What Drives Business Cycle Synchronization in OECD Countries?

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Abstract

We analyse factors driving business cycle synchronization in the OECD area using a two-step approach. We first identify variables that are robustly related to business cycle synchronization. These variables are then included in a structural model to examine their economic importance and potential endogeneity. We conclude that trade intensity is robustly related to business cycle synchronization, but has a smaller impact on synchronization than usually reported. We also find that specialization and similar monetary and fiscal policies have a robust and positive impact on business cycle synchronization. Their impact on synchronization is about as large as that of trade intensity.

Key words: business cycles, synchronization of business cycles,

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1. Introduction

Business cycles may differ across nations for various reasons (Wynne and Koo, 2000). Countries may experience different shocks or respond differently to common shocks due to, for instance, differences in the reaction of policy-makers to a common shock or differences in the national composition of output.

In various recent papers many factors have been put forward that may affect business cycle co-movement, ranging from trade relations (Frankel and Rose, 1998), specialization (Imbs, 2004), exchange rate stability (Fatás, 1997), financial integration (Imbs, 2004) and similar monetary and fiscal policies (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 co-movement. The difficulty is that there are many potential candidate explanations." (Baxter and Kouparitsas 2005, p. 114). Baxter and Kouparitsas (2005) therefore apply the Extreme Bounds Analysis (EBA) of Leamer (1983) to assess to which extent variables are robustly related to business cycle synchronization. They conclude that bilateral trade is robust but various other variables that previous studies found to be important determinants of business cycle co-movement – including specialization and currency unions – are not robustly related to synchronization.

This paper extends the analysis of Baxter and Kouparitsas in various ways. First, we focus on OECD countries only, as recent evidence suggests that the determinants of business cycle synchronization differ across country groups. For instance, Calderón *et al.* (2002) find that bilateral trade intensity has a positive effect on business cycle co-movement in industrial countries, but has less effect on synchronization of business cycles in less developed economies. Second, we consider a much longer list of factors that may influence business cycle synchronization. There is a trade-off between the number of countries and the number of variables that can be taken up in the analysis, as data on various potential determinants of business cycle synchronization is not available for many countries. Third, we apply Sala-i-Martin's (1997) variant of the EBA, as the EBA as proposed by Leamer (1983) and applied by Baxter and Kouparitsas (2005) is extremely restrictive. Finally, as the EBA does not provide any insights as to economic significance and neglects endogeneity problems, we include the variables that the EBA

analysis singles out as being robustly related to business cycle synchronization into a structural model to test for their economic relevance and potential endogeneity.

Similar to Baxter and Kouparitsas (2005), we conclude that trade intensity is robustly related to business cycle synchronization, but the effect is much smaller than reported by Frankel and Rose (1998). However, we also find that specialization has a robust and strong impact on business cycle synchronization. In addition, similar monetary and fiscal policies have a robust and positive impact on business cycle co-movement. The impact of these factors on business cycle synchronization is about as large as the impact of trade intensity.

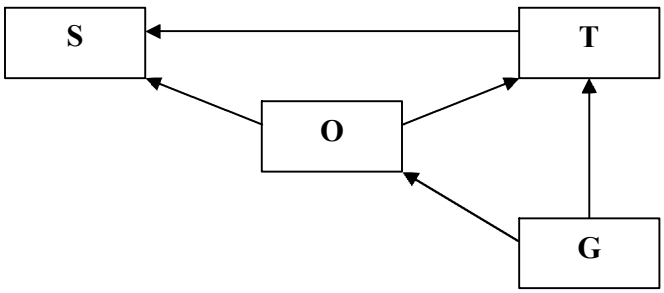
The remainder of the paper is organized as follows. Section 2 outlines our methodology. Section 3 reviews the extensive literature on the determinants of business cycle synchronization and describes the data used. Sections 4 and 5 present the estimation results of the Extreme Bounds Analysis and our structural models. The final section offers some concluding comments.

2. Methodology

We apply a two-step approach. In the first step we follow Baxter and Kouparitsas (2005) and examine which variables are robustly related to business cycle synchronization. As will be explained below, we employ the EBA as suggested by Sala-i-Martin (1997) as this is a less restrictive approach than the EBA suggested by Leamer (1983). In the second step, we include the robust variables in a structural model for two reasons. First, we are not only interested in robustness of a variable, but also in its economic importance. By its very construction, the EBA is not well suited to provide insights on this issue. Second, we want to in take into account the possible endogeneity of various determinants of business cycle synchronization. A serious problem with the EBA – no matter which version is being used – is that endogeneity issues are not taken into account, while many variables that may affect business cycle synchronization are likely to be endogenous. We may illustrate this for trade intensity. Since trade intensity is endogenous an OLS regression of bilateral economic activity correlation on trade intensity is inappropriate. For example, countries that follow a similar monetary policy are likely to stabilize their economies in similar ways, but also to stimulate trade since the similar monetary policy will generally lead to

more stable exchange rates. 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 pointed out by Gruben *et al.* (2002), this is not appropriate if the gravity variables (*G*) not only affect bilateral trade intensity (*T*) but are also possibly related to some other variables (*O*) that affect business cycle synchronization (*S*), as illustrated in Figure 1. For instance, neighbouring countries are more likely to coordinate their monetary policies, or even to have a common currency, than countries that are further 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 (De Grauwe and Mongelli, 2005).

