Assessing European business cycles synchronization

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ASSESSING EUROPEAN BUSINESS CYCLES SYNCRONIZATION

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ABSTRACT

***Objectives**: We analyzed the level of economic integration in Europe by analyzing the degree of growth cycle synchronization between 36 countries and its evolution over the past 17 years. Information whether the business cycles in a currency union are synchronized or not is of key importance for policymakers, because lack of synchronization will lead to suboptimal common monetary policy. The article has three objectives: extend the literature on the business cycles synchronization by using dataset that includes countries that have never been analyzed before, test the robustness of the results to extraction and synchronization measures used and propose new method for assessing evolution of the synchronization over time.*

***Data/methods**: Quarterly GDP series from Eurostat database covering period 2000q1-2016q3 were used with two exceptions (industrial productions indexes for Bosnia and Herzegovina and Montenegro). Series were prepared by removing seasonal component using X13-ARIMA procedure. To assess robustness of synchronization tests results to alternative methods of detrending, business cycles were extracted using two filters: Corbae-Ouliaris ideal band filter and double Hodrick-Prescott filter. For assessing synchronization of the business cycles two methods were used: concordance index and cross-correlation function. Rolling cross-correlations at three lags were used to assess evolution of synchronization over time.*

***Conclusions**: Both concordance index and cross-correlations indicated that business cycles of most old EU members are synchronized with EU cycle. However, rolling cross-correlations suggested that this synchronization decreased after 2012. Majority of new EU members cycles were weakly or not at all synchronized with EU cycle until 2004/5. After 2004 most of them were synchronized in the same quarter but with greater variations between countries. For most of them after 2010/12 the degree of synchronization dropped significantly. These results are quite robust across the cycles extraction and synchronization measures used.*

Keywords: Business cycles, European Union, synchronization, HP filter, FD filter, concordance index, cross-correlations, rolling cross-correlations

1. INTRODUCTION

According to the optimum currency area theory business cycle synchronization is a necessary condition for conducting an optimal monetary policy in a monetary union. If the union member states economies are not synchronized, i.e. being in different phases (expansion or recession), then the different policies would be required to bring the major economic indicators in these economies on the optimal path. If the monetary union authorities is setting monetary

policy taking into account an average level of economic activity that might disadvantage both economies performing better or worse than an average level of economic activity suggest. Identifying the degree of synchronization is an important issue because of the possible costs involved if there is no synchronization. For instance, if two economies in a monetary union are in opposite phases then for an economy in recession lower interest rate would be appropriate monetary measure, while for an economy in expansion higher interest rate would be more appropriate measure because that would curb down inflation. In such case two different monetary policies would be required and that would lead toward increasing costs and the sub-optimal policy in the monetary union.

Therefore, the detection of degree of synchronization is important when making decision about joining a monetary union because of the costs and advantages that the common currency adoption imply. The main objective of this study is to explore to what extent the European business cycles are synchronization. More specifically the time series from the Eurostat database were used to achieve the following objectives:

- extend the literature on the business cycles synchronization by assessing data from 36 European countries including countries never been analyzed before,

- test robustness of the results to extraction methods and synchronization measures used,

- propose a novel approach for assessing evolution of the degree of synchronization between business cycles.

This paper contributes to the existing literature by bringing further evidence on the European business cycle stylized facts using the latest data and by including in the analysis data for countries rarely included in previous work on European countries business cycle analysis (such as Bosnia & Herzegovina, FRY Macedonia, Montenegro and Serbia). Robustness of the findings are checked using different cycle extraction methods, synchronization measures and different parameters used in the rolling cross-correlations approach. The rolling cross-correlations have been used in business cycles analysis for a long time. However, to the best of our knowledge, suggested approach with maximal cross-correlation coefficient and the corresponding lag together with the cross-correlations on the lags, one on each side of the selected lag time was not used before.

The paper is organized as follows: first, a brief review of the latest empirical studies on business cycle synchronization is presented. A description of methodology and data is presented next describing the data preparation, cycle

extraction methods and briefly outlining the synchronization measures and their computation. Empirical results are presented and discussed in the section that follows. The conclusion section summarizes the main results.

2. LITERATURE REVIEW

The main findings of individual empirical studies published after 2010 are summarized in Table 1. Majority of these studies used quarterly GDP and/or industrial production index seasonally adjusted. The most commonly used cycle extraction method was Hodrick-Prescott filter, though in a few studies robustness of the results was assessed using different cycle extraction methods.

