechanisms. They compare utility under autarky, where the consumption possibilities are constrained by the country's own GDP, and under full cross-country risk sharing. In the latter case, consumption possibilities are equal to a fraction of total GDP of the area with risk sharing. Moving from autarky to full risk sharing will generally bring utility gains and Kalemli-Ozcan *et al.* (2001) derive the following measure for these gains when assuming log utility:[15]

$$G^i = \frac{1}{\delta}\left(\frac{1}{2}\sigma^2 + \frac{1}{2}\sigma_i^2 - \mathrm{cov}^i\right) \tag{1}$$

where δ is the inter-temporal discount rate. This measure states that the gains from risk-sharing for country i will be larger when the standard deviation of GDP growth in country i is higher, when the standard deviation of GDP growth in the rest of the risk-sharing area is larger and when the covariance between country i and the rest of the area is smaller. The interpretation of this negative sign on the covariance is straightforward as joining an area with largely unrelated fluctuations will provide more insurance by stabilizing aggregate output. Furthermore, the higher the standard deviations of growth, the more is gained by risk sharing.

Interestingly, equation (1) bears close resemblance to the correlation coefficients that are often used in the study of business cycle synchronicity since the standard deviations of the two series and the covariance between the series are the main components both of equation (1) and of the standard correlation coefficient.

The final problem to be discussed is how to judge the change in co-movement between cycles over time. The simplest solution is to compare correlations in two periods, for example, before and after the establishment of the Exchange Rate Mechanism (ERM) (Artis and Zhang, 1997, 1999), or for multiple periods as in Inklaar and De Haan (2001). A more general and less-arbitrary approach is to use rolling windows as in Massmann and Mitchell (2004). The state-space representation of Koopman and Azevedo (2003) allows them to estimate time-varying correlations without even making assumptions about the size of the rolling windows. As noted above though, this method has some drawbacks due to the assumption of a monotone development of correlations over time.

The use of a correlation coefficient as dependent variable in models examining the determinants of business cycle synchronization (see Section 4 for further details) leads to some complications. Since the dependent variable lies between -1 and 1, the error terms in a regression model of the determinants of business cycle synchronization are likely not to be normally distributed. Indeed, the evidence presented by Otto *et al.* (2001) and Inklaar *et al.* (2007) suggests that it is necessary

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to transform the dependent variable. Unfortunately, this issue has not been addressed in most papers reviewed in Section 4.

2.4 *Measuring Synchronization: 'Shock Accounting'*

All the measures discussed so far take business cycles for granted. A different strain of literature seeks to directly classify fluctuations as originating from, for example, common shocks or country-specific shocks. Clark and Shin (2000) review the literature that uses vector autoregression (VAR) models or factor models to identify the sources of fluctuations and present the following general model:

$$e_{c,i,t} = a_t + b_{c,t} + c_{i,t} + u_{c,i,t} \tag{2}$$

Equation (2) states that shocks in industry i of country c can be decomposed into common shocks (a), country-specific shocks (b), industry-specific shocks (c) and idiosyncratic shocks (u). Obviously this model is stripped down as no dynamics are incorporated, but it serves to highlight the main points. Alternatively, studies estimate models using data on industries within regions of a country (e.g. Norrbin and Schlagenhauf, 1996; Clark and Shin, 2000) or on regions within countries in Europe (e.g. Fátas, 1997; Forni and Reichlin, 2001).

The most common identifying assumption in these models is that the various shocks are uncorrelated. This means that an industry-specific shock at time t is a shock to that industry in all countries but not to other industries. Clark and Shin (2000) argue that, although this is restrictive, it can be seen as providing a lower bound to the importance of industry- or country-specific shocks. A more conceptual problem with this type of model is that economic theory is relatively silent on the sources of the identified shocks. For example, it seems plausible to attribute industry-specific shocks to changes in product demand and productivity shocks, but more definitive statements cannot be made in the absence of an economic model.

The 'shock accounting' method seems a complement to the methods described earlier to look at common cyclical movements across countries. In a way, the correlation between cycles is a 'gross' measure of co-movement, capturing all commonality, regardless of the source of the shock, as well as the policy reaction to shocks. The shock-accounting literature tries to push this a step further by deriving a 'net' measure of co-movement. This measure includes only shocks that occur in all countries and industries, netting out the contribution from industry-specific shocks. From a policy point of view, the gross measure is probably more interesting since it gives an indication how appropriate a common monetary policy will be. However, the shock-accounting literature provides additional insights. For example, a large share of common shocks can point to important influences from, say, oil price shocks.

Finally, some recent papers use a somewhat different approach by analysing to what extent supply and demand shocks in countries are correlated. A good example is the study by Fidrmuc and Korhonen (2003), who examine the correlation of supply and demand shocks in the current and (potential) future members of the monetary

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union in Europe, following the approach suggested by Bayoumi and Eichengreen (1993). Shocks are identified using two-variable VARs for output and prices and the Blanchard and Quah (1989) assumptions, i.e. the identification of the reduced-form VAR model is based on the assumption that demand shocks do not have permanent effects on output, whereas supply shocks do.

3. Business Cycle Synchronization in the Euro Area

3.1 *Correlation of Cyclical Indicators*

Various studies examining the correlation of cyclical indicators over time in the countries in the euro area come to diverging conclusions. Table 1 summarizes the main aspects of these studies. A good illustration of this line of research is the controversy between Artis and Zhang (1997, 1999), who conclude that European business cycles have become more synchronized,[16] and Inklaar and De Haan (2001), who find that cycles are better correlated (against Germany) in the period 1971–1979 than in the period 1979–1987. They argue that this is inconsistent with Artis and Zhang's (1999) view that increased monetary integration, specifically after the creation of the European ERM in 1979, and business cycle synchronization are positively related. Massmann and Mitchell (2004) re-consider the evidence that sparked this controversy, using 40 years of monthly IP data and eight different measures for the business cycle. They compute pairwise correlation coefficients between the 12 countries' business cycles using a method of moments estimator that also yields an associated measure of uncertainty. To examine the evolution of this estimate over time Massmann and Mitchell use a series of rolling windows, rather than windows of fixed width. Interestingly, Massmann and Mitchell find that there have been periods of convergence and periods of divergence. The estimated mean correlation coefficient between the 12 European business cycles is on average positive and significant, but there has been considerable volatility. The correlation is trending upwards until the mid-1970s, reaching peaks of around 0.8 for most measures of the business cycle. Then, correlation in general falls to zero in the mid to late 1980s and is statistically insignificant, lending support to Inklaar and De Haan's (2001) finding that correlations of euro area countries with Germany are higher in 1971–1979 than 1979–1987. Correlation then rises in the late 1980s to values in the range 0.6 to 0.8, before slumping quite rapidly in the early 1990s. The estimates for the most recent period suggest that correlation between the 12 European cycles is statistically positive, and has risen from the trough in the early 1990s. Similarly, Altavilla (2004) reports evidence that after 1991 synchronization of (some) euro countries has increased.

