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Business cycle synchronisation and currency unions: A review of the econometric evidence using meta-analysis☆

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ABSTRACT

This paper offers a systematic evaluation of the evidence on the effects of currency unions on the synchronisation of economic activity. Focusing on Europe, we construct a database of about 3000 business cycles synchronisation coefficients including their design and estimation characteristics. We find that: (1) synchronisation increased from about 0.4 before the introduction of the euro in 1999 to 0.6 afterwards; (2) this increase occurred in both euro and non-euro countries (larger in former); and (3) there is evidence of country-specific publication bias.

1. Introduction

The debate about the future of the EMU requires a careful examination of the costs and benefits of the single currency. A fundamental criterion for optimal currency areas is the degree of synchronisation of economic activity. Synchronisation is often measured as the correlation between two data series that capture economic activity in two countries or between one country and a group of countries (e.g. euro area). This paper takes stock of the empirical evidence on synchronisation of business cycles in Europe. It tries to identify whether and by how much synchronisation changed across European countries after the introduction of the euro.

The objective of this paper is to systematically examine the evidence on the effects of the introduction of the euro on business cycle synchronisation in Europe. The present study complements, updates and extends previous efforts, chiefly Fidrmuc and Korhonen (2006) and De Haan, Inklaar, and Jong-A-Pin (2008). We conclude that the available evidence suggests a significant increase in synchronisation: larger in the eurozone core countries and after the introduction of the euro.

This paper offers a systematic evaluation of the evidence on the effects of currency unions on the synchronisation of economic activity using meta-regression analysis techniques. There have been recent concerns about transparency and reproducibility of economics research. New approaches have been proposed to improve research credibility (Ioannidis, Stanley, & Doucouliagos, 2017). In a review of new techniques, Christensen and Miguel (2018) single out meta-regression analysis for systematically summarising findings of a body of scientific literature on a given topic. Unlike conventional literature reviews, meta-analysis applies statistical methods that make it less susceptible to reviewer's tastes, preferences and biases (Stanley & Doucouliagos, 2012).

Synchronisation of economic activity occupies a central place in the debate about the extent to which monetary unions affect symmetry (Frankel & Rose, 1998; Krugman, 1993, 2013; Mundell, 1961). This paper uses a unique hand-collected database encompassing results, design and estimation characteristics of 2959 estimates from 62 studies on

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business-cycle correlations between European countries over the past six decades. These econometric studies use several variables for synchronisation (e.g. GDP, industrial production or inflation), a variety of ways of calculating correlations (e.g. simple correlations of growth rates and correlation of de-trended variables) as well as multiple econometric methods (e.g. HP filter and structural VAR). Meta-regression analysis is designed to produce a systematic, transparent and rigorous summary of the evidence accounting for these differences.

Our main findings are as follows. First, business-cycle correlation coefficients in Europe have significantly increased over time from about 0.4 before the introduction of the euro in 1999 to 0.6 afterwards. Second, the increase is observed in all euro zone core countries, euro zone periphery countries and non-euro countries in Europe, but the increase is heterogeneous. Third, we identify various factors that help explain the variation over time and across countries in synchronisation estimates. For example, use of quarterly data or Blanchard-Quah decomposition systematically lowers synchronisation estimates. Fourth, the evidence of publication bias appears to be restricted to a few countries, most notably Greece, the UK, Bulgaria and Latvia. These results are robust to an extensive battery of sensitivity checks.

This paper is organised as follows. Section 2 briefly introduces our unique data set. Section 3 presents our empirical results on the magnitude of the changes in business-cycle synchronisation. Section 4 discusses our econometric (meta-regression analysis) results on the factors that may explain the variations of these coefficients across counties and over time. Section 5 concludes.

2. Data

We apply meta-analysis and meta-regressions using a unique hand-collected database that encompasses the estimates, design and estimation characteristics of >60 studies. We focus on papers that estimate business-cycle correlations between European countries.

We follow the general guidelines for meta-analysis (Stanley et al., 2013). We start by searching for papers from online sources Google Scholar, Research Papers in Economics (RePEc) bibliographic database and SSRN online paper repository with the following search string: business AND cycle AND (correlation OR synchronisation OR synchronisation) AND (EU OR EMU OR "European Union" OR "Euro Area" OR "Euro zone").

This search should capture any paper that estimates business-cycle correlations between two or more European countries. We include only those papers that report correlation coefficients for at least one well-defined time interval. We note that, unfortunately, it is common in this body of literature to report results only in graphic form. Our data set was completed in February 2017 meaning that it should include all papers published in 2016.