The most common synchronization measures used were correlations in different sub-periods (before and after economic crisis, or before and after joining European Union, EU hereafter) and concordance index. The latest studies (Benčík, 2011; Dimitru & Dimitru, 2010; Gouveia, 2014; Kolasa, 2013; Obradović & Mihajlović, 2013) are investigating degree of synchronization for those European countries who recently joined EU, i.e. those who joined in 2004 and after (Bulgaria, Romania and Croatia), or are in the process of joining (e.g. Serbia). A few studies focused on an individual country (e.g. Turkey (Akar, 2016), Bulgaria (Filis et al, 2010) and Croatia (Šergo, Poropat & Gržinić, 2012)) analyzing different segments of the economy and how well the country is synchronized with EU cycle.

The main results suggests that the founding and old EU members with Greece as an exception, are all well synchronized with the Euro Area (EA hereafter) and EU. France and Germany are the most synchronized countries with the rest of Europe, while Portugal, Greece, Ireland and Finland do not show statistically relevant degrees of synchronization. While the degree of synchronization was very high in period around economic crisis in 2008, in the latest period, after 2012, some countries experienced drop in the degree of synchronization with the EU cycle.

Among new EU members, Slovenia and Czech Republic cycles were the most synchronized with EU cycle while Hungary, Romania and Serbia were least synchronized. However, when analyzing level of synchronization in different sub-periods, even for these countries there were tendencies to increase degree of synchronization after they joined EU, but still below the level of synchronization that was recorded for old EU members. These results imply that the cost of adopting common currency would be quite high for these countries (such as Romania and Bulgaria) if that would occur at this time. However, the adoption of euro by these countries will occur only when they meet all the euro convergence criteria, which is still not the case.

Table 1. Summary of literature after 2010 and main findings

Authors	Data used	Measure of cycle	Synchronization measure	Conclusions
Aguiar-Conraria & Soares (2011)	Period: 1975m7-2010m5 Countries: EU15 & EA12 Series: Industrial production	Wavelet power spectra between 1.5 and 8 years frequencies	Metric based on wavelet spectra	France and Germany most synchronized countries with the rest of Europe. Portugal, Greece, Ireland and Finland do not show statistically relevant degrees of synchronization.
Akar (2016)	Period: 1998q1-2014q4 Country: Turkey Series: financial and economic time series	Hodrick-Prescott filter	Concordance index, cross-correlations and dynamic conditional correlation (DCC)	Financial and business cycles are highly synchronized. During the 2008 global crisis DCC dropped to statistically non-significant values.
Artis, et al (2011).	Period: 1880-2006 Countries: 25 advanced and emerging economies Series: Annual GDP	Hodrick-Prescott filter	Correlations in different sub-periods	Synchronization increased during 1950–1973 and accelerated since 1973 within a group of European countries. In other regions country-specific shocks were the dominant forces of business cycle dynamics
Benčík (2011)	Period: 1995q1-2010q3 Countries: Czech Republic, Hungary, Poland, Slovakia and EA15 Series: GDP	Hodrick-Prescott filter	Cross-correlations in different sub-periods	Before 2000, at least one significant negative correlation for each country. Between 2001 and 2007 for the Czech Republic and Hungary, the contemporaneous correlations are significant. For Poland, there are no significant correlations. For Slovakia, the first and third lag and third lead are significant.
Bergman & Jonung (2011)	Period: 1834-2008 Countries: Sweden, Norway, Denmark & selected OECD countries Series: annual GDP	Christiano-Fitzgerald filter	Rolling average cross-correlations	Business cycles in the three Scandinavian countries were more synchronized during the SCU compared to the post-World War II period but not more than during the period prior to the establishment of the union. For the European countries an increase in average cross-correlations was recorded.
Dimitru & Dimitru (2010)	Period: 1997q1-2009q2 Countries: EA and 11 countries that joined the EU in 2004 and 2007, and for Eurozone. Series: quarterly GDP	Quadratic trend, Hodrick-Prescott, Band-Pass filter, Beveridge-Nelson decomposition and Wavelet transformation	Cross-correlations in different sub-periods and concordance index	The correlation of Romania with Eurozone was the lowest, after Hungary. The correlation increased in time, the most in the case of Slovakia and Romania. Slovenia was the most synchronized country.
Filis et al (2010)	Period: 1999q1-2007q2 Countries: Bulgaria and EA15 Series: GDP	Hodrick-Prescott filter and spectral analysis	Squared coherency	Cycles are correlated at 17 and 34 quarters. But a negative phase shift, implies that their phases are not coordinated.
Gouveia (2014)	Period: 2000q1-2011q4	Hodrick-Prescott and	Concordance index, rolling concordance	Degree of synchronization of Balkan countries (except