Darvas and Szapáry (2004) also find evidence in support of more business cycle synchronization in the euro area since the run-up period to EMU. These authors not only focus upon GDP, but also analyse synchronization of the major expenditure and sectoral components of GDP. Their results suggest that Austria, Belgium, France, Germany, Italy and the Netherlands show a high degree of synchronization according

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Table 1. Studies on Business Cycle Synchronization in the Euro Area.

Study	Data used	Measure of cycle	Convergence measure	Conclusions
Fatás (1997)	Employment growth, EU12, 1966–2002 and subsamples	Employment growth	Correlation with EU12	Post-EMS correlations are generally higher than pre-EMS correlations
Artis and Zhang (1997, 1999)	OECD monthly IP data (15 countries in 1997 paper, 19 in 1999 paper), 1960–1993 (1997) and 1960–1995 (1999)	PAT, HP, linear trend; two subsamples (pre- and post-ERM)	Lead and lag bivariate correlation with Germany and US	Cycles have become more group-specific after ERM, correlations not different across filters after ERM
Angeloni and Dedola (1999)	IP, GDP, stock prices, GDP deflator, CPI, quarterly data 1965–1997, 12 EU countries, US, CAN, JPN	Year-on-year growth rates	Correlations with Germany and US	Significant increase in correlation after 1992
Döpke (1999)	OECD data of 'big 5' euro area countries	HP, linear, segmented trend	Rolling contemporaneous correlations based on five-year moving average of each country with euro area	Correlation between most countries and the euro area increases, but that of BEL falls

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Table 1. *Continued.*

Study	Data used	Measure of cycle	Convergence measure	Conclusions
Wynne and Koo (2000)	Penn World Tables of GDP, annual data	Baxter–King	Pairwise correlations, using GMM	Null of no correlation between EU founding members rejected, but lower correlation with more recent members
Inklaar and De Haan (2001)	OECD monthly IP data, 1960–1997	HP, two subsamples (pre- and post-ERM)	Bivariate correlation with Germany and US	Mixed outcomes, no replication of results of Artis and Zhang (1999)
Agresti and Mojon (2001)	ECB Euro Area Wide Model (AWM) data of GDP and GDP components for 10 countries	Baxter–King	Contemporaneous and lagged cross-correlation between each country and the euro area	Each country highly correlated with euro area as whole, with lowest values for periphery
Belo (2001)	GDP, EU15 countries, US, JPN, annual for 1960–1999	HP filter	Correlation, concordance, rank correlation, with euro (11) area	High and increasing association for most euro area countries after ERM

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Croux *et al.* (2001)	GDP, EU15, SWI, NOR, plus personal income for US states, annual for 1962–1997	Spectral decomposition	Dynamic correlations and cohesion (weighted average of dynamic correlations)	Cycles of US states are more similar than cycles of European countries
Harding and Pagan (2001)	ECB AWM data of GDP for euro area, OECD data for US	Harding–Pagan rule on level series and de-trended (linear, HP, PAT) series	Correlation and regression methods on binary series	Relatively low correlation between member countries and euro area
Azevedo (2002)	GDP, EU15 countries, US, JPN, annual from 1960–1999	Co-spectrum of HP filtered series	Dynamic correlation with euro (11) area	High correlation of in-phase cyclical movements
Beine *et al.* (2003)	Unemployment, FIN, FRA, GER, ITA, NLD, NOR, PRT, SPA, SWI, SWE, UK, quarterly 1975–1996	Recession probabilities from a Markov switching VAR model	Several indicators based on recession probabilities similar to concordance indices	More synchronization amongst EMU members, compared to European periphery

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Table 1. *Continued.*

Study	Data used	Measure of cycle	Convergence measure	Conclusions
Koopman and Azevedo (2003)	GDP, FRA, GER, ITA, NLD, UK, US, euro (12), quarterly 1970–2001	Christiano–Fitzgerald filter	Correlations and phase shifts with euro (12) area	Increases in correlation and synchronization within euro zone
Sopraseuth (2003)	Quarterly data GDP, consumption, investment, exports 1971.3–1979.2 and 1987.1–1998.4, 17 countries	HP filter	Correlations of filtered data	Membership in EMS did not result in increased correlations, but during EMS period countries are more synchronized with German than with the US cycle
Garnier (2003)	Monthly IP for 18 countries, 1962–2001; before and after EMS	Analysis is based on various characteristics (including concordance index) of classical cycle determined by BB procedure	Comparison with cycles of Germany and US	Core group of euro countries (which does not include Belgium) shows increased similarity with German cycle

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Massmann and Mitchell (2004)	OECD monthly IP data, 1960.1–2000.8	Various methods	Pairwise correlation coefficients using a method of moments estimator; the entire distribution of all correlation coefficients is focused upon, using rolling windows	Euro area has 'switched' between periods of convergence and divergence many times in the last 40 years; in more recent period evidence of increasing synchronization
Darvas and Szapáry (2004)	OECD's Quarterly National Accounts GDP and components for 10 euro area countries; quarterly data between 1983 and 2002 grouped in four non-overlapping five-year periods	HP and BP filter	Cycle correlation with euro area, leads/lags, volatility, persistence of the cycle and a measure of impulse–response	Rather strong co-movement with the euro area for most EMU members; more synchronization over time according to all the correlation measures calculated, particularly since 1993

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Table 1. *Continued.*

Study	Data used	Measure of cycle	Convergence measure	Conclusions
Artis *et al.* (2004)	Industrial production, AUT, BEL, FRA, GER, ITA, NLD, SPA, 1970–1996, monthly	Probability of being in a recession based on Markov switching models	Correlation, contingency coefficient, variance decomposition	Considerable commonality but also important domestic (non-EU) component
Altavilla (2004)	GDP of BEL, FRA, GER, ITA, SPA, UK, US 1980–2002, quarterly	Classical and deviation cycles based on BB and Harding–Pagan procedures; trend for deviation cycle determined using HP and BP filters; for classical cycle Markov switching model is used	Characteristics of cycles (like duration, amplitude, steepness) and (correlation of) concordance measure compared with euro area average	Deviation cycles of EMU countries are reasonably aligned, but classical cycles diverge more; after 1991 EMU countries became more synchronized