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



The regression model that corresponds to the figure above is:

$$\begin{aligned} S &= \beta_1 T + \beta_2 O + \varepsilon \\ T &= c_1 G + c_2 O + \mu \\ O &= c_3 G + \omega \end{aligned} \tag{1}$$

The model shows that the business cycle correlation depends on bilateral trade as well as other policy-related and structural variables. Some of these variables may be influenced by the exogenous gravity variables, while, in turn, they may affect trade intensity.

Many variables have been suggested that may be related to business cycle co-movement. To identify the other variables to be included in our model, we follow Baxter

and Kouparitsas (2005) and apply the Extreme Bounds Analysis (EBA) to examine which variables are robustly related to business cycle synchronization in the OECD area. However, we use a much longer list of potential explanatory variables than examined by Baxter and Kouparitsas. Furthermore, we employ the EBA as suggested by Sala-i-Martin (1997) since Leamer's (1983) EBA is extremely restrictive.

The EBA can be exemplified as follows. Equations of the following general form are estimated:

$$Y = \alpha M + \beta F + \gamma Z + u \tag{2}$$

where Y is the dependent variable (in our case: business cycle synchronization); M is a vector of 'standard' explanatory variables (that may be empty); F is the variable of interest; Z is a vector of up to three (here we follow Levine and Renelt, 1992) possible additional explanatory variables, that – according to the literature – may be related to the dependent variable; and u is an error term. In our analysis only trade intensity is included in the M vector as this variable has been found to be related to business cycle synchronization in many studies.[1] The extreme bounds test for variable F says that if the lower extreme bound for β – i.e. the lowest value for β minus two standard deviations – is negative, while the upper extreme bound for β – i.e. the highest value for β plus two standard deviations – is positive, the variable F is not robustly related to Y.

Sala-i-Martin (1997) rightly argues that the test applied in the EBA is too strong for any variable to really pass it. If the distribution of the parameter of interest has some positive and some negative support, then one is bound to find one regression for which the estimated coefficient changes sign if enough regressions are run. Instead of analysing the extreme bounds of the estimates of the coefficient of a particular variable, Sala-i-Martin (1997) suggests to analyse the entire distribution of the estimates of the parameter of interest. Broadly speaking, if the averaged 90 per cent confidence interval of a regression coefficient does not include zero, Sala-i-Martin classifies the corresponding regressor as a variable that is strongly correlated with Y.

[1] Here we deviate from Baxter and Kouparitsas (2005) who either have no variables in the M vector, or only gravity variables. As Figure 1 shows, gravity variables do not have a direct impact on business cycle co-movement and are therefore not included in the EBA analysis. Gravity variables are, of course, taken up in the structural model.

Following Sturm and De Haan (2005), we report the percentage of the regressions in which the coefficient of the variable *F* is significantly different from zero at the 5 percent level as well as the outcomes of the cumulative distribution function (CDF) test. The CDF test is based on the fraction of the cumulative distribution function lying on each side of zero. CDF(0) indicates the larger of the areas under the density function either above or below zero; in other words, regardless of whether this is CDF(0) or 1-CDF(0). So CDF(0) will always be a number between 0.5 and 1.0. In our analysis, a variable is considered to be robust if the CDF(0) test statistic > 0.95 and if the variable has a significant coefficient (at the 5% significance level) in 90% of all regressions ran. Sala-i-Martin considers a variable to be robust if the CDF(0) > 0.90, but we consider this to be too low given the one-sidedness of the test.[2]

In the next step in our analysis we estimate model (1) to examine the economic importance of those variables that are robustly related to business cycle synchronization, and to take care of endogeneity problems. The appropriate method to estimate the model depends on the correlation between the error terms of the three equations. Given the exogeneity of gravity variables, it is crucial whether μ and ε are correlated. If so, using OLS for the first equation results in inconsistent estimates and instrumental variables estimation should be preferred. If not, OLS estimates are consistent and at least as efficient. We use the Hausman (1978) test to resolve which estimation method should be chosen.[3]

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[2] Recently, Sala-i-Martin *et al.* (2004) proposed a so-called Bayesian Averaging of Classical Estimates (BACE) approach to check the robustness of different explanatory variables in growth regressions. This approach builds upon the approach as suggested by Sala-i-Martin (1997) in the sense that different specifications are estimated (by OLS) to check the sensitivity of the coefficient estimate of the variable of interest. The major innovation of BACE as compared to the Sala-i-Martin's approach is that there is no set of fixed variables included and the number of explanatory variables in the specifications is flexible. The biggest disadvantages of the BACE approach are the need of having a balanced data set, i.e. an equal number of observations for all regressions (due to the chosen weighting scheme), the restriction of limiting the list of potential variables to be less than the number of observations and the computational burden.