Our search procedure yields 62 individual papers published between 1993 and 2016. As is customary in meta studies, we do not list the individual papers in the references but in Appendix A. Many of these papers have been revised several times before they were published so we only use information from the most recent version. These 62 papers provide 2959 individual estimates for up to 25 countries. Reported estimates per paper range from a minimum of 8 to a maximum of 384.

We quantify several characteristics related to individual studies in addition to all reported synchronisation estimates. Specifically, we collect information related to authors (number and affiliations), publication (journal articles and working papers), data and sample (frequency; variable used for computing synchronisation; start and end of sample; whether correlations are calculated only against a single country/grouping; whether benchmark country/group is Germany, entire euro area or something else), as well as various features of the econometric methodology (simple correlation, time series models, Blanchard-Quah decomposition, etc.)

There is striking fluctuation in publications on the topic. Fig. 1 shows changes in the number of papers published on business-cycle correlation over time starting with the initial contribution by Bayoumi and Eichengreen (1993). Interest seems to peak with the introduction of euro coins and banknotes in 2002, and then spikes several times thereafter as researchers return to the topic with each addition of new members to the euro area.[1] The number of publications for each main European region is similar, except Eastern Europe.

The average value of the business cycle synchronisation correlation coefficient over all 2979 estimates is 0.48, with a relatively high standard deviation of 0.34. To assess how these change over time (especially before and after the euro's introduction in 1999), we use two methods. First, we consider all estimates and separate them into two groups according to the middle year of their estimation window, i.e. one group where the middle year of the sample occurs before 1999 and the other where the middle year is 1999 or later. The two groups overlap. Fig. 2 illustrates how average of reported correlation coefficients changes over time for different countries. Darker shades of blue indicate higher correlation.

Our second method only includes studies where the estimation window ends before 1999 or starts in or after 1999 (the year the euro was introduced). This second method generates two non-overlapping sets of estimates.

The overlapping set consists of 2010 pre-euro estimates and 969 euro-era estimates. From our non-overlapping cut (i.e. where we exclude all correlation coefficients with estimation window spanning both before and after 1999), we obtain a more balanced set of 742 before-1999 estimates and 501 estimates for 1999 and after.

In our overlapping set, we find that the value of the business cycle synchronisation correlation coefficient increases from an average of 0.43 before the euro to an average of 0.60 afterwards. In the non-overlapping case, the value of the business cycle synchronisation correlation coefficient increases even more starkly from an average of 0.38 before the euro to an average of 0.73 afterwards.

We find that about 52% of these estimates are taken from working papers, while approximately 48% come from published articles. Around 75% of authors are affiliated with universities and 35% with central banks or international institutions (overlap indicates dual affiliation).

Almost 60% of the estimates measure synchronisation of economic activity between countries using GDP, while the rest rely mainly on industrial production, inflation, demand or supply shocks (each accounting for approximately 10% of the estimates).

Synchronisation in 48% of the estimates is reported with respect to the EU, 38% with respect to Germany and 14% with respect to the euro area. For 52% of the estimates, the frequency of the data is quarterly, while for 38% it is annual, and for about 10% of the cases it is monthly. The most popular methodology remains the HP filter (56% of the estimates). The Blanchard-Quah decomposition is used in about 20% of the estimates, simple correlations in 17% and other time-series methods in the remaining 7% of the cases.

[1] The euro was first introduced in 1999 with eleven members (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Spain and Portugal). Physical euro banknotes and coins were issued in 2002. The euro area thereafter experienced several expansions. Greece joined in 2001, Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2011, Latvia in 2014 and Lithuania in 2015. Denmark maintains a tight peg of the crown to the euro.