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Hughes Hallett and Richter (2004, 2006)	GDP of US, UK, Eurozone and Germany, quarterly for 1980–2003	Spectral decomposition	Time-varying coherence	Coherence between GER and Eurozone has decreased, while coherence between UK and Eurozone is unstable, but stronger than link with US
Camacho *et al.* (2006)	Monthly IP for most current and future EU countries and CAN, JPN, NOR and US, 1965–2003	Comprehensive measure that consists of average of three measures of synchronization	Pairwise correlation of comprehensive measure	Relatively high linkages across euro countries, but these are prior to the establishment of the monetary union

AUT, Austria; AUS, Australia; BEL, Belgium; CAN, Canada; FIN, Finland; FRA, France; GER, Germany; GRE, Greece; IRE, Ireland; ITA, Italy; JPN, Japan; NLD, Netherlands; NOR, Norway; PRT, Portugal; SPA, Spain; SWE, Sweden; SWI, Switzerland; UK, United Kingdom; US, United States; euro (12), euro area; euro (11), euro area, excluding Greece; EU15, European Union as of 1995.

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to all the measures used (high correlation, low volatility, small leads/lags, similar and high persistence, similar impulse–response). This result applies not only for GDP, but for its components as well. The synchronization has significantly increased between 1993–1997 and 1998–2002. Portugal, Finland and Ireland show the lowest correlation with the euro area cycle, particularly for consumption and services. It should be pointed out, however, that when correlations are calculated with the euro area, an upward bias is created since all countries are – by definition – included in the euro area aggregate. This bias may be quite substantial for the bigger countries. This criticism also applies to Agresti and Mojon (2001) who find that the business cycle fluctuations of GDP, consumption and investment of most euro area countries were, even before stage three of EMU, highly synchronized with, respectively, the business cycle fluctuations of GDP, consumption and investment of the euro area.

Overall the evidence on changes in the amount of business cycle synchronization is mixed and it partly depends on the periods distinguished and the benchmark that is used. However, most of the current evidence suggests that periods of greater and lesser synchronization tend to alternate. Still, there is quite some evidence that during the 1990s, business cycle synchronization in the euro area has increased.

3.2 *Other Approaches*

Apart from correlation of business cycle indicators, other approaches have been employed to assess business cycle synchronization. A good example is the study by Artis (2003) who examines whether a European business cycle can be identified. He comes to less-optimistic conclusions than in his previous work with Zhang: 'the European business cycle is a more elusive phenomenon than we might have expected; whilst some European countries seem "to stick together", there are many that do not. In any case, the US and Japan are often to be found as closely associated with those European countries that do stick together as with others' (p. 2). In line with the conclusions of Massmann and Mitchell (2004), Artis finds that there is not a monotone movement towards the emergence of a highly coherent and exclusive 'European' cycle. Table 2 provides a summary of this study and others that do not fit into the approach as discussed in the previous section.

As discussed in Section 2, one particular strain of literature is interested not so much in synchronicity of business cycles, but in accounting for the sources of fluctuations across regions, industries and countries. Here we focus on what can be learned from these studies about business cycle synchronicity in Europe. Clark and Shin (2000) provide an extensive overview of the different methods that are used in this line of research, as well as an overview of results. These authors find that around half of the variation in industry growth is due to country-specific shocks and about one-third is idiosyncratic noise. Of the variation that could lead to synchronicity of business cycles, around 12% is due to shocks that are common across industries and countries and 7.5% is due to industry-specific shocks. There is quite some dispersion around these averages, but in nearly all countries, country-specific and idiosyncratic shocks are responsible for more than two-thirds of total variation.

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Table 2. Studies on a World and/or European Business Cycle.

Study	Data used	Approach	Conclusions
Canova and Marrinan (1998)	GDP of US, GER and JPN, quarterly, 1960–1994	Multi-country general equilibrium model based on impulse–response functions	In the short run, common shocks are most important in accounting for business cycles in the three countries
Beine *et al.* (2000)	IP for AUT, BEL, FRA, GER, NLD, monthly, seasonally unadjusted, 1975–1997	Common features and codependence analysis in VAR models	Countries do not constitute a perfect currency area as no common cyclical features are found. Finding of codependence similar to Rubin and Thygesen (1996)
Artis (2003)	22 OECD countries, 1970–2001, quarterly GDP	Multidimensional scaling and clustering	Cautiously identifies a 'core' group of European countries. Also suggest role for globalization in similarity between countries
Kaufman (2003)	EU15, AUS, NOR, CAN, JPN and US, quarterly growth of IP, 1978–2001	Markov switching model with Bayesian sampling	European countries are a cyclically coherent group, separate from Australia, Canada and US
Mansour (2003)	113 countries, 1961–1989, GDP annual growth rate	Dynamic factor analysis	World component is generally more important than the European component; European component varies widely among EU members (ranging between 18% for Ireland and 50% for Belgium). However, EU emerges as the most integrated block in the world

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Table 2. *Continued.*

Study	Data used	Approach	Conclusions
Kose *et al*. (2003a)	60 countries, covering seven regions of the world, 1960–1991, annual growth rates of output, consumption and investment	Bayesian dynamic latent factor model to estimate common components	No evidence of a European cycle as little of the volatility of the European aggregates can be attributed to the common European factor
Kose *et al*. (2003b)	G7, 1960–2001 (three subperiods), GDP, investment and consumption	Bayesian dynamic latent factor model to estimate common components	Common factor explains a larger fraction of output, consumption and investment volatility in the globalization period than it does in the Bretton Woods period
Lumsdaine and Prasad (2003)	17 OECD countries, 1963–1994, monthly IP growth rate	Time-varying weights in constructing the common component; weights are constructed on the basis of a GARCH specification	Strong positive correlation with common component, particularly after 1973. Correlations of individual country fluctuations with European component are strongly positive for virtually all European (EMU) countries, especially after 1973. For most European (EMU) countries correlation with European (EMU) component is stronger than with world component
Montfort *et al*. (2003)	G7 countries, quarterly GDP and monthly IP growth, 1970–2002	Dynamic factor analysis	France, Germany and Italy form a more or less coherent area, distinct from Canada and the US, which is more important than the global factor

*See Notes to Table 1 for an explanation of the abbreviations.

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Table 3. Correlation of Supply and Demand Shocks between the Euro Area and Individual Countries.