Authors	Data used	Measure of cycle	Synchronization measure	Conclusions
	Countries: 8 countries in Southeastern Europe Series: GDP	Baxter-King filters	index, Spearman's rank-order correlation coefficients, rolling correlation coefficients and	Greece) tends to increase with slight degrease at the end of the period.
Grigoraş & Stanciu (2016)	Period: 1960/95q1-2014q3 Countries: 30 European and US Series: GDP	Classical definition of business cycles	Concordance index and correlations	A high level concordance with both US and Germany characterizes old EU members, while the most recent countries to join the EU demonstrate the lowest level of concordance.
Kolasa (2013)	Period: 1996q1-2011q4 Countries: Czech Republic, Hungary, Poland, Slovenia, Slovakia Series: major economic series	Hodrick-Prescott filter	Correlations in different sub-periods	Degree of synchronization increased for all countries after joining EU.
Konstantakopoulou & Tsionas (2014)	Period: 1960q1-2010q4 Countries: main OECD countries Series: GDP	Hodrick-Prescott, Christiano-Fitzgerald and Baxter-King filters	Cross-correlations	Synchronization is stronger between the Euro-area's countries. Cycles of Germany, France, Italy, Netherlands, Austria and Belgium are high synchronized.
Mink, Jacobs & de Haan (2011)	Period: 1970q1-2006q4 Countries: 11 European countries Series: GDP	Christiano-Fitzgerald, Hodrick-Prescott and Baxter-King filters	Synchronicity and similarity	The EA output gaps are not more synchronous or similar at the end of our sample period than in the 1970s. Synchronicity and similarity between output gaps of individual countries and the EA fluctuate over time, and often are not higher than would be expected under output gap independence.
Obradović & Mihajlović (2013)	Period: 2001q1-2009q4 Countries: Bulgaria, Croatia, Hungary, Romania, Serbia and Slovenia Series: GDP	Hodrick-Prescott and Baxter-King filters	Correlations in different sub-periods and rolling cross-correlations	With Hungary as the only exception Serbian cycle is not synchronized with cycles in other countries. However, there is a tendency of increasing a degree of synchronization.
Papageorgiou, Michaelides & Milios (2010)	Period: 1960-2009 Countries: major European countries, US & Japan Series: Major annual macroeconomics series	Hodrick-Prescott filter	Correlations in different sub-periods and mean rolling correlations	There is a different degree of synchronization between core and peripheral European countries. European countries increased their synchronization in 1992–1999, but decreased in 2000–2009.
Šergo, Poropat & Gržinić (2012)	Period: 1991m1 and 2010m3 Countries: Croatia Series: 15 macroeconomic series	Hodrick-Prescott filter	Concordance index	Co-movement exists between unemployment and industrial production cycles. The new job position on openings coincides with the growth of exports, construction and tourist arrivals. There is almost perfect synchronization between the construction industry and imports cycles, and slightly less with export cycles.

3. METHODOLOGY

3.1 DATA PREPARATION

There are four methodological problems that have to be addresses when conducting research on business cycle synchronization. They are related to preparation of time series, selection of cycle extraction methods, dating business cycles and selection of synchronization measures. These four issues are addressed in this and the following subsections.

The quarterly time series of GDP at market prices (chain linked volumes, index 2010 = 100) seasonally unadjusted are extracted from the Eurostat Database. The sample period for most of the GDP series used in this study runs from 2000q1 to 2016q3. For Bosnia & Herzegovina and Montenegro quarterly GDP time series were not available, so the quarterly index of industrial production was used instead. Since the focus in this study is on economic fluctuation at business cycle frequencies rather than short-term, seasonal fluctuations and long-term growth it was necessary to remove all seasonal fluctuations and trend. Series were prepared by removing seasonal component using X13-ARIMA procedure. The logarithm of seasonally adjusted real GDP was used, so that the deviations around trend are expressed as percentages.

Non-parametric approach is one of the business cycles extraction methods discussed with other methods in Massmann, Mitchell & Weale (2003). The most commonly used non-parametric approach is a filtering method. It is well known that business cycle analysis results depend on the cycles extraction methods (e.g. Massmann & Mitchell, 2004). In order to assess how robust are the synchronization measures results on using different extraction methods two filters were applied: Hodrick-Prescott (hereafter HP) and Corbae-Ouliaris (hereafter FD) filters.