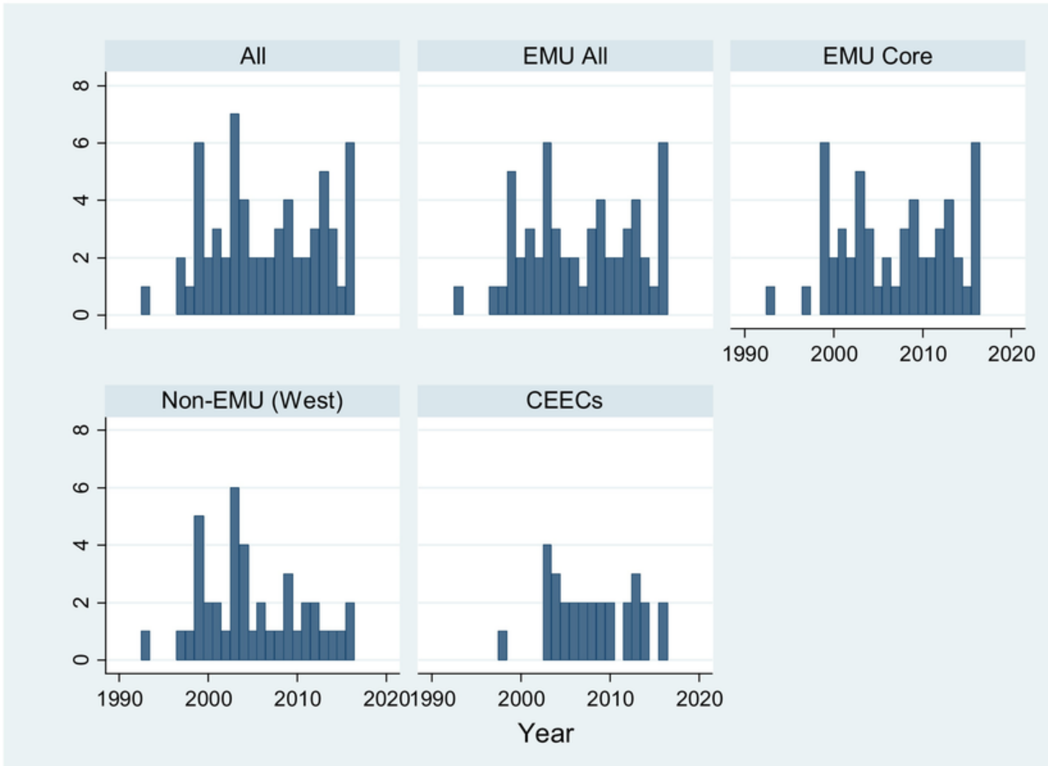

Fig. 1. Number of publications per year by selected regions. Source: Own calculations.

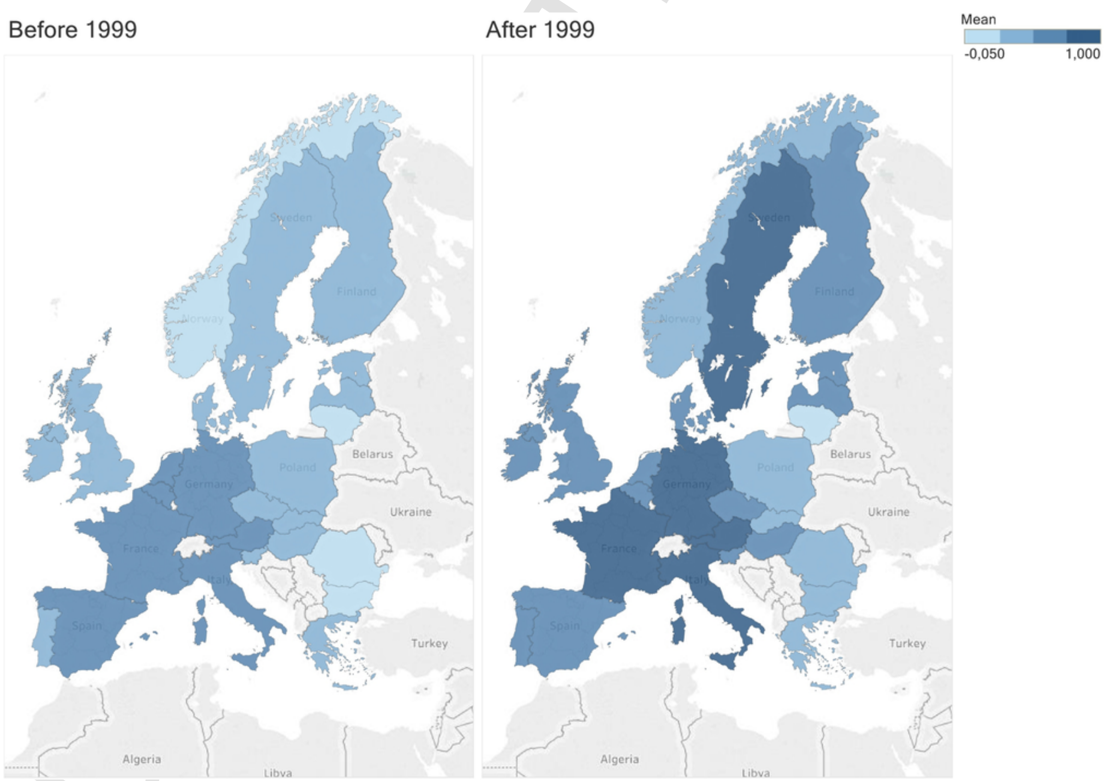

Fig. 2. Reported correlation coefficients for European countries (overlapping samples). Source: Own calculations.