	Fidrmuc and Korhonen (2003)		Ramos and Suriñach (2004)		Fidrmuc and Korhonen (2004a)		Frenkel and Nickel (2005)	
	1991–2000		1988–1998		1991–2002		1995–2001	
	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
Austria	0.38	0.08	n.a.	n.a.	0.40	0.10	0.18	−0.04
Belgium	0.53	0.00	0.53	0.56	0.71	0.02	1.00	0.94
Finland	0.30	0.06	0.06	0.43	0.38	0.01	0.54	−0.10
France	0.69	0.30	0.60	0.74	0.57	0.29	0.74	0.35
Germany	0.66	0.18	0.34	0.48	0.68	0.04	0.62	0.31
Greece	0.05	−0.01	n.a.	n.a.	0.29	0.08	−0.10	−0.01
Ireland	−0.14	0.13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Italy	0.52	0.57	0.46	0.48	0.47	0.41	0.76	0.55
Netherlands	0.47	0.04	0.28	0.14	0.44	0.18	−0.07	−0.58
Portugal	0.45	0.09	n.a.	n.a.	0.05	0.19	−0.18	0.11
Spain	0.22	0.16	0.46	0.30	0.56	0.39	0.42	0.03

These results broadly accord with the work of others such as Norrbin and Schlagenhauf (1996, see Table 3). Clark and Shin (2000) also show that across regions of the United States the common component is much larger than in Europe. However, the analysis of fluctuations of regions within European countries by Forni and Reichlin (2001) shows that the European component is responsible for nearly half of the fluctuations, while for EMU regions the country-specific component is reduced to 25%–30%. This can partly be due to the data frequency, which is quarterly for Norrbin and Schlagenhauf (1996) and Clark and Shin (2000), but annual for Forni and Reichlin (2001). As Clark and Shin (2000) show, the explanatory power of the common component is larger in annual data than in quarterly data, largely at the expense of country-specific and idiosyncratic shocks.[17]

In general, the common component in the cross-country studies that Clark and Shin (2000) survey is a relatively modest fraction of total variation.[18] Furthermore, quite a noticeable part of the common fluctuations can be attributed to industry-specific shocks. This suggests that if industrial specialization accelerates within the EMU, synchronicity might decrease. However, these results also suggest that within monetary unions, country-specific fluctuations become less important. The net effect of EMU on synchronization is therefore uncertain.

Also some more recent studies, which were not summarized by Clark and Shin (2000), examine to what extent business cycle fluctuations are generated by 'global' or 'common' shocks. Various authors focus on G-7 economies. For instance, Monfort *et al.* (2003) show that G-7 countries share common dynamics in real economic activity, with clearly identifiable common swings across countries. Other studies examine whether common shocks in the G-7 have become more important over

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time. A good example is the paper of Kose *et al.* (2003b) who employ a Bayesian dynamic latent factor model to estimate common components in output, consumption and investment of the G-7 countries to estimate common and country-specific factors. These factors are used to quantify the relative importance of the common and country components in explaining co-movement in each observable aggregate over three distinct time periods: the Bretton Woods (BW) period, the period of common shocks and the globalization period. They find that the common factor explains a larger fraction of output, consumption and investment volatility in the globalization period than it does in the BW period. However, other studies find less support for this view. For instance, Doyle and Faust (2002) study the changes in the correlations between the growth rate of GDP in the United States and in the other G-7 countries over time and find that there is no significant change in the correlations.[19] Canova and Marrinan (1998) examine the United States, Germany and Japan by estimating some parameters for a structural multi-country general equilibrium model. They conclude that in the short run, shocks common to these countries dominate the business cycle.

Other similar decompositions have been attempted for larger groups of countries by Mansour (2003), Artis (2003), Lumsdaine and Prasad (2003) and Kose *et al.* (2003a). From the perspective of the present paper, this line of literature yields some interesting findings.[20] For instance, Mansour (2003) reports that the EU emerges as the highest integrated group of countries. When he decomposes the variance of output growth in European countries into a world, a European and a country component, this author finds that the European component is generally more important than the world component, although there is quite some variation among the European countries when it comes to the importance of the European component. This is roughly in line with the results of Artis (2003), who concludes that a set of European countries shows a reasonable degree of commonality, although there is no overwhelming evidence for a purely European business cycle. However, Kose *et al.* (2003a) find no evidence of a European cycle as little of the volatility of the European aggregates can be attributed to the common European factor. This result is robust to redefinitions of the European group. In contrast, Lumsdaine and Prasad (2003) find that the European component is more important than the world component.

It follows from the discussion so far that there is no consensus in the literature as to how important the global factor is, whether the importance of the global factor has increased, and whether the European component is more important than the global component. Still, the various studies agree that business cycles are not just country-specific phenomena, but that shocks common across a number of countries are important. A higher percentage of variance explained by common shocks will generally be related to a higher degree of business cycle synchronization.

Finally, Table 3 summarizes four recent studies that applied the Bayoumi–Eichengreen method to calculate the correlation of supply and demand shocks between the euro area and individual countries. Three conclusions can be drawn. First, despite the common methodology, the estimation results vary widely. Take, for instance, the correlation of demand shocks in the Netherlands, for which the estimates range from −0.58 to 0.18. Likewise, the correlation of demand shocks in

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Belgium varies between 0.00 and 0.94. Apparently, the results of this method are highly sensitive to the period under consideration. Unfortunately, none of the papers discussed employ moving windows to address this issue in depth. Second, despite this divergence across studies Germany, France and Italy are always identified as the countries with the highest correlation with supply and demand shocks in the euro area, although that may also be due to the large share of these countries in euro area output. Finally, for quite a few countries (Austria, Finland, Greece, Ireland and Portugal) the correlation of demand shocks is extremely low. A similar conclusion applies for the correlation of supply shocks in these countries, although here the results are somewhat more mixed across the studies under consideration.

4. Factors Driving Business Cycle Synchronization

Many factors have been suggested that may drive business cycle synchronization, the most prominent one being *trade intensity*. Theoretically, trade intensity has an ambiguous effect on the co-movement of output. Intensive trade relations between countries may lead to the export or import of a business cycle caused by demand fluctuations, as changes in income in one country will normally also lead to a changed demand for foreign goods. Standard trade theory predicts that openness to trade will lead to increased specialization in production and inter-industry patterns of international trade. If business cycles are dominated by industry-specific shocks, trade-induced specialization leads to decreasing business cycle correlations.[21] However, if trade is dominated by intra-industry trade industry-specific shocks may lead to more symmetric business cycles.