The starting point of the HP filter (Hodrick & Prescott, 1980) is the following representation of time series

$$y_t = \tau_t + c_t \tag{1}$$

where τ_t is a trend component, and c_t cyclical component we want to extract using HP filter. HP filter minimises variance of the cyclical component penalising the variability in the trend, relative to the cyclical component:

$$\min_{\tau_t} \sum_t (y_t - \tau_t)^2 + \lambda \sum_t (\tau_{t+1} - 2\tau_t + \tau_{t-1})^2 \tag{2}$$

where parameter λ controls smoothness of the trend. When applying HP filter the two-step procedure was used. The most common value used for smoothing

parameter for quarterly series in the first step is $\lambda = 1600$. Since the extracted cycles still contain random component HP filter was applied for the second time on the extracted cycle from the first step. This time smoothing parameter $\lambda = 10$ was used. With this two-step procedure all the random variations were smoothed out. There is no recommendation in the literature for the value of parameter λ in the second step. After conducting experiment with different values for this parameter $\lambda = 10$ was chosen. HP filter has been subject of many critics (e.g. Kaiser & Maravall, 2001). In one of the latest critics Phillips & Hin (2015) demonstrated that against common expectation HP filter does no eliminate unit root in time series and what is even more critical, it could generate cycles that do not exist in the original series.

The other cycle extraction method used is FD filter (Corbae & Ouliaris, 2006), which is an approximation of so-called ideal band pass filter. This filter isolate components of time series within a given range. In business cycle analysis that would be cycles from 1.25 years (5 quarters) to 8 years (32 quarters). The advantage of FD filter over other filters is that it can handle series with nonstationarity (e.g. unit root and heteroscedasticity) without prior testing for type of nonstationarity as it was requested by Christiano-Fitzgerald and Baxter-King filters.

The nonparametric dating rule to isolate turning points in the cycles proposed by Harding & Pagan (2002) was used. Though this rule does not depend on the detrending method used it requires specifying the minimum duration of the cycle. Harding & Pagan recommendation was followed and we set the phases to last at least two quarters and completed cycles to last at least five quarters.

3.2 SYNCHRONIZATION MEASURES

There are a few methods for measuring business cycles synchronizations. The most popular are based on Harding-Pagan concordance index (Harding & Pagan, 2006) and cross-correlation. To assess the changing nature of business cycles synchronization the rolling cross-correlation method on one lag on each side of the lag with the maximal absolute value of the cross-correlation coefficient was used.

3.2.1 CONCORDANCE INDEX

The concordance index measures the proportion of time when two cycles are in the same phase (both in expansion or both in recession). There is a perfect synchronization, i.e. perfect concordance, when the concordance index takes value 1, and when it takes value 0 then there is a perfect discordance, i.e. cycles are always in opposite phases. Index values between 0.5 and 1 indicate

weak to perfect synchronization. Index values from 0 and 0.5 indicate perfect to weak discordance.

First, we determine the business cycles turning points and then define the variable $S_{X,t}$

$$S_{X,t} = \begin{cases} 1, \text{ if } X \text{ is in expansion in time } t \\ 0, \text{ otherwise} \end{cases} \quad (3)$$

Similarly we define $S_{Y,t}$. Then the concordance index between X and Y, C_{XY}, is defined with:

$$C_{XY} = \frac{1}{T}\sum_{t=1}^{T}\left[S_{X,t}S_{Y,t} + \left(1 - S_{X,t}\right)\left(1 - S_{Y,t}\right)\right] \quad (4)$$

For instance, index value of 0.8 shows that the cycles X and Y in the same phase (at the same time in expansion or recession), i.e. they are synchronized 80% of time. For series X we say it is procyclical with Y for concordance index values between 0.5 and 1, and countercyclical for values between 0 and 0.5.

To test the hypothesis that two cycles are synchronized the linear model in (5) is estimated.

$$\frac{s_{Y,t}}{\sigma_{S_Y}} = \nu + \rho_S\left(\frac{s_{X,t}}{\sigma_{S_X}}\right) + \varepsilon_t \quad (5)$$

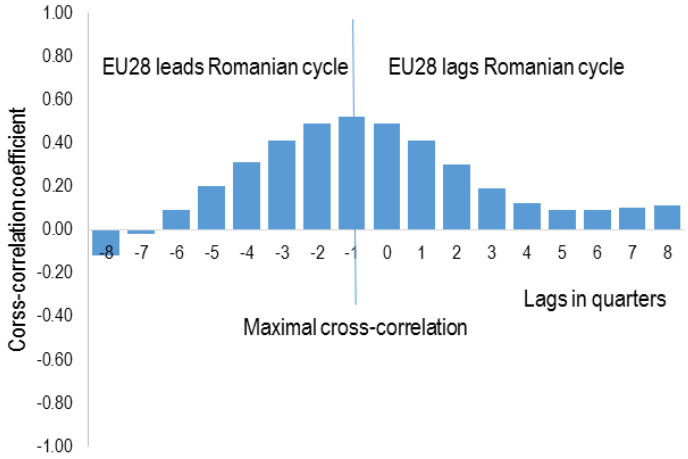
Null hypothesis states that the two cycles are not synchronized, which is equivalent to hypothesis that $\rho_S = 0$. Because of the possible problems with the error in model (5) the Newey-West heteroscedasticity and autocorrelation consistent (HAC) adjusted standard error was used when conducting *t*-test to test the null hypothesis.