[3] Imbs (2004) estimates a system of equations. Apart from an equation explaining the degree of business cycle synchronization, extra equations are introduced to explain the degree of trade, industrial specialization and financial integration. The main advantage of this approach is that the total effects of certain variables on synchronization can be divided up into more detailed channels, such as the effect of intra-industry trade versus inter-industry trade. The other advantage is that indirect effects can be identified, such as increasing specialization leading to a lower trade intensity and hence, lower business cycle synchronization. Drawbacks of this modelling approach are an increased risk of misspecification and less scope for examining the robustness of the effects. For example, our results suggest a more important role for policy variables and Gruben *et al.* (2002) argue that gravity variables affect not just trade but other

3. Data

3.1 Dependent variable

In our analysis we use two measures of economic activity, namely (quarterly) GDP and the (monthly) index of industrial production (IIP). The latter is attractive as it is available for a long period of time and (for most countries) at a monthly frequency. However, the coverage of the economy is limited to the manufacturing sector. The main reason for using GDP is that it is the most comprehensive measure of economic activity even though it is available at a quarterly frequency (at most) and time series are generally shorter than for industrial production. These trade-offs argue for using both measures.

Most previous papers on the determinants of business cycle synchronization (including Frankel and Rose, 1998) use the Hodrick-Prescott (HP) filter to detrend the original series. The HP filter can be interpreted as a high-pass filter that removes fluctuations with a frequency of more than 32 quarters and puts those fluctuations in the trend. Baxter and King (1999) argue that the combination of such a high-pass filter and a low-pass filter (which removes high frequencies) 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 frequencies beyond the predetermined cut-off points. Since most studies find qualitatively similar results for different filtering methods, we restrict ourselves to the Baxter-King filter.[4]

Following most previous studies, our measure of business cycle synchronization is the correlation coefficient of the detrended measures of economic activity (GDP or IIP). Data is available for the period 1970 to 2003 for 21 OECD countries. Most countries report industrial production at a monthly frequency back to at least 1970.[5] Australia, New Zealand, and Switzerland only report quarterly industrial production, so their correlation vis-à-vis all countries is based on quarterly data. As the data do not suggest some obvious

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determinants of sycnhronization too. On balance, we feel that agreement on a robust set of net effects of variables on synchronization should be a higher priority than identifying some of the more subtle contributions and indirect effects.

[4] Artis and Zhang (1997) and Calderon *et al.* (2002) conclude that the choice of filtering method is not crucial for their conclusions. Likewise, Massmann and Mitchell (2004), who consider the largest number of business cycle measures, report substantive similarities across alternative measures of the business cycle.

[5] Exceptions are Denmark (1974) and Ireland (1975).

way to split our sample period in particular sub-periods, so we have split our sample into three periods of equal length (i.e. 11 years: 1970-1981, 1981-1992 and 1992-2003), leaving us with a maximum of 630 observations (0.5*(3*21*20)).

In our regressions we use Fisher's *z*-transformations of the correlation coefficients as dependent variable. The transformed correlation coefficients are calculated as $C_t = 1/2 \ln((1+C)/(1-C))$, where C is the pair-wise correlation coefficient for each country couple. Since a (Pearson's) correlation coefficient is bounded at –1 and 1, the error terms in a regression model of the determinants of business cycle synchronization are unlikely to be normally distributed if the untransformed correlation coefficients are used. This complicates reliable inference. The transformed correlations do not suffer from this problem, since the transformation ensures that they are normally distributed (see David, 1949).

3.2 Explanatory variables

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. First, 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 normally cause changes in demand for foreign goods. Second, 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 reduces business cycle correlations. However, if trade is dominated by intra-industry trade industry-specific shocks may lead to more symmetric business cycles.

In previous studies on the determinants of business cycle synchronization various indicators of trade intensity have been used.[6] For instance, Frankel and Rose (1998) employ total trade (i.e. exports *X* and imports *M*) between two countries (*i,j*) scaled by total GDP (*Y*) or total trade.[7] Instead of using the sum of trade or GDP of the two

[6] The source for all our data on trade between countries is the new database by Feenstra *et al.* (2005).

[7] As pointed out by Otto *et al.* (2001), the first measure suffers from obscuring one-way interdependence, the second suffers from not measuring the relative importance of trade in the total economy. Note that when using GDP as a scaling factor, we convert GDP at current national prices to U.S. dollars using purchasing

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. An alternative indicator is suggested by Otto *et al.* (2001), who take the maximum of:

$$\sum_t \frac{X_{ijt} + M_{ijt}}{Y_{it}}, \sum_t \frac{X_{ijt} + M_{ijt}}{Y_{jt}} \tag{3}$$

arguing that what matters is whether or not at least one country is exposed to the other. In this measure also trade can be used for normalization. We have calculated these six trade intensity measures. As they are (imperfect) proxies for trade intensity and it is not obvious which one has to be preferred, we combine these measures into a single one using principal component analysis. Our trade intensity measure is therefore based on the common variation in the six individual trade intensity measures. This combined measure is based on the largest eigenvalue and accounts for 64 percent of the total variance.[8]

As pointed out by Imbs (2004), in case of *specialization* two economies producing the same types of goods will be subject to similar stochastic developments in 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. We use three indicators of specialization, namely measures based on industrial specialization, export similarity and the share of intra-industry trade. Our first measure (*industrial specialization*) is suggested by Imbs (2004):

$$\frac{1}{T}\sum_t \sum_{n=1}^{N} | s_{in} - s_{jn} | \tag{4}$$

where $s_{n,i}$ denotes the GDP share of industry n in country i. We have constructed three measures based on industry specialization. Apart from the index suggested by Imbs, we also use the squared differences – instead of the absolute difference of output shares as in equation (4) – as well as the correlation between the shares. Following Baxter and Kouparitsas (2005), we recast these specialization measures as similarity measures by subtracting the specialization measure from one. We have constructed these three

power parities from the OECD (2002) to take price differences between countries into account. All trade data are already converted using current exchange rates.