3. Assessing the evidence

We now discuss how we used this database described above to provide a detailed picture of the evolution of business-cycle synchronisation across countries and over time. Regarding the time scale, our emphasis is to contrast the periods before and after the introduction of the euro. For cross-country variation, we report results for individual countries. Given that the literature covers 25 EU members (almost every study on this subject excludes Cyprus, Luxembourg and Malta), we also create artificial groupings to help in carrying out comparisons.[2] Armed with these stylised facts, we present and discuss statistical tests on whether the introduction of the euro significantly changed the level of business cycle synchronisation and whether the econometric evidence is affected by publication bias.

3.1. Statistical tests for structural change in business cycle synchronisation

The creation of the EMU represents a major economic policy event and, as such, can be expected to have a significant influence on the degree of synchronisation of business cycles. To compare the period before and after the introduction of the euro in 1999, analysis of business-cycle synchronisation must be carried out for periods of several years to encompass multiple cycles. Most papers estimate business cycles over a period covering many years before and after the introduction of euro. We consider each study as a moving window for the correlation estimation (Gächter & Riedl, 2014), which we attribute to the middle year of each relevant sample.

The shifts in business cycle synchronisation in the above figures suggest that it has increased in the EU in general. In line with previous literature (Havranek, Horvath, Irsova, & Rusnak, 2015; Havranek & Rusnak, 2013), the descriptive statistics in Table 1 reveal considerable heterogeneity across countries, regions and periods. Therefore, further statistical analysis is needed to obtain a sharp picture of structural changes in EU-wide business cycles.

Table 1 presents the *t*-tests on whether the mean of the correlation coefficients have changed before and after the euro's introduction. The tests confirm that synchronisation of business cycles has generally increased for all main groupings and nearly all countries. Significant heterogeneity, however, remains at the country level. The level of business cycle synchronisation does not change significantly in some countries (Bulgaria, Estonia, Greece, Latvia, Lithuania, Slovakia and Norway). In addition, the synchronisation of business cycles in Germany, among the highest in our sample, remains relatively stable over time. As the mean equality test draws an incomplete picture, we return to this issue with more rigorous econometrics below.

3.2. Publication bias

Economic policy debates that spill out into the wider public discussion are sometimes influenced by cherry-picked academic results (Bruns, 2017). This can lead to publication bias when authors, reviewers and publishers follow their preferences for statistically strong, significant and theoretically expected results that bolster, or at least do not contradict, a preferred hypothesis. Moreover, general expectations of specific results, as well as corresponding publication bias, can differ across countries. In this subsection, we assess whether the publications in our database suffer from publication bias.

Funnel plots are the standard and intuitive way to analyse publication selection bias. A funnel graph is a scatter diagram that plots the precision of the reported effect on the vertical axis against the measured effect size on the horizontal axis (Stanley & Doucouliagos, 2012). In the absence of publication bias, the estimates will normally be distributed around the "true" effect. The plot is expected to resemble an inverted funnel, with the more precise estimates being close to the true effect. In contrast, publication bias may be significant if the funnel plot appears asymmetric.

The precision of published results is usually measured by standard errors. However, standard errors are often unavailable for correlation coefficients, so they are commonly proxied by the inverse of number of observations. The drawback to this approach is that the number of observations tends to be higher for quarterly or monthly data. Therefore, we also construct funnel plots for studies using only quarterly data and use number of available years in the sensitivity analysis.

The funnel plots for the main European regions are quite symmetrical, despite some observations with large positive numbers (Fig. 3). The figures for different country groupings seem to miss the upper part of the inverted funnel. For individual countries, this is mainly because the precise estimates tend to be highly heterogeneous. The robustness analysis shows that the results are highly similar when the number of available years is used instead of number of observations. Quarterly data shows a more clear-cut picture of the genuine effect and publication bias than funnel plots for data at different frequencies.

Because funnel plots themselves are inconclusive for detecting asymmetry, we employ a funnel asymmetry test (FAT) based on a simple meta-regression of available effects and corresponding standard errors (Card & Krueger, 1995; Egger, Smith, Scheider, & Minder, 1997), such that

$$\frac{1}{2}\ln\left(\frac{1+\rho_{ij}}{1-\rho_{ij}}\right) = \widetilde{\rho}_i + \beta SE_{ij} + \varepsilon_{ij}, \qquad (1)$$

where we use the Fisher transformation for correlation coefficients, ρ, which is not truncated between −1 and 1. Subscript i signifies country and j publication. The precision of the individual reported correlation coefficient, as usually measured, is proxied by the inverse number of observations, $SE = 1/T$. Publication bias can be country-specific for idiosyncratic reasons, so we allow the coefficient of the standard error to vary across countries to obtain

$$\frac{1}{2}\ln\left(\frac{1+\rho_{ij}}{1-\rho_{ij}}\right) = \widetilde{\rho}_i + \sum_{i=1}^{N}\beta_i SE_{ij} + \varepsilon_{ij}. \qquad (1')$$

The FAT approach is based on the expected symmetry of publications results around the most precise estimates. If estimates are distributed symmetrically, then the coefficient β should not significantly differ from zero. By the same token, a significant coefficient β implies a tendency to report certain parameter values or only significant results. Rejection of the null confirms the presence of publication bias (presence of asymmetry).