Frankel and Rose (1998) present empirical evidence that higher bilateral trade between two countries is associated with more synchronized business cycles. Their measure for synchronization is the correlation of business cycles. Frankel and Rose (1998) acknowledge the possible contrasting effects of inter- and intra-industry trade on business cycle synchronization, but focus on the net effect of total trade on income correlation. Gruben *et al.* (2002) criticize this approach and conclude that the coefficients of inter-industry and intra-industry trade are different, but as pointed out by Inklaar *et al*. (2007), in OECD countries intra-industry trade is highly correlated with inter-industry trade so that including both variables simultaneously leads to serious multicollinearity problems.

Most studies examining the impact of trade on income correlation find a positive association between the trade between countries and business cycle synchronization, regardless of the way in which the trade relationship is modelled, but more recent studies tend to find somewhat lower effects than Frankel and Rose (1998).[22] For instance, Gruben *et al.* (2002), using the same 21-country sample as Frankel and Rose, confirm their general conclusion, that increased trade leads to increased business cycle correlation, but find that the trade effect on business cycle correlation is about half of Frankel and Rose's point estimate. Also Calderón *et al.* (2007) find a lower impact of trade intensity than Frankel and Rose for their full sample; however, their results for OECD countries are similar to those of Frankel and Rose. Using a data set that includes over 100 developed and developing countries and the

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'robustness' approach advocated by Leamer (1983), Baxter and Kouparitsas (2005) find that the effect of bilateral trade is robust: countries that trade more with each other have more correlated business cycles. Table 4 summarizes these and other studies.

Various indicators for trade intensity have been used in the studies summarized in Table 4. For instance, Frankel and Rose (1998) employ total trade between two countries scaled by total GDP or total trade.[23] Instead of using the sum of trade or GDP of the two countries as scaling factor, some authors prefer scaling by the product of GDP or trade of the two countries concerned (see, for instance, Clark and van Wincoop, 2001) as this indicator is not size dependent. It seems that the qualitative conclusion concerning the impact of trade on income correlation is not dependent on the exact measure chosen (see, for instance, Calderón *et al.*, 2007; Inklaar *et al.*, 2007).

The main problem in correctly estimating the impact of trade intensity on business cycle synchronization is that trade intensity is endogenous, which makes a simple ordinary least squares (OLS) regression of bilateral economic activity correlation on trade intensity inappropriate. Frankel and Rose (1998) deal with this problem by using gravity variables (distance, border dummy, common language dummy) as instruments to identify the effect of trade on business cycle correlation. However, as Figure 1 shows, this is not appropriate as the gravity variables (Z) not only affect trade intensity (T) but are also possibly related to some other variables (F) that affect business cycle synchronization (C). For instance, neighbouring countries are more likely to coordinate their monetary policies, or to have a common currency, than countries that are far away from each other. In turn, the introduction of a single currency will contribute to reducing trading costs both directly and indirectly, e.g. by removing exchange rate risks (and the cost of hedging) and diminishing information costs.

The regression model that corresponds to the figure is

$$\begin{aligned} C &= \beta_1 T + \beta_2 F + \varepsilon \\ T &= c_1 Z + c_2 F + \mu \\ F &= c_3 Z + \omega \end{aligned} \tag{3}$$

The model shows that the business cycle correlation depends on trade as well as some other policy-related and structural variables. As will be discussed below, the literature has come up with a rather long list of variables that may be related to business cycle synchronization. As long as some of these variables are related to the gravity variables IV will not suffice; if the other variables (F) are not included in the model the estimated trade coefficients will be biased. Unfortunately, most studies on the effect of trade on business cycle synchronization do not include (many) other potential determinants of income correlation so that the estimated trade effects are likely to be biased. Inklaar *et al.* (2007) estimate a multivariate model including variables capturing specialization, financial integration, similarity of economic policies and economic structure. They confirm that trade intensity affects business cycle synchronization, but the effect is much smaller than reported

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Table 4. Recent Studies Examining the Determinants of Business Cycle Synchronization

Study	Countries and time period	Business cycle synchronization measure	Model	Conclusion
Frankel and Rose (1998)	21 industrial countries, 1959–1993; four subsamples	Bilateral correlation of cyclical component of GDP, IP and (un)employment (four detrending methods: fourth-differencing, quadratic detrending, HP, HP on the SA residuals)	Instrumented trade intensity is regressed on correlation. Instruments: log of distance, adjacency dummy, common language dummy	Bilateral trade intensity has strong and positive effect on business cycle synchronization; dummy reflecting bilateral fixed exchange rate is not robust
Otto *et al.* (2001)	17 OECD countries, 1960.I–2000.IV (and two subsample periods)	Bilateral correlation of GDP growth	Correlation explained by (instrumented) trade intensity, financial integration (FDI and long interest and return spreads), degree of policy interdependence (volatility of short-term interest rate and exchange rate) and similarity of economic structure	Trade intensity (+), FDI (+), spreads (−), volatility of interest rates and exchange rates (−) are significant, but the latter only in isolation. Also industry structure difference (−) is significant. However, in a more general model trade intensity and industry structure are no longer significant. Instead good accounting practices, common take-up of new technology and a common legal system (language) are significant

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Table 4. *Continued.*

Study	Countries and time period	Business cycle synchronization measure	Model	Conclusion
Clark and van Wincoop (2001)	Nine US census regions, regions in four big EU countries and 14 EU countries, various samples	Bilateral correlation of employment and GDP using percent changes and HP filter	Correlation explained by (instrumented) trade intensity (instruments: distance, adjacency, common legal system, sum of CBI) and monetary and fiscal policy	Cycles in US and in EU regions substantially more synchronized than in EU countries. Trade has significant positive influence but monetary and fiscal policy does not affect synchronization
Kalemli-Ozcan *et al.* (2001)	US states, 11 OECD countries, various sample periods	Asymmetry index	Regression to examine relationship between asymmetry and specialization	More specialized production structure is related to less-symmetric fluctuations
Calderon *et al.* (2007)	147 countries for 1960–1999 (33,676 country pairs)	Bilateral correlation of cyclical component of output, determined using various detrending techniques (quadratic trend, first differences, HP and BP)	Instrumented trade intensity and production similarity are regressed on correlation	Bilateral trade intensity has positive effect on business cycle synchronization but less in LDCs; countries with more asymmetric structures of production exhibit a smaller business cycle correlation; the impact of trade intensity on cycle correlation is smaller the greater the production structure asymmetries between the countries