[8] The selection of one principal component is based on both the latent root criterion and the scree plot criterion. Furthermore, a measure based on the largest two eigenvalues has a correlation of 0.99 with the measure we use.

similarity indicators using the 60-industry database of the Groningen Growth and Development Centre (GGDC, 2004), which has data on 56 industries covering the entire economy at the 2-digit and sometimes 3-digit level of industry detail (according to the ISIC revision 3 classification).[9] As might be expected, the three measures of output similarity are highly correlated (between 0.87 and 0.96), so following similar reasoning and criteria as for the trade intensity measures, we use the first principal component in the regressions as our first specialization indicator.[10]

Furthermore, we follow Baxter and Kouparitsas (2005) and also consider the *similarity of exports* as our second main indicator for specialization. As these authors point out, countries with similar baskets of traded goods will be affected similarly in the event of sector-specific shocks hitting their export sectors. Using the trade data by commodity (at the 4-digit SITC revision level of detail) of Feenstra *et al.* (2005), export shares are calculated for each country. The same three similarity measures as for output shares are calculated for export shares. The correlation between these export similarity measures varies between 0.54 and 0.84. The first principal component accounts for 78% of the variance and is justified by the selection criteria and will therefore be used as our second specialization indicator.

As a final indicator of specialization we use the *intra-industry share*, *IIT*. The variable *IIT* measures the share of bilateral trade that can be attributed to intra-industry trade. As pointed out before, if trade is primarily of an intra-industry nature industry-specific shocks may lead to more symmetric business cycles. This index is defined as follows:

$$IIT_{ij} = 1 - \frac{\left|\sum_k \left(E_{ij}^k - E_{ji}^k\right)\right|}{\sum_k \left(E_{ij}^k + E_{ji}^k\right)} \tag{5}$$

The share of intra-industry trade is calculated as one minus the absolute difference between exports of industry k from country i to country j and exports from country j to country i, divided by total bilateral trade (see Grubel and Loyd, 1971). We calculate these indices using the same source as for all our trade data, namely the new database by

[9] See www.ggdc.net for further information on this database.
[10] The first principal component accounts for 94% of the variance.

Feenstra *et al*. (2005). The trade data by commodity are allocated to industries using a detailed concordance.[11]

Also *financial integration* has been argued to affect business cycle synchronization (see Imbs, 2004). 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. Furthermore, contagion effects that are transmitted through financial linkages could also result in heightened cross-country spill-over 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.

We consider two indicators of financial integration: a dummy for capital account restrictions, and the (absolute) difference between the net foreign asset (NFA) positions of a country couple.[12] The capital account variable is based on information provided by Lane and Milesi-Ferretti (2001) and updated using the IMF publication *Exchange arrangements and exchange* restrictions, which gives an overview of capital and current account restrictions for each country. Our indicator equals one if at least one of the two countries had capital account restrictions during the period considered. For the NFA data, we again rely on Lane and Milesi-Ferretti (2001). They present two estimates, one based on cumulated current account data and one based on cumulated capital accounts. As the capital account-based measure is available for fewer years in most countries, we rely on the cumulated current accounts.

Some studies have examined whether *fiscal policy* matters when it comes to business cycle synchronization (see, for instance, Clark and van Wincoop, 2001, and

[11] Industries are defined at the 4-digit level of the international standard classification (ISIC rev. 2). See http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeConcordances.html.

[12] These measures are also employed by Imbs (2004).

Camacho *et al.*, 2005). The results of these studies yield conflicting conclusions. Our indicator of the similarity of fiscal policy is the correlation of cyclically adjusted government budget deficits as provided by the OECD.

There is also little agreement whether a *common currency* will lead to more similar business cycles. An argument can be made in both directions. A common currency may lead to less asymmetry in monetary policy. Also via the impact of exchange rate stability on trade relations a common currency may affect business cycle synchronization. Rose (2000) reports extremely large positive effects of common currencies on the volume of trade, but other studies arrive at considerably lower effects. A common currency may, however, also lead to less business cycle synchronization. If exchange rates 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. To examine the impact of exchange rate stability, we use the exchange rate variability, measured as the standard deviation of the changes in the bilateral exchange rate (following De Haan *et al*., 2002).

As pointed out above, *similar monetary policies* may also lead to business cycle synchronization. We employ the correlation of short-term interest rates (following Clarck and van Wincoop, 2001) to examine the influence of similar monetary policies on business cycle synchronization.