3.2.2 CROSS-CORRELATIONS

Cross-correlations analysis is one of the methods used to determine the relationship between the referent country cycle (usually cycle in GDP series of the European Union) and the cycle in GDP series of an individual country. Cross-correlations measure linear dependency between two series at different time lags. The maximum of absolute value of cross correlation is used to indicate whether the individual country cycle is leading, coincident or lagging the referent country cycle.

Figure 1 illustrates use of the cross-correlation coefficients in assessments of business cycle synchronization.

Figure 1. Cross-correlation coefficients between European Union and Romanian business cycles



The cross-correlation coefficient on zero lag is a measure of cyclicality. Its value of 0.49 indicates positive, but weak relationship between EU28 and Romanian cycles. The largest cross-correlation coefficient is on the negative lag, i.e. lead, of one quarter and its value is 0.52. This coefficient indicates that the Romanian cycle in the current quarter is lagging one quarter behind the European Union cycle.

In general, two types of co-movements can be analyzed with the cross-correlation coefficients. First, contemporaneous co-movement which could be: a) procyclical (zero lag correlation is positive), b) countercyclical (zero lag correlation is negative), c) acyclical (if the zero lag correlation is not statistically different from zero). Second, non-contemporaneous co-movements or phase shift which suggest that the series is leading if the largest absolute value of cross-correlation is on negative lag; series is coincidental if the largest absolute value of cross-correlation is on zero lag and lagging if the largest absolute value of cross-correlation is on positive lag.

3.2.3 ROLLING CROSS-CORRELATIONS

To assess whether the business cycles synchronization is changing over time the rolling cross-correlation coefficients have been used. The cross-correlations are calculated in a sub-period (called window). Then the window is shifted ahead for one observation and the coefficients are calculated again. This has been repeated until we reach the last observation in the series. We picked out the lag time corresponding to the maximum correlation between two cycles. For most European countries this is 0 quarters. Then the correlations on one lead and one lag around the selected lag time are calculated. When the cross-correlation coefficient drops down towards zero, there is little

synchronization between two cycles. If the lag 1 value jumps above the lag 0 value, this indicates that the delay time has changed, i.e. one cycle started lagging behind the other cycle. When applying this method we can see whether the synchronization has been maintained over time or changed in some periods resulting in a different lead/lag relationship between two cycles.

When conducting rolling cross-correlations analysis the width of the rolling window, i.e. number of observations in the sub-period used to calculate cross-correlations should be set. The rolling window too "wide open" would result in shorter series of rolling cross-correlations because too many observations would be "lost" at the beginning and end of the cycle. In our analysis two different widths of the rolling window have been used: 16 and 20 quarters. This would allow us to assess how robust are the results to using different rolling window widths.

4. RESULTS

4.1 SUMMARY STATISTICS

Summary statistics of European business cycles are presented in Table 2 (FD filter) and Table 3 (HP filter). We will briefly comments on the volatility of business cycles measured with standard deviation, asymmetry of the business cycles measured with skewness coefficient and flatness of the business cycles distribution measured with kurtosis coefficient using the summary statistics from Table 2. The most volatile business cycles in the last 17 years are in Baltic countries (Estonia, Latvia and Lithuania) with average standard deviation of 6.08 which is more than 5 times larger than volatility in three countries with the least volatile cycles (Belgium, France and Norway). Business cycles of the new EU members, those who joined EU after 2004, are twice as volatile as the cycles of the EU founding members. These results are consistent with findings obtained for developing countries (Agénor, McDermott & Prasad, 2000; Rand & Tarp, 2002).

When it comes to asymmetry of business cycles the EU founding members and old EU members (joined EU before 2004) are less asymmetric with skewness coefficient 0.26 and 0.23 respectively, than the cycles of new EU members with skewness coefficient 0.57. Only five countries (Montenegro, Turkey, Sweden, Germany and Cyprus) had negative skewness coefficient (only 14% of all countries in this study), but not all of these coefficients were statistically significant. Negative skewness coefficient implies asymmetry deepness.

Excess kurtosis was identified in business cycles of Slovakia, Croatia, Luxembourg and Slovenia (kurtosis coefficient ranging from 3.90 to 5.26). This means that big positive and negative values in deviation around trend in these countries are more likely than the normal distribution would suggest.