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Gruben *et al.* (2002)	Same countries as Fankel–Rose, 1965–1998; four periods	Same as Frankel-Rose and BP filter	Inter- and intra-industry trade intensity is regressed on correlation; gravity variables in OLS	Results for inter-industry trade (specialization) are very mixed; effect of intra-industry trade is substantially less than found by Frankel–Rose, but significant
Kose and Yi (2002)	21 countries, 1970–2000 (annual)	Bilateral correlation of HP and (log) first differenced GDP	Instrumented trade intensity is regressed on correlation. Instruments: log of distance, adjacency dummy, common language dummy	Larger effects than those found by Frankel and Rose (1998)
De Haan *et al.* (2002)	18 OECD countries, 1961–1997, four periods	Bilateral correlation of HP filtered IP	Correlation explained by trade intensity and exchange rate volatility	Trade intensity and exchange rate volatility have positive impact on synchronization

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Table 4. *Continued.*

Study	Countries and time period	Business cycle synchronization measure	Model	Conclusion
Bordo and Hebling (2003)	59 countries, 1880–2001, and 120 countries, 1952–2001	Bilateral correlation of GDP growth	Correlation explained by instrumented trade intensity (same instruments as Frankel–Rose), relative number of years during which capital restrictions were in place and relative number of years during which exchange rate was pegged	Strong effects of trade intensity; capital restrictions variable not significant and exchange rate variable is not robust
Kose *et al.* (2003c)	76 countries, 1960–1999 (10-year periods)	Correlation of each country's output or consumption growth with corresponding world aggregates	Correlation explained by instrumented trade openness, trade linkages with G7, capital account restrictions, financial openness, relative income, terms-of-trade volatility and fiscal impulse	Trade openness insignificant, but trade with G7 (+), capital account restrictions (−) and terms of trade volatility (−) are significant in model for output correlations

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Imbs (2004)	24 countries, 1980/90s	Bilateral correlation of BP filtered quarterly GDP	System of three equations estimated by TSLS; correlation depends on trade intensity, specialization and capital account restrictions or foreign asset positions	Financial integration affects specialization, but also positively and directly affects synchronization (but not for the index based on restrictions). Specialization and trade intensity are significant
Garnier (2004)	16 OECD countries, 1967.01–2001.01	Relationship between (intra)-industry trade and synchronization (filtered IP)	Spectral analysis and model of Frankel–Rose	Link between intra-industry trade and synchronization is sometimes quite weak
Bergman (2004)	14 EU and five non-EU countries, 1961Q1–2001Q4	Correlation of BP filtered IP	Pairwise correlation explained by various variables (instrumented trade intensity and policy variables)	Trade intensity, standard deviation of money market rates and exchange rate volatility are positively related to synchronization. There is also a trade-off between synchronization and the relative magnitude of business cycles in EU member states

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Table 4. *Continued.*

Study	Countries and time period	Business cycle synchronization measure	Model	Conclusion
Baxter and Kouparitsas (2005)	>100 countries; 1970–1995	Correlation of BP (6, 32) filtered quarterly real GDP	Fixed effects model with various explanatory variables, using EBA	Variables that are robust include trade intensity and the distance between the two countries; variables that are not robust include measures of industrial similarity; currency union; total trade undertaken by the two countries; measures of similarity in export and import baskets; and measures of factor intensity
Camacho *et al.* (2006)	Most current and future EU countries and Canada, Japan, Norway and US, 1965–2003	Comprehensive measure that consists of average of three measures of synchronization	Pairwise difference in business cycle explained by differences in specialization (share of industry and agriculture in total production), average saving ratio, labour productivity, instrumented trade intensity and policy variables	Specialization, saving, labour productivity, trade intensity and fiscal policy significant, but monetary policy variables not related to cyclical differences

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Babetskii (2005)	10 accession countries, 1990Q1–2002Q2	Real GDP	Time-varying demand and supply shock convergence (Kalman filters applied to Blanchard–Quah type of VAR) are explained by trade intensity	More trade intensity is associated with more demand shock similarity; the link with supply shocks is ambiguous. Exchange rate volatility is negatively (not) related to demand (supply) shock convergence
Inklaar *et al.* (2005)	21 OECD countries, 1970–2003	Correlation of BP filtered real GDP (quarterly) and IP (monthly)	Pairwise correlation explained by various variables in structural model; selection of variables determined by EBA	Trade intensity is found to affect business cycle synchronization, but the effect is much smaller than reported by Frankel and Rose (1998). Also the similarity of trade flows (i.e. the composition of trade), similarity of monetary and fiscal policies and common currency have a positive impact on business cycle synchronization. The impact of these factors on business cycle synchronization is about as large as the impact of trade intensity

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Table 4. *Continued.*

Study	Countries and time period	Business cycle synchronization measure	Model	Conclusion
Darvas *et al.* (2005)	21 OECD countries, 1964–2003	Correlation of first difference, HP and BP filtered GDP and unemployment (annual)	Pairwise correlation explained by fiscal policy variables (and trade)	Difference in (cyclically adjusted) budgetary positions between countries affects correlation
Imbs (2006)	41 countries	GDP and consumption correlations	System of four equations; correlation depends on trade intensity, specialization and capital account restrictions or foreign asset positions	Financial integration affects trade and specialization, but also positively and directly affects synchronization. Specialization and trade intensity are significant

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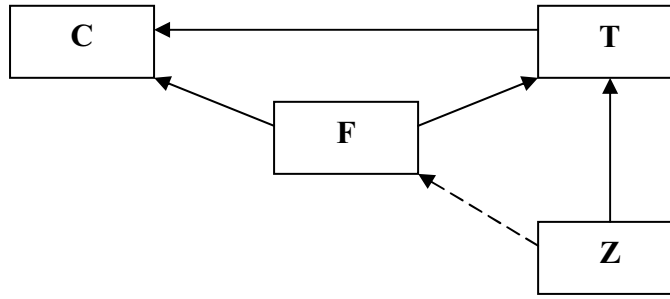

Figure 1. The Relationship between Business Cycle Correlation, Trade, Gravity Variables and Other Variables.

by Frankel and Rose (1998). Other factors in their model have a similar impact on business cycle synchronization as trade intensity.