Finally, various other variables have been included in the analysis as they were suggested in one or more studies (see the Appendix for further details). For instance, Artis (2003) argues that the variables "relative financial structure" (measured as the ratio of private credit to stock market value traded) and "relative share of oil imports" have a significant negative impact on business cycle synchronization.

4. Results

Tables 1 and 2 show the results of the Extreme Bounds Analysis for the full sample period using GDP and industrial production indicators of business cycle synchronization, respectively. As explained in section 2, we apply the EBA as suggested by Sala-i-Martin (1997) and do not focus on the extreme bounds but examine the entire distribution of the estimated coefficients. Apart from the variables discussed in the previous section, various other variables that have been suggested in the literature as potential determinant of business cycle co-movement are taken up in the analysis (see the Appendix for further details). When testing for robustness, we made sure not to include other proxies for the same "driving force" in the set of control variables. This is especially relevant for financial integration and specialization, since we have two measures of financial integration and three indicators of specialization (see section 3 for further details).

It follows from Tables 1 and 2 that various variables are robustly related to business cycle synchronization. Not surprisingly, trade intensity appears robustly related to business cycle synchronization However, also the specialization measures and some other variables are considered robust, including the correlation of short-term interest rates and the correlation of cyclically-adjusted budget deficits. The latter variables are robustly related to business cycle co-movement, no matter whether we focus on GDP correlation or IP correlation. For the GDP-based measure of synchronization, exchange rate variability is also robust. Our findings contrast with those of Baxter and Kouparitsas (2005) who found that only trade intensity is robustly related to business cycle synchronization.

Table 1: EBA results for GDP-based business cycle synchronization (21 OECD countries, 1970-2003, 3 sub periods)

Similarity measure:	Export similarity		Export similarity		Output similarity		Output similarity		IIT		IIT	
Financial integration measure:	NFA		Capital restrictions		NFA		Capital restrictions		NFA		Capital restrictions	
Variables:	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. Sign.	CDF(0)
Trade intensity	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	99.82	1.00	99.82	1.00
Similarity measure	100.00	1.00	100.00	1.00	64.62	0.98	66.15	0.98	100.00	1.00	99.56	1.00
Financial integration measure	2.42	0.75	26.59	0.83	3.74	0.78	35.60	0.87	48.57	0.85	25.05	0.82
Similarity of basket of import goods	0.88	0.62	1.10	0.63	2.42	0.60	2.86	0.61	72.75	0.96	1.32	0.63
Correlation budget deficits	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Stand. dev. exchange rate	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	15.60	0.82	100.00	1.00
Correlation money market rates	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Correlation inflation	13.19	0.88	20.88	0.89	13.19	0.86	21.10	0.87	93.41	0.99	21.32	0.90
Openness	90.77	0.99	84.18	0.98	90.99	0.99	84.62	0.98	21.54	0.74	69.01	0.97
Difference perc. labour force with at least secondary education	0.00	0.52	0.00	0.50	1.98	0.51	1.98	0.54	75.60	0.97	0.00	0.53
Difference perc. labour force with tertiary education	20.66	0.91	21.10	0.91	21.54	0.93	21.98	0.93	1.10	0.52	35.38	0.94
Absolute difference in capital-output ratio	0.00	0.54	0.00	0.53	0.00	0.55	0.22	0.55	99.78	1.00	0.00	0.53
Average fuel import share	4.84	0.61	6.15	0.67	4.84	0.62	6.37	0.68	35.60	0.83	6.15	0.71
Absolute difference arable land-output ratio	13.41	0.83	13.19	0.83	16.04	0.83	14.73	0.83	97.58	1.00	21.10	0.84
Log GDP per hour worked	3.30	0.83	3.30	0.83	0.00	0.72	0.00	0.71	0.00	0.65	0.00	0.81
Absolute difference stock market traded to private credit	1.10	0.75	0.88	0.73	10.33	0.80	9.01	0.77	26.59	0.78	0.66	0.68
Absolute difference in savings ratio	53.85	0.95	59.78	0.95	53.85	0.93	59.78	0.93	52.97	0.91	63.96	0.97

Table 2: EBA results for IP-based business cycle synchronization (21 OECD countries. 1970-2003, 3 sub periods)