Table 2. Summary statistics of European business cycles; Period 2000q1-2016q3 (FD filter)

Country	Mean	Median	Max	Min	StdDev	Skewness	Kurtosis	JB	p-val
Austria	0.03	0.11	3.53	-3.06	1.51	0.25	2.65	1.06	0.59
Belgium	0.00	-0.13	2.89	-2.39	1.22	0.37	2.94	1.54	0.46
Bosnia & Herz	0.00	-0.55	6.71	-5.73	3.05	0.31	2.49	1.17	0.56
Bulgaria	-0.21	-1.04	6.02	-3.91	2.97	0.74	2.27	7.54	0.02
Croatia	0.00	-0.14	5.02	-3.16	1.70	0.88	4.38	13.99	0.00
Cyprus	0.03	0.40	3.57	-3.62	2.36	-0.05	1.51	6.19	0.05
Czech Republic	-0.10	-1.01	6.01	-4.40	2.91	0.63	2.18	6.28	0.04
Denmark	-0.04	-0.17	3.85	-3.71	1.79	0.17	2.65	0.66	0.72
Estonia	-0.24	-0.49	12.46	-14.24	5.91	0.09	3.44	0.61	0.74
Finland	-0.05	-0.28	5.96	-5.00	2.44	0.35	2.69	1.67	0.43
France	0.04	-0.09	2.45	-2.41	1.13	0.01	2.60	0.44	0.80
Germany	0.06	-0.14	4.35	-4.52	1.79	-0.10	3.24	0.27	0.87
Greece	-0.25	-0.33	5.71	-6.40	3.33	0.02	2.01	2.73	0.26
Hungary	-0.10	-1.02	4.62	-4.64	2.65	0.24	1.80	4.67	0.10
Iceland	-0.22	-0.74	10.24	-6.10	4.09	0.70	3.09	5.50	0.06
Ireland	-0.29	-0.77	10.64	-8.24	4.85	0.35	2.35	2.57	0.28
Italy	0.04	-0.09	3.24	-3.16	1.47	0.08	2.42	1.01	0.60
Latvia	-0.44	-2.09	15.37	-13.47	7.00	0.46	2.98	2.39	0.30
Lithuania	-0.44	-0.71	13.07	-11.11	5.33	0.49	3.31	2.99	0.22
Luxembourg	0.00	-0.16	7.90	-5.05	2.61	0.96	4.31	15.17	0.00
Macedonia	0.00	-0.26	6.71	-4.40	2.74	0.61	2.82	4.24	0.12
Malta	0.00	-0.47	4.09	-3.35	2.01	0.27	2.04	3.41	0.18
Montenegro	0.00	1.74	6.70	-9.63	4.74	-0.53	2.16	2.04	0.36
Netherlands	0.00	-0.39	4.32	-3.42	2.02	0.23	2.40	1.58	0.45
Norway	-0.09	-0.18	2.77	-2.44	1.25	0.21	2.71	0.74	0.69
Poland	0.00	-1.10	4.50	-3.08	2.42	0.39	1.61	6.23	0.04
Portugal	-0.01	-0.11	3.56	-3.23	2.04	0.11	1.75	4.49	0.11
Romania	-0.18	-1.01	10.25	-6.74	4.60	0.49	2.34	3.94	0.14
Serbia	-0.25	-0.86	6.29	-5.80	2.80	0.52	2.78	3.14	0.21
Slovakia	-0.37	-1.56	8.96	-3.10	2.92	1.74	5.26	47.93	0.00
Slovenia	-0.15	-0.44	8.22	-4.45	2.90	1.05	3.90	14.68	0.00
Spain	-0.06	-0.07	4.18	-3.30	1.94	0.30	2.28	2.46	0.29
Sweden	-0.02	-0.51	4.36	-5.58	2.12	-0.18	3.14	0.43	0.81
Switzerland	0.04	-0.13	3.53	-2.64	1.53	0.35	2.60	1.81	0.40
Turkey	-0.35	0.30	7.92	-9.72	4.83	-0.22	2.19	2.37	0.31
UK	-0.06	-0.39	4.24	-3.54	1.68	0.49	3.15	2.78	0.25
EU28	-0.01	0.02	3.96	-2.87	1.46	0.63	3.35	4.79	0.09
EA19	0.01	-0.06	3.88	-2.71	1.51	0.48	2.81	2.64	0.27

Note: All series are filtered using the Corbae-Ouliaris (FD) filter. In case of Bosnia and Herzegovina and Montenegro industrial cycles were used. Period covered in case of Bosnia and Herzegovina 2006q1-2016q3, Montenegro 2010q1-2016q3 and Poland 2002q1-2016q3. StdDev denotes standard deviation of the cycle; Skewness is a skewness coefficient; Kurtosis is a kurtosis coefficient; JB-test is the Jarque-Bera test statistic for testing normality of the cycle distribution and *p*-val is the Jarque-Bera test statistics *p*-value.