Economic integration may lead not only to more trade, but also to better income insurance through greater capital market integration, which in turn will induce higher *specialization* in production rendering fluctuations less symmetric across countries (Kalemli-Ozcan *et al*., 2001, 2003). As pointed out by Imbs (2004), in the case of specialization two economies producing the same types of goods will be subject to similar stochastic developments in the case of sector-specific shocks. Countries with similar production patterns will also react similarly to aggregate shocks. Imbs (2004) finds that similarities in economic structure result in correlated business cycles. Also Calderón *et al.* (2007) report that symmetric production structures lead to more synchronization. However, Baxter and Kouparitsas (2005) report that sectoral similarity is not robustly related to cycle co-movement. Also Otto *et al.* (2001) do not confirm the results of Imbs. Likewise, Gruben *et al.* (2002) find that increases in inter-industry trade – which may also indicate specialization – turn out not to have a significant effect on business cycle synchronicity. Inklaar *et al*. (2007) use industrial similarity, export similarity and the share of intra-industry trade as alternative indicators for specialization and find them to be significantly related to business cycle synchronization.

There is also little agreement whether *monetary integration* will lead to more similar business cycles. An argument can be made in both directions. Monetary integration may lead to more similarity, since there will be less asymmetry in monetary policy. Also indirectly monetary integration may lead to more synchronization via the impact of exchange rate stability on trade relations. Rose (2000) reports extremely large positive effects of common currencies on the volume of trade. The most dramatic, and widely cited, of his findings is that 'two countries sharing the same currency trade three times as much as they would with different currencies' (Rose, 2000, p. 7). Glick and Rose (2002) use a much larger data set and find that a common currency doubles trade. Other studies by Mélitz (2001) and Persson (2001) arrive at considerably lower effects, with trade expanding by 40%–50%. Frankel and Rose (2002) combine estimates of the effects of a common currency on trade and

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the follow-on effects of higher trade on GDP, to derive estimates of the effects of common currencies on GDP. They find that membership in a typical currency union raises the ratio of trade to GDP by an estimated 10 to 26 percentage points. But joining a currency union with particularly important trading partners (e.g. large and close neighbours) can have a larger impact.[24]

Monetary integration may, however, also lead to less business cycle synchronization. If exchange rate changes are considered as a shock absorbing mechanism, a common currency may lead to less synchronization if the countries in the monetary union face asymmetric shocks. In face of an external shock, a fixed exchange rate regime requires the central bank to follow a policy so as to maintain the peg, forcing all the adjustment to take place in the real economy rather than the exchange rate.

According to Artis and Zhang (1997), business cycles in Europe were more similar after the start of the ERM than before, which they interpret as evidence that monetary integration will enhance business cycle synchronization. Other studies report less support for the view that exchange rate stability in Europe led to more synchronization of business cycles.[25] For instance, Baxter and Stockman (1989) report no effect of exchange rate stability on business cycle synchronization. Bordo and Helbling (2003) find that their exchange rate policy variable (relative number of years during which the exchange rate between two countries was pegged) is not robustly related to co-movement of GDP growth.

Bergman (2004) reports that exchange rate volatility is positively related to synchronization of business cycles. The fact that more exchange rate volatility leads to more business cycle synchronization may be interpreted as support for the view that exchange rates may function as an adjustment tool. In contrast, Otto *et al*. (2001) and Inklaar *et al.* (2007) find that exchange rate volatility leads to lower correlation of output.

Also *financial integration* has been argued to affect business cycle synchronization. However, the impact of financial integration on synchronization is also not unambiguous. Financial linkages could result in a higher degree of business cycle synchronization by generating large demand side effects. For instance, a decline in a particular stock market could induce a simultaneous decline in demand in other countries if investors in these countries have invested in this particular stock market. Furthermore, contagion effects that are transmitted through financial linkages could also result in heightened cross-country spillover effects of macroeconomic fluctuations. However, international financial linkages could also stimulate specialization of production through the reallocation of capital in a manner consistent with countries' comparative advantages. Specialization of production, which could result in more exposure to industry- or country-specific shocks, would typically lead to less synchronization of business cycles. If international financial markets are used to diversify consumption risk financial integration should result in stronger co-movement of consumption across countries. Using a variety of alternative measures of financial integration, Imbs (2004) reports evidence suggesting that economic regions with strong financial links are significantly more synchronized. Imbs concludes that the positive direct effect of finance on synchronization dominates the negative, indirect one, working via higher specialization. His results are not

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confirmed by Baxter and Kouparitsas (2005) and Inklaar *et al.* (2007). Jansen and Stokman (2004) find that capital flows have played a role in synchronizing business cycles in recent years.

Some studies summarized in Table 4 have examined whether *fiscal policy* matters when it comes to business cycle synchronization (see, for instance, Clark and van Wincoop, 2001; Darvas *et al.*, 2005; Camacho *et al.*, 2006; Inklaar *et al.*, 2007). It might be argued that fiscal convergence raises business cycle synchronization by eliminating idiosyncratic fiscal shocks. The results of these studies yield conflicting conclusions: whereas Inklaar *et al*. (2007) and Darvas *et al*. (2005) find support for this view, others do not.

Most studies summarized in Table 4 examine whether business cycle correlation is determined by the factors outlined above. Babetskii (2005) follows a somewhat different approach by examining whether supply and demand shock convergence – where shocks are identified on the basis of the Blanchard–Quah methodology – are related to trade intensity. Babetskii finds that an increase in trade intensity leads to higher symmetry of demand shocks.

5. Concluding Comments

Our survey of business cycle synchronization in the current members of the European monetary union has made it clear that although the results of some studies suggest that after the beginning of the 1990s business cycles in the euro area have become more similar, the business cycles of many euro countries are still substantially out of sync. Furthermore, there is not a monotone movement towards the emergence of a 'European' business cycle. A common monetary policy will be easier to implement if the member countries' business cycles are aligned. If various countries in the monetary union are not at the same points in the business cycle, decision making on the appropriate monetary policy stance becomes a difficult task. So the survey suggests that Trichet was wrong when he claimed that 'we can be reasonably confident in the increasing integration of European countries, and in the fact that economic developments are becoming more and more correlated in the area. This has been highlighted, in the academic field, by several empirical investigations . . . [that] found evidence that business cycles are becoming more synchronous across Europe' (Trichet, 2001, pp. 5–6).

Of course, the future may be different than the past. Indeed, our survey shows that trade intensity is found to lead to more synchronization. The trade relationships of the members of the European currency union are intense causing further synchronization. However, the point estimates vary widely. Furthermore, the survey also showed that trade intensity only explains a fraction of business cycle correlations. The evidence for other factors affecting business cycle synchronization is quite mixed. Although there are papers (like Inklaar *et al.*, 2007) suggesting that the well-known critique on EMU that a common monetary policy may not be equally good for all countries in the union ('one size does not fit all') has lost force due to the economic and monetary integration process, others come to less-optimistic conclusions.