Similarity measure:	Export similarity		Export similarity		Output similarity		Output similarity		IIT		IIT	
Financial integration measure:	NFA		Capital restrictions		NFA		Capital restrictions		NFA		Capital restrictions	
Variables:	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. Sign.	CDF(0)
Trade intensity	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	95.18	1.00	95.18	1.00
Similarity measure	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Financial integration measure	46.15	0.82	32.09	0.68	45.93	0.88	48.35	0.81	48.57	0.85	32.53	0.66
Similarity of basket of import goods	72.75	0.96	70.33	0.96	67.03	0.95	65.71	0.95	72.75	0.96	70.33	0.96
Correlation budget deficits	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Stand. dev. exchange rate	16.26	0.83	20.66	0.84	16.26	0.84	23.52	0.86	15.60	0.82	20.00	0.83
Correlation money market rates	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Correlation inflation	84.40	0.99	83.96	0.99	76.70	0.93	78.46	0.94	93.41	0.99	92.75	0.99
Openness	27.25	0.85	22.20	0.83	41.10	0.88	36.04	0.85	21.54	0.74	16.48	0.71
Difference perc. labour force with at least secondary education	83.08	0.99	82.20	0.99	92.53	0.99	91.43	0.99	75.60	0.97	74.51	0.97
Difference perc. labour force with tertiary education	0.22	0.60	0.22	0.60	0.00	0.60	0.00	0.60	1.10	0.52	1.10	0.52
Absolute difference in capital-output ratio	100.00	1.00	100.00	1.00	85.71	0.99	85.49	0.99	99.78	1.00	99.78	1.00
Average fuel import share	27.69	0.78	32.53	0.81	26.81	0.73	32.53	0.78	35.60	0.83	39.12	0.86
Absolute difference arable land-output ratio	97.58	1.00	97.58	1.00	88.79	0.98	89.01	0.98	97.58	1.00	97.58	1.00
Log GDP per hour worked	0.44	0.71	0.44	0.68	0.00	0.63	0.00	0.61	0.00	0.65	0.00	0.63
Absolute difference stock market traded to private credit	30.77	0.90	25.49	0.88	41.32	0.92	33.85	0.89	26.59	0.78	21.32	0.76
Absolute difference in savings ratio	48.57	0.85	54.07	0.86	48.57	0.85	54.07	0.86	52.97	0.91	58.68	0.92

As the next step in our analysis, we estimate various models based on Figure 1, including only variables that are robustly related to business cycle synchronization. Tables 3 and 4 show our estimation results. We run a separate analysis for each of the similarity measures (output similarity, export similarity, and IIT) as these measures are robustly related to business cycle synchronization.[13] The tables show both OLS and IV results. In addition to the instruments used by Frankel and Rose (1998), i.e. distance, an adjacency dummy, and a dummy for common language, we also use a variable measuring geographical remoteness and a dummy for common legal origin.[14] The Hausman tests do not reject the null hypothesis that the OLS estimates are consistent, except for one regression.

Table 3: Determinants of GDP-based business cycle synchronization (21 OECD countries, 1970-2003, 3 sub periods)

	OLS			**IV**		
				Similarity measure:		
Variables:	Output similarity	Export similarity	IIT	Output similarity	Export Similarity	IIT
Trade intensity	0.055*	0.06*	0.052*	0.061*	0.117*	0.11*
Similarity measure	0.044	0.07*	0.358*	0.043	0.057*	0.221
Correlation money market rates	0.271*	0.159*	0.168*	0.269*	0.148*	0.168*
Correlation budget deficits	0.196*	0.159*	0.152*	0.195*	0.152*	0.148*
Stand. dev. exchange rate	-1.798*	-1.54*	-1.549*	-1.748*	-1.142*	-1.217*
# of obs	343	472	472	343	472	472
Hausman test				0.09	4.73	3.32
Critical value 5%				11.07	11.07	11.07

Note: * significant at 5% level

[13] The measure of industrial similarity does not pass the test when GDP correlation is used as the dependent variable, but we include it to facilitate the comparability of results across specifications.

[14] All these instruments are highly significant in explaining trade intensity and the F-statistic of the first-stage regression is 157. Legal origin has also been used to directly explain output co-movement (e.g. Otto *et al.*, 2001) but we argue that the main effect of a common legal origin is via trade: the correlation between legal origin and trade intensity is 0.40, while the correlation with the GDP and IP correlations are 0.23 and 0.11, respectively. As the 95% lower bound of the legal origin-trade intensity correlation is 0.27, the link with trade is significantly stronger than the link with output correlations.

Table 4: Determinants of IP-based business cycle synchronization (21 OECD countries, 1970-2003, 3 sub periods)

	OLS			IV		
	Similarity measure:					
Variables:	Output similarity	Export similarity	IIT	Output similarity	Export Similarity	IIT
Trade	0.094*	0.072*	0.049*	0.101*	0.13*	0.1*
Similarity measure	0.077*	0.124*	0.759*	0.075*	0.106*	0.625*
Correlation money market rates	0.389*	0.175*	0.182*	0.387*	0.17*	0.183*
Correlation budget deficits	0.149*	0.176*	0.167*	0.148*	0.172*	0.165*
# of obs	397	630	630	397	630	630
Hausman test				0.32	13.19*	7.11
Critical value 5%				9.49	9.49	9.49

Note: * significant at 5% level

5. Discussion and further sensitivity tests

In the previous section we have found that apart from trade intensity also specialization and similarity of economic policies are significantly related to business cycle co-movement.

However, significance does not shed much light on economic importance. Table 5 therefore shows the standardized coefficients of these variables. It follows that the standardized coefficient of most variables is larger than the coefficient of trade intensity. So, our evidence suggests that variables that reflect common economic policies and specialisation are at least as important as strong trade ties for synchronization of business cycles.