Table 3. Summary statistics of European business cycles; Period 2000q1-2016q3 (HP filter)

Country	Mean	Median	Max	Min	StdDev	Skewness	Kurtosis	JB	p-val
Austria	0.03	-0.08	2.57	-2.21	1.08	0.32	3.04	1.17	0.56
Belgium	0.03	-0.11	1.90	-1.56	0.83	0.34	2.61	1.72	0.42
Bosnia & Herz	0.00	-0.36	4.00	-6.71	2.03	-0.53	4.78	7.64	0.02
Bulgaria	-0.10	-0.46	4.19	-2.62	1.55	1.27	4.06	21.25	0.00
Croatia	0.00	-0.59	4.48	-2.12	1.64	1.35	3.91	22.73	0.00
Cyprus	0.07	0.16	3.77	-3.44	1.59	-0.33	2.75	1.39	0.50
Czech Republic	0.03	-0.09	3.92	-2.18	1.63	0.69	2.74	5.47	0.06
Denmark	0.03	-0.02	2.59	-2.56	1.27	0.13	2.62	0.60	0.74
Estonia	-0.04	-0.40	9.59	-9.73	4.13	0.14	3.88	2.39	0.30
Finland	0.02	-0.29	4.26	-3.69	1.67	0.39	3.53	2.44	0.30
France	0.06	-0.04	1.80	-1.81	0.83	0.01	2.87	0.05	0.98
Germany	0.06	0.02	2.96	-3.11	1.35	-0.09	2.93	0.10	0.95
Greece	-0.02	-0.30	3.46	-4.74	2.27	-0.23	2.41	1.56	0.46
Hungary	0.03	-0.22	2.75	-2.65	1.40	0.26	2.40	1.75	0.42
Iceland	-0.03	-0.33	6.76	-3.96	2.64	0.84	3.40	8.28	0.02
Ireland	0.11	-0.08	6.13	-6.79	3.18	-0.17	2.68	0.60	0.74
Italy	0.07	-0.01	2.37	-2.26	1.12	0.12	2.31	1.51	0.47
Latvia	-0.13	-0.83	11.17	-9.50	4.57	0.54	3.79	5.05	0.08
Lithuania	-0.21	-0.41	8.95	-7.47	3.49	0.60	4.04	7.01	0.03
Luxembourg	0.00	-0.23	5.26	-3.28	1.76	1.23	4.95	27.48	0.00
Macedonia	0.00	0.16	5.96	-3.07	1.76	0.73	4.36	11.07	0.00
Malta	0.00	-0.03	2.20	-1.99	1.08	0.23	2.60	1.03	0.60
Montenegro	0.00	0.67	5.56	-4.83	2.70	-0.11	2.46	0.38	0.83
Netherlands	0.05	-0.03	2.71	-1.73	1.26	0.40	2.09	4.10	0.13
Norway	-0.03	0.02	1.79	-1.46	0.80	0.26	2.77	0.92	0.63
Poland	0.00	-0.06	1.74	-1.43	0.81	0.26	2.34	1.72	0.42
Portugal	0.04	0.12	1.74	-2.39	1.19	-0.27	1.87	4.38	0.11
Romania	-0.02	-0.41	6.15	-2.39	2.03	1.46	4.78	32.54	0.00
Serbia	-0.15	-0.17	3.40	-4.33	1.53	-0.14	3.90	2.48	0.29
Slovakia	-0.22	-0.85	5.47	-2.04	1.84	1.80	5.56	54.44	0.00
Slovenia	-0.01	-0.33	5.33	-2.75	1.90	1.13	3.96	16.86	0.00
Spain	0.06	0.02	3.05	-2.56	1.37	0.18	2.63	0.73	0.69
Sweden	0.04	-0.05	3.16	-3.67	1.52	-0.10	2.92	0.13	0.94
Switzerland	0.04	-0.09	2.30	-1.72	1.05	0.36	2.46	2.31	0.32
Turkey	-0.15	0.84	4.89	-6.53	3.00	-0.35	2.35	2.58	0.28
UK	0.02	-0.22	2.68	-2.34	1.06	0.42	3.72	3.42	0.18
EU28	0.04	-0.07	2.65	-2.01	1.06	0.54	3.04	3.22	0.20
EA19	0.05	-0.03	2.62	-1.96	1.10	0.45	2.58	2.73	0.25

Note: All series are filtered using the Hodrick-Prescott (HP) filter. In case of Bosnia and Herzegovina and Montenegro industrial cycles were used. Period covered in case of Bosnia and Herzegovina 2006q1-2016q3, Montenegro 2010q1-2016q3 and Poland 2002q1-2016q3. StdDev denotes standard deviation of the cycle; Skewness is a skewness coefficient; Kurtosis is a kurtosis coefficient; JB-test is the Jarque-Bera test statistic for testing normality of the cycle distribution and *p*-val is the Jarque-Bera test statistics *p*-value.