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Notes

1. However, as pointed out by Kalemli-Ozcan *et al.* (2001), insurance possibilities against idiosyncratic shocks could increase aggregate utility and the more so with asynchronous business cycles.
2. However, Clark and van Wincoop (2001) argue that specialization is roughly the same in the US census regions and EU nations and that there is a trend in the United States towards decreased specialization.
3. See Fidrmuc and Korhonen (2004b) for a survey on business cycle synchronization in the future member countries of the euro area.
4. However, in the literature on 'shock accounting' (see Section 2.4), monthly or quarterly data are often not available due to the use of industry or regional data.
5. The co-movement of GDP and GNP in a sample of countries can be considered as an indication of insurance against idiosyncratic GDP shocks. If income smoothing is perfect, idiosyncratic GNP does not co-move with idiosyncratic GDP at all; see Kalemli-Ozcan *et al*. (2004) for a further discussion.
6. Still, movements in the manufacturing sector are likely to have a more than proportionate impact on GDP since sectors such as transport and trade earn their revenues from transporting and trading manufactured goods. The correlation between manufacturing output growth and GDP growth from the Groningen Growth and Development Center (GGDC) 60-industry database is 0.88 for the euro zone over the period 1979–2001.
7. Using annual data on value added growth from the GGDC 60-industry database we find that the standard deviation of annual output growth in the manufacturing sector is more than twice as large as the standard deviation of GDP growth for the euro zone over the period 1979–2001.
8. A fundamental criticism to filtering was raised by Benati (2001), who argues that the use of filters is not problematic if the economy is characterized by deterministic trends. However, if the trends are stochastic, economic fluctuations at business cycle frequencies will also contain fluctuations in those stochastic trends. Even more damaging, monetary and fiscal policy aimed at stabilizing the economy may reduce business cycle fluctuations. These considerations are important to discern what the cyclical component of a series actually includes. However, when central banks decide on monetary policy, they are faced by the same identification problem. So if two countries are estimated to be in different business cycle phases, that would still be problematic for the European Central Bank even if these cyclical signals are 'contaminated' by possible changes in the underlying stochastic trends.
9. If the original series is expressed in natural logs, first differencing yields growth rates. Various studies employ growth rates (e.g. Frankel and Rose, 1998; Otto *et al.*, 2001; Kose *et al.*, 2003c).
10. An alternative method has been proposed by Den Haan (2000), in which co-movement between series is analysed using the forecast errors from a VAR that includes (at least) the two series of interest. This way, the dynamics and possible cointegration of the series can be taken into account. So far, only Camacho

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et al. (2006) have used this method. Canova (1998) and Massmann and Mitchell (2004) discuss a number of parametric methods such as the Beveridge–Nelson decomposition and unobserved component models. However, these methods are hardly used in the literature on business cycle synchronization in the euro area.

11. The HP filter has often been criticized for inducing spurious cycles (Cogley and Nason, 1995). Pedersen (2001) discusses these criticisms and points out that even an ideal filter would suffer from the phenomena the critics describe.
12. A different approach to extracting cyclical information is by estimating Markov switching models. These models, introduced by Hamilton (1989), allow the economy to switch discretely between expansions and recessions. The probability of being in a recession can then be compared across countries to gauge the commonality of business cycles across countries. This methodology is relatively less established for comparing business cycles across countries, although Artis *et al.* (2004) implement this method.
13. Belo (2001) also applies Spearman rank correlations. Camacho *et al.* (2006) use the simple average of various measures (including those of Croux *et al.* (2001), Harding and Pagan (2002) and Den Haan (2000)), yielding what they call a comprehensive measure of distance.
14. Hughes Hallett and Richter (2004) discuss a measure of business cycle coherence that is similar in spirit to the dynamic correlation of Croux *et al.* (2001). The main innovation is that Hughes Hallett and Richter allow for time variation in their estimated spectra. This not only allows them to judge how strongly two countries co-move at a certain frequency, but also how this degree of co-movement changes over time. The drawback is that it is as yet hard to gauge how statistically important some of these changes are.
15. The authors also consider a constant relative risk aversion functional form for utility. The resulting expression for risk-sharing gains is more complicated, but the intuition is similar.
16. Using a different method based on classical business cycles Garnier (2003) reports similar results to Artis and Zhang.
17. Other possible sources of differences include the period covered, the coverage of the economy and the exact method used for the variance decomposition. It is beyond the scope of this study to go into these possibilities.
18. Even when common shocks (such as oil or productivity shocks) were to be relatively unimportant, country-specific shocks could spill over to other countries through trade or financial links. Stock and Watson (2003) allow for this by assuming that a country-specific shock has an immediate effect on the country in question, but can spill over to other countries in the next quarters. Using this identification scheme, Stock and Watson (2003) find that these spill-over effects are generally small, between 5% and 15% of total variance, with most of the fluctuations stemming from either country-specific or common shocks.
19. We refer to Kose *et al.* (2003b) for a discussion of other studies on co-movement over time.
20. Only in that case are they included in Table 2.
21. However, as pointed out by Frankel (2004), a positive shock at one point in the chain of value-added in one country will tend to have positive spill-over effects at the other points along the chain in other countries. Thus trade in inputs and intermediate products gives rise to positive correlations but may be recorded as inter-industry trade.

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22. An exception is Kose and Yi (2002) who find larger effects than Frankel and Rose; Garnier (2004) finds weak effects.
23. As pointed out by Otto *et al.* (2001), the first measure suffers from obscuring one-way interdependence, and the second suffers from not measuring the relative importance of trade in the total economy.
24. Some studies explicitly focus on the trade-enhancing effects of the introduction of the euro. For instance, Micco *et al.* (2003) find that the effect of EMU on bilateral trade between member countries ranges between 4% and 10%, when compared to trade between all other pairs of countries, and between 8% and 16%, when compared to trade among non-EMU countries. Bun and Klaassen (2002), using a dynamic panel model for annual bilateral exports, find that the euro has significantly increased trade, with an effect of 4% in the first year and cumulating to around 40% in the long run. See Rose (2004) for a summary of other studies on the effects of the euro on trade.
25. Furthermore, possible evidence that since the run-up to EMU there is more business cycle synchronization – as, for instance, reported by Angeloni and Dedola (1999) – may not reflect the effect of monetary integration. As pointed out by Darvas and Szapáry (2004), also the non-EMU European countries and even the United States and, to some extent, Japan and Russia have shown greater co-movement with the business cycle in the euro area.

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