Table 5A: Standardized coefficients in model (1), using GDP-based indicator of business cycle synchronization (21 OECD countries, 1970-2003, 3 sub periods)

Standardized coefficients	**OLS**		
	Output similarity	Export similarity	IIT
Trade	0.13*	0.12*	0.11*
Similarity measure	0.10	0.15*	0.13*
Correlation money market rates	0.23*	0.14*	0.14*
Correlation budget deficits	0.23*	0.17*	0.16*
Stand. dev. exchange rate	-0.19*	-0.15*	-0.15*

Table 5B: Standardized coefficients in model (1), using IP-based indicator of business cycle synchronization (21 OECD countries, 1970-2003, 3 sub periods)

Standardized coefficients	**OLS**		
	Output similarity	Export similarity	IIT
Trade	0.23*	0.16*	0.11*
Similarity measure	0.18	0.27*	0.30*
Correlation money market rates	0.35*	0.16*	0.17*
Correlation budget deficits	0.18*	0.19*	0.18*

Our findings are good news for supporters of the Economic and Monetary Union (EMU) in Europe. Our results suggest 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. Not only more trade and especially more intra-industry trade – which has increased substantially over time in the EMU countries – leads to business cycles that are more in sync, also similar economic policies lead to more business cycle synchronization.[15] These findings lend support to Trichet's claim 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).

Finally, we have examined to what extent our results are affected by omitting variables that may also influence business cycle synchronization, but that were not included in the analysis due to data availability. Unfortunately, there is a trade-off between the length of the sample period and the number of variables that can be included in the analysis. Table 6 present the EBA outcomes for the GDP-based measure of business cycle co-movement using a longer list of variables over the period 1992-2003. First, we include a number of s*tructural characteristics* as suggested by Otto et al. (2001):

[15] 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.

- common accounting standards, measured as the absolute difference in accounting standards index (source: La Porta *et al*. 1998);
- openness to new technology measured as the absolute difference in number of mobile phones per capita, the absolute difference in number of personal computers per capita and the absolute difference in ICT expenditure share in GDP (source: World Bank).

We have also included *relative labour market flexibility*, which is proxied by the absolute difference in employment protection legislation index (source: OECD). Artis (2003) argues that asynchronous cycles may arise from the interaction of different (non-symmetric) propagation mechanisms with common shocks just as much as they arise from asymmetric originating shocks with similar kinds of propagation mechanisms at work. For instance, more or less flexible labour markets will make for less or more persistence in the response to a shock. Similarly, the *flexibility of the goods market* may be relevant for the same reason. Our proxy for this variable is the absolute difference in product market regulation index as provided by the OECD.

Finally, we have included FDI as some previous papers have included this variable as well, albeit with different results. Whereas Otto *et al*. (2001) find that this variable is not related to business cycle co-movement, Jansen and Stokman (2004) conclude that FDI affects business cycle synchronization.

It follows that our previous conclusions are not at all affected: trade intensity, specialization, the correlation of short-term interest rates, the correlation of cyclically-adjusted budget deficits and exchange rate variability appear robustly related to business cycle synchronization. When we use these variables in model (1), our previous findings are confirmed (not shown, results available on request).

6. Conclusions

We have examined the driving forces of business cycle synchronization for a sample of 21 OECD countries over the period 1970-2003, using the bilateral correlation of detrended real economic activity (GDP and industrial production) as dependent variable. We have applied a two-step approach. In the first step we follow Baxter and Kouparitsas

(2005) and examine which variables are robustly related to business cycle synchronization, using the EBA as suggested by Sala-i-Martin (1997). In the second step, we include the robust variables in a structural model for two reasons. First, we are not only interested in significance of a variable, but also in its economic importance. By its very construction, the EBA is not suited to provide insights on this issue. Second, we want to in take into account the possible endogeneity of various determinants of business cycle synchronization. Since a correlation coefficient lies between –1 and 1, the error terms in a regression model of the determinants of business cycle synchronization are unlikely to be normally distributed. We therefore employ transformed correlation coefficients as the dependent variable in our regression models. Including variables capturing similarity of monetary and fiscal policies, and specialization in a multivariate model, instead of using instrumental variables estimation, we confirm the finding that trade intensity affects business cycle synchronization, but the effect is much smaller than previously reported. Furthermore, the other factors included in the model have at least as strong an effect on business cycle synchronization as trade intensity.

Table 6: EBA results for GDP-based business cycle synchronization (21 OECD countries, 1992-2003)