Our FAT analysis (Table 2 and Fig. 4 for country-specific biases) also confirms the asymmetries revealed previously by the funnel plots. However, there is ambiguity in these results. Standard errors as proxied by the inverse of simple number of observations show a positive publication bias in general. In contrast, we can see a negative publication bias when standard errors are proxied by the inverse of number of available years. This is due to studies that rely on extremely short time spans. There is a positive, but insignificant, publication bias when we only include studies covering more than five years, which is approxi-

[2] Somewhat arbitrarily, but still following many papers on the topic, we group countries as follows: EMU core (Germany, France, Austria, Netherlands, Belgium and Finland); EMU (EMU core plus Estonia, Greece, Portugal, Ireland, Spain, Italy, Latvia, Slovakia and Slovenia); Non-EMU West (Denmark, Sweden, UK and Norway); and the CEECs (countries of Central and Eastern Europe). We also report results for individual countries, so these groupings are only provided for ease of exposition.

Table 1
Descriptive statistics (by region and period).
Source: Own estimations.

	Before 1999			After 1999			*t*-Test
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	
All countries	2001	0.427	0.323	958	0.600	0.358	−13.150***
EMU	587	0.420	0.304	274	0.610	0.350	−8.140***
EMU core	669	0.553	0.286	297	0.733	0.266	−9.212***
Non-EMU West	339	0.334	0.309	96	0.620	0.327	−7.907***
CEECs	406	0.308	0.347	291	0.449	0.399	−3.655***
Austria	116	0.579	0.254	49	0.750	0.231	−4.043***
Belgium	120	0.626	0.230	47	0.718	0.259	−2.234**
Bulgaria	5	−0.012	0.427	3	0.347	0.526	−1.061
Czech Rep.	52	0.236	0.344	35	0.499	0.358	−3.439***
Denmark	88	0.401	0.275	33	0.590	0.360	−3.082***
Estonia	46	0.347	0.352	30	0.484	0.406	−1.560
Finland	115	0.316	0.285	45	0.690	0.302	−7.331***
France	134	0.611	0.235	59	0.770	0.252	−4.246***
Germany	61	0.730	0.212	44	0.790	0.244	−1.352
Greece	101	0.357	0.287	55	0.368	0.387	−0.197
Hungary	55	0.439	0.304	35	0.586	0.318	−2.204**
Ireland	108	0.338	0.317	54	0.635	0.301	−5.709***
Italy	132	0.519	0.286	58	0.747	0.295	−5.015***
Latvia	44	0.346	0.365	29	0.488	0.423	−1.522
Lithuania	5	−0.071	0.340	13	0.179	0.377	−1.289
Netherlands	123	0.529	0.313	53	0.679	0.297	−2.966***
Norway	29	0.107	0.245	4	0.224	0.257	−0.891
Poland	53	0.334	0.284	37	0.440	0.293	−1.714*
Portugal	118	0.377	0.302	53	0.587	0.317	−4.131***
Romania	39	0.165	0.373	25	0.343	0.434	−1.752*
Slovakia	53	0.257	0.352	43	0.254	0.498	0.032
Slovenia	54	0.375	0.326	41	0.608	0.295	−3.603***
Spain	128	0.477	0.288	54	0.709	0.320	−4.783***
Sweden	102	0.378	0.266	25	0.806	0.165	−7.677***
UK	120	0.303	0.350	34	0.560	0.326	−3.824***

Note: Own calculations.
*** Significance at 1% level.
** Significance at 5% level.
* Significance at 10% level.

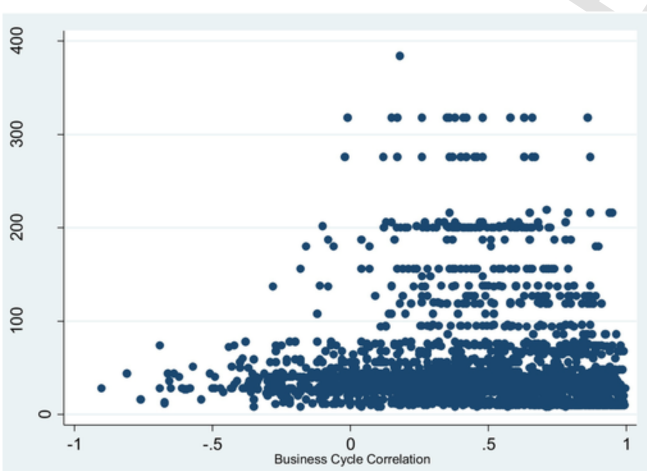

Fig. 3. Funnel plot. Note: Precision proxied by number of observations. Source: Own calculations.

mately the length of a full business cycle. Publication bias is also significant for this proxy variable if we only include studies spanning more than eight years.

Fig. 4 shows that publication bias is highly country-specific. The largest bias is found in the CEECs (Bulgaria and Latvia). They are positive for number of observations used and negative for number of available years. A comparably low, but still significant, bias is found for the UK and Greece.

Table 2
Funnel asymmetry test.
Source: Own estimations.

Proxy for standard errors	(1)	(2)	(3)
	Observation	Years	Years (>5)
Publication bias	7.712***	−0.452**	0.169*
	(0.411)	(0.162)	(0.429)
Observations	2959	2959	2745
R^2	0.151	0.003	0.000

Note: Standard errors clustered for countries in parentheses.
*** Significance at 1% level.
** Significance at 5% level.
* Significance at 10% level.

4. Understanding the variation of synchronisation estimates through meta-regression

We present a detailed study of the main factors that explain cross-country, between-study and over-time variations for reported correlation coefficients. We select a preferred specification that is robust to different estimation strategies, from a version of the specific-to-general approach to Bayesian model averaging analysis. We discuss several sensitivity tests regarding alternative estimation methodologies and subsamples.

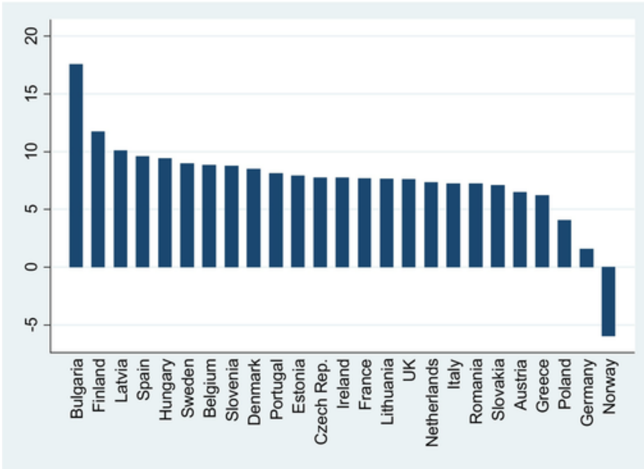

Fig. 4. Country-specific publication bias. Note: Country-specific coefficients for funnel asymmetry test estimated according to Eq. (1′). Standard errors are proxied by the inverse number of observations reported by studies. All coefficients are significant at 1% level. Source: Own calculations.

4.1. Meta-regression results

We employ meta-regressions to assess the degree of business cycle synchronisation between the euro area as a whole and members and non-member countries. We control for various characteristics of individual studies in these regressions.

While there are many ways to approach meta-regression analysis, we start with a specific-to-general formulation because of transparency and tractability. For ease of presentation, we divide our control variables into four groups. The first group includes variables related to each publication. In this group, we construct dummy variables for whether the paper was published in a journal and whether the focus of the publication is a single country. Moreover, we construct a dummy variable for whether at least one of the authors is affiliated with a central bank.

Second, we consider the reference region for synchronisation. Early studies of business cycle correlation in Europe relied on proxies for the euro area as a reference for synchronisation as the eurozone did not exist at that point. Some studies use Germany, while others use broad groups of EU countries (typically core countries or the twelve member states of the European Community). We distinguish empirically among these possibilities.

Third, we account for which econometric methodologies are influential. Business cycles correlations can be computed in different ways, so we include dummies for simple correlations in time-series models, Blanchard-Quah decomposition, and filters such as the Hodrick-Prescott filter.

Fourth and finally, authors may select different variables in estimating business cycle synchronisation. We thus include dummies for GDP, industrial production, supply and demand shocks and inflation. Similarly, we consider different data frequencies (monthly or annual as compared to quarterly frequency, our base category).

Most explanatory variables are dummy variables, taking the value of one if the specified criterion is fulfilled and zero otherwise. All other variables (e.g. publication year, number of observations and number of analysed countries) are demeaned.

Our empirical strategy centers on Eq. (2). The reported correlation coefficients (that capture synchronisation) denoted by ρ_{ij} are truncated between −1 and +1. Therefore, we use the Fisher transformation to remove the truncation problem such that:

$$\frac{1}{2}\ln\left(\frac{1+\rho_{ij}}{1-\rho_{ij}}\right) = \rho_i + \sum_{k=1}^{K}\beta_{ijk}D_{ijk} + \sum_{i=1}^{N}\gamma_i Trend_{ij} + \varepsilon_{ij}. \quad (2)$$

Country dummy ρ_i gives the average correlation coefficient for country i, controlling for analysed K characteristics of publication j such as publication year, variable, methodology, sample size, frequency, author affiliation or whether the publication is a journal. We try to use the common best-practice option as our base category (Doucouliagos, 2016). Thus, we can interpret country dummies as the best-practice level estimate of business cycle correlation, controlling for all sources of bias mentioned above.