Similarity measure:	Export similarity		Export similarity		Output similarity		Output similarity		IIT		IIT	
Financial integration measure:	NFA		Capital restrictions		NFA		Capital restrictions		NFA		Capital restrictions	
Variables:	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. sign.	CDF(0)	Perc. Sign.	CDF(0)
Trade intensity	97.29	1.00	97.35	1.00	96.84	1.00	96.95	1.00	90.57	0.99	90.63	0.99
Similarity measure	100.00	1.00	99.94	1.00	73.31	0.96	70.00	0.96	99.87	1.00	99.87	1.00
Financial integration measure	56.69	0.91	71.36	0.94	57.99	0.92	75.65	0.95	57.34	0.91	69.42	0.94
Similarity of basket of import goods	65.71	0.81	65.58	0.81	67.27	0.82	67.21	0.82	65.45	0.81	65.45	0.81
Correlation budget deficits	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00	100.00	1.00
Stand. dev. exchange rate	97.92	1.00	98.38	1.00	98.44	1.00	98.83	1.00	97.86	1.00	98.31	1.00
Correlation money market rates	100.00	1.00	100.00	1.00	99.94	1.00	99.94	1.00	100.00	1.00	100.00	1.00
Correlation inflation	55.78	0.93	59.81	0.94	56.69	0.93	60.78	0.94	53.70	0.93	57.79	0.94
Openness	90.84	0.98	87.99	0.97	91.23	0.98	88.44	0.97	86.30	0.97	83.31	0.97
Difference perc. labour force with at least secondary education	12.66	0.83	12.73	0.84	13.90	0.84	13.96	0.86	20.65	0.86	20.84	0.87
Difference perc. labour force with tertiary education	0.65	0.59	0.52	0.54	1.56	0.57	1.43	0.52	0.84	0.56	0.71	0.51
Absolute difference in capital-output ratio	6.95	0.65	6.95	0.65	7.08	0.66	7.14	0.66	7.08	0.66	7.08	0.65
Average fuel import share	58.70	0.80	57.73	0.78	58.12	0.80	57.21	0.77	58.05	0.79	57.08	0.77
Absolute difference arable land-output ratio	15.65	0.64	19.22	0.65	20.71	0.66	24.29	0.67	18.12	0.61	21.36	0.62
Log GDP per hour worked	0.97	0.58	0.97	0.57	0.00	0.51	0.00	0.50	0.00	0.56	0.00	0.55
Absolute difference stock market traded to private credit	17.27	0.85	15.65	0.84	20.00	0.86	17.92	0.85	16.95	0.83	15.19	0.82
Absolute difference in savings ratio	79.61	0.98	81.95	0.98	84.87	0.98	87.21	0.98	83.96	0.99	86.56	0.99
Absolute difference in accounting standards	22.53	0.92	18.31	0.87	22.47	0.92	18.38	0.87	20.97	0.91	16.95	0.86
Absolute difference in number of mobile phones per capita	1.95	0.53	2.01	0.54	2.14	0.56	2.40	0.57	2.99	0.50	3.05	0.52
Absolute difference in number of personal computers per cap.	3.83	0.66	3.44	0.60	6.10	0.69	5.00	0.63	3.77	0.66	3.38	0.60
Absolute difference in ICT expenditure share in GDP	55.52	0.90	54.55	0.89	49.22	0.84	48.38	0.83	48.64	0.87	47.79	0.86
Absolute difference in employment protection index	51.23	0.88	49.81	0.88	49.35	0.88	47.86	0.87	49.09	0.87	47.73	0.87
Absolute difference in product market regulation index	1.95	0.66	1.95	0.67	1.56	0.63	1.56	0.65	1.43	0.65	1.43	0.66
Max. of bilateral inward plus outward FDI positions to GDP	12.14	0.64	17.47	0.68	12.27	0.64	17.47	0.68	13.83	0.64	19.16	0,68

Appendix. Description and sources of explanatory variables used in section 4

Variable:	Source:	Suggested by:
Trade intensity (first principal component of six different measures)	Feenstra *et al.* (2005)	Frankel and Rose (1998)
Industrial similarity (first principal component of three different specialization measures)	GGDC 60-industry database	Imbs (2004)
Export similarity (first principal component of three different specialization measures)	Feenstra *et al.* (2005)	Baxter and Kouparitsas (2005)
Share of intra-industry trade (IIT)	Feenstra *et al.* (2005)	
Capital account restrictions	Milesi-Feretti and IMF	Imbs (2004)
Difference (absolute) in Net foreign asset positions	Milesi-Feretti and IMF	Imbs (2004)
Similarity of basket of import goods	Feenstra *et al.* (2005)	Baxter and Kouparitsas (2005)
Cyclically-adjusted budget deficits correlation	OECD Economic Outlook (vol. 76)	Camacho *et al.* (2005)
Exchange rate variability	IFS	Otto *et al.* (2001)
Short-term interest rate correlation	IMF, International Financial Statistics (IFS)	Otto *et al.* (2001)
Correlation of inflation rates	IFS	Camacho *et al.* (2005)
Average openness (export plus import/GDP)	IFS & GGDC Total Economy Database	Baxter and Kouparitsas (2005)
Human capital difference (secondary or tertiary education)	OECD Labour Force Statistics	Baxter and Kouparitsas (2005)
Physical capital difference	GGDC Total Economy Growth Accounting Database	Baxter and Kouparitsas (2005)
Average oil import share	World Bank, World Development Indicators (WDI)	Artis (2003)
Arable land difference	WDI	Baxter and Kouparitsas (2005)
Relative labour productivity level	GGDC Total Economy Database	Baxter and Kouparitsas (2005)
Relative financial structure (stock/credit)	Beck *et al.* (1999)	Artis (2003)
Difference in national savings ratio	OECD National Accounts	Camacho *et al.* (2005)

Note: A more detailed description of the variables and sources, as well as the data is available at www.rug.nl/economics/inklaarrc

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