The meta-regression analysis involves several choices. We always include country fixed effects and country-specific time trends. The latter was computed as country dummies multiplied by the middle year of the sample. We then add stepwise the four groups of explanatory variables.

Table 3 shows our baseline results. The first four columns show results for including control variables related to publication, reference country, methodology and econometric specification, respectively. The final column displays our preferred specification, where we include all the control variables that were significant in the first four specifications.

Our main results are as follows. First, we examine the individual group of variables related to the papers. Journals usually report a lower level of business cycle synchronisation than working papers. As in Fidrmuc and Korhonen (2006), authors from central banks report more conservative results for business cycle synchronisation in Europe. In contrast, it seems it is not important whether the publication focuses on a particular country (*Single_country*). If a proxy for the euro area has been used (*Reference_EU*), the studies systematically show a higher degree of correlation. Correlation coefficients calculated against Germany are not significantly different from the "authentic euro area" (base category).

Somewhat surprisingly, the use of annual data (*Annual*) yields systematically higher levels of business cycle synchronisation than other frequencies. Monthly data (*Monthly*) are not robustly different from quarterly data.

Methodological choices affect the reported correlation coefficients as well. Time series (*Time_series*) and structural VAR models (*Blanchard-Quah*) yield significantly lower results than standard filters (*Hp-filter*). Similarly, the reported degree of synchronisation is found to be lower if supply and demand shocks are used.

Our preferred specification is presented in the last column. We include only those variables that were statistically significant at least at the 10% level in the previous steps. We then drop one by one the least significant variable and proceed to the final specification, i.e. whether the reported level of business cycle synchronisation is determined mainly by type of publication (journal), characteristics related to the reference choice (EU), methods (HP filter) or variable definition (supply and demand shocks).

4.2. Bayesian model averaging

As an alternative model selection strategy, we use the Bayesian model averaging (BMA) methodology to identify those variables that can explain the distribution of business cycle correlation coefficients. BMA has become an important tool for dealing with model uncertainty in meta-analysis in economics (Havranek et al., 2015; Havranek & Rusnak, 2013). The BMA approach has the advantage of considering all possible combinations of explanatory variables and weighting them according to model fit. BMA results are designed to be robust to model

Table 3
Meta-regressions of business cycle synchronisation.
Source: Own estimations.

	(1)	(2)	(3)	(4)	(5)	(6)
Journal	−0.244***					−0.072***
	(0.015)					(0.021)
Single_country	−0.065					
	(0.315)					
Central_bank	−0.216***					
	(0.017)					
Refc_Germany		−0.135**				
		(0.062)				
Refc_EU		0.204***				0.148***
		(0.039)				(0.032)
Correlation			0.054			0.108***
			(0.034)			(0.034)
Time series			−0.216***			−0.131***
			(0.032)			(0.035)
Blanch-Quah			−0.338***			
			(0.028)			
HP filter			0.287***			0.155***
			(0.021)			(0.023)
GDP				0.127**		
				(0.052)		
Industrial prod				−0.131*		
				(0.070)		
Demand shocks				−0.503***		−0.390***
				(0.074)		(0.041)
Supply shocks				−0.413***		−0.317***
				(0.062)		(0.035)
Inflation				−0.223***		−0.188***
				(0.066)		(0.046)
Monthly					0.077**	
					(0.029)	
Annual					0.379***	0.167***
					(0.030)	(0.032)
No. of obs.	2959	2959	2959	2959	2959	2959
Adjusted R^2	0.694	0.690	0.734	0.734	0.703	0.759

Note: Standard errors clustered by countries in parentheses.
*** Significance at 1% level.
** Significance at 5% level.
* Significance at 10% level.

uncertainty when the correct set of explanatory variables is largely unknown. Thus, we consider all possible specifications where business-cycle correlation is explained by all possible combinations of explanatory variables.

Our data set consists of 66 possible explanatory variables. This number includes variables such as country fixed effects and country-specific trends (a total of 50 variables), which we argue should be included in all estimated models to reflect the underlying data heterogeneity. As our "focus variables" (De Luca & Magnus, 2011), we always include these so that we concentrate on which of the remaining 16 auxiliary regressors should be included in the final models. This gives us a model space with $2^{16} = 65{,}536$ possible models. In Table 4, we compare the BMA results with a weighted-average least-squares (WALS) estimator that relies on the Laplace priors to select important auxiliary regressors.[3]

The key BMA statistic is the posterior inclusion probability (PIP) which reflects the importance of each variable. Using it as a criterion, a PIP above 0.5, or even 0.75, gives a similar specification to the one we selected previously.[4] The most important explanatory variables are: journal, Germany as a reference country (instead of EU), simple correlations, HP filter, demand or supply shocks, inflation and annual data. The WALS results generally concur, but give slightly more weight to GDP.

5. Conclusions

The objective of this paper was to take stock, in a systematic and quantitative manner, of the body of econometric evidence on the dynamics of the synchronisation of business cycles within Europe. Several findings deserve mention. First, business-cycle correlation coefficients have significantly increased over time, from an average of 0.4 before the introduction of the euro in 1999 to 0.6 during the euro era. Second, this increase happened in the core and periphery euro countries, as well as in the non-euro countries of Western Europe such as Sweden and the UK. However, the increase seems to have been larger for countries in the euro area and particularly in the euro area core. Third, our analysis identified a set of robust factors that account for the variation over time and across countries in the reported correlation coefficients. For example, the use of quarterly data or Blanchard-Quah decomposition systematically lowers correlation estimates, while the affiliation of article authors (university or government agency) had no effect on the estimated correlation coefficients. Fourth, country-specific publication bias was found for several countries.

The main policy lesson that emerges from this exercise is that business cycle synchronisation in Europe seem to have increased after the introduction of the euro. This increase is significant statistically and

[3] These are implemented using *Stata* commands *bma* and *wals* from De Luca and Magnus (2011).

[4] Following Kass and Raftery (1995), the significance of each indicator is weak, positive, strong or decisive if the PIP lies above 0.5, 0.75, 0.95 or 0.99, respectively.

Table 4
Bayesian model averaging and weighted-average least squares.
Source: Own estimations.

	BMA			WALS		
	Post mean	Std. error	PIP	Coefficient	Std. error	*t*-Stat
Journal	−0.086	0.019	1.00^{+++}	−0.082	0.017	-4.73^{***}
Single_country	−0.002	0.044	0.02	−0.037	0.309	−0.12
Central_bank	0.000	0.003	0.02	0.000	0.021	−0.01
Refc_Germany	−0.207	0.021	1.00^{+++}	−0.189	0.028	-6.63^{***}
Refc_EU	0.000	0.005	0.02	0.028	0.026	1.09
Correlation	0.098	0.044	0.90^{++}	0.093	0.028	3.32^{***}
Time_series	−0.108	0.045	0.92^{++}	−0.081	0.033	-2.48^{**}
Blanch-Quah	0.011	0.043	0.08	0.074	0.074	1.00
HP filter	0.156	0.033	1.00^{+++}	0.143	0.024	5.88^{***}
GDP	0.007	0.029	0.08	0.093	0.035	2.67^{***}
Industrial prod	0.009	0.036	0.08	0.058	0.045	1.28
Demand shocks	−0.399	0.060	1.00^{+++}	−0.359	0.079	-4.56^{***}
Supply shocks	−0.324	0.057	1.00^{+++}	−0.297	0.074	-4.00^{***}
Inflation	−0.167	0.050	0.95^{++}	−0.088	0.044	-2.00^{**}
Monthly	0.003	0.014	0.06	0.050^{*}	0.033^{+}	1.48
Annual	0.173	0.021	1.00^{+++}	0.168	0.022	7.50^{***}

*** Significance at 1% level.
** Significance at 5% level.
* Significance at 10% level.
$^{+++}$ PIP indicates decisive significance (PIP above 0.99).
$^{++}$ PIP indicates strong significance (0.95).
$^{+}$ PIP indicates positive significance (0.75).

economically. The heterogeneity of the effects is of particular interest as our results suggest that increases in synchronisation are substantially more pronounced in core euro countries than in the euro periphery.

Our results also suggest various avenues for future research. A theoretical framework that relates synchronicity to other relevant features (e.g. trade openness and factor mobility) of endogenous currency unions (Frankel & Rose, 1998; Glick, 2017; Glick & Rose, 2016) remains lacking. Moreover, future work should better consider the dynamics of different groupings of countries, ideally starting with the simple core and periphery groupings used here before going further. Evidence on the effect of the euro should be more systematic. Finally, individual country studies will doubtless remain valuable in the future, but authors need to make substantial efforts at understanding the robustness of their key findings by considering alternative statistical methodologies. This could be done through more direct comparisons between HP filters and Blanchard-Quah results, or choice of variables (e.g. GDP vs. industrial production).

Uncited references

Blanchard and Quah, 1989
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Appendix A. List of papers used in the meta-analysis

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