Distributions with light tails were identified in Cyprus, Poland, Portugal and Hungary cycles with kurtosis coefficients ranging from 1.51 to 1.80. Distributions with absence of kurtosis were identified in Latvia, Belgium, Iceland and Sweden cycles with kurtosis coefficients ranging from 2.94 to 3.14.

To assess robustness of these results to extraction methods used the Spearman's rank-order correlations were calculated between standard deviations, skewness coefficients and kurtosis coefficients in Tables 2 (FD filter) and 3 (HP filter). There is a high degree of agreement between two rank lists in case of standard deviations and skewness coefficients (0.95 and 0.91 respectively). The Spearman's rank-order correlation value 0.68 in case of kurtosis indicates not so strong monotonic relationship between two kurtosis coefficients series. These results would suggest that the business cycle volatility and asymmetry results are quite robust across the cycle extraction methods used.

4.2 CONCORDANCE INDEX

A quick look at the values of the concordance indexes in Tables 4 and 5, shows that generally concordance indexes are very high indicating that most countries (54% of them in Table 4) spent more than three quarters of the time in the same phase with EU28 aggregate in period from 2000q1 to 2016q3. These are mostly old EU members and some non-EU countries (Switzerland and Iceland).

Results slightly vary with the cycle extraction methods used (FD and HP filters) and whether we are computing concordance index with EU28 or EA19 aggregates. The following countries have degree of concordance about 90% in at least one of these four lists: Belgium, Slovenia, Czech Republic, Italy, Sweden and Cyprus. The highest degree of concordance (above 90%) seems to be between the EU28 and Belgium with 98% (HP filter and EU28), along with Czech Republic with 97% (HP filter and EA19).

At the other end of concordance scale are the countries who are identified to be not synchronized with EU28 or EA19 aggregates in period from 2000q1 to 2016q3. They are Montenegro, Serbia, Romania, Latvia, Lithuania, Turkey and UK with concordance indexes ranging from 0.37 to 0.67 (Table 4). As explained before concordance index values below 0.5 indicate that the two cycles are in opposite phases in some sub-periods. However, any concordance index value below 0.7 could be treated as statistically not significant at the 5% significance level. Border cases are Bosnia and Herzegovina, Croatia, Norway and Poland who could be described as only weakly synchronized with either EU28 or EA19 aggregates. This means that Poland, some Western Balkan and Baltic countries would not have net benefits from euro adoption.

Table 4. Concordance index, 2000q1-2016q3 (FD filter)

	Austria	Belgium	B&H	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	EA19	Estonia	EU28	Finland	France
Austria	1	.85	.67	.62	.68	.83	.68	.71	.83	.59	.79	.91	.85
Belgium	.00	1	.63	.71	.65	.83	.77	.80	.89	.65	.88	.88	.79
B&H	.03	.12	1	.77	.72	.65	.79	.63	.70	.49	.70	.77	.65
Bulgaria	.02	.00	.00	1	.61	.73	.85	.70	.79	.58	.83	.71	.62
Croatia	.02	.10	.03	.17	1	.73	.64	.61	.73	.58	.68	.68	.71
Cyprus	.00	.00	.23	.00	.00	1	.79	.73	.91	.58	.86	.77	.77
Czech Republic	.02	.00	.00	.00	.14	.00	1	.76	.85	.67	.89	.77	.68
Denmark	.02	.00	.20	.00	.29	.01	.00	1	.82	.67	.86	.77	.80
EA19	.00	.00	.01	.00	.01	.00	.00	.00	1	.64	.95	.86	.80
Estonia	.28	.04	.88	.45	.46	.36	.10	.11	.15	1	.68	.65	.59
EU28	.00	.00	.01	.00	.05	.00	.00	.00	.00	.03	1	.85	.79
Finland	.00	.00	.00	.00	.06	.00	.00	.00	.00	.10	.00	1	.85
France	.00	.00	.06	.09	.01	.01	.04	.00	.01	.28	.00	.00	1
Germany	.00	.00	.02	.01	.00	.00	.00	.06	.00	.59	.00	.00	.00
Greece	.57	.11	.18	.15	.12	.11	.10	.24	.03	.83	.08	.34	.56
Hungary	.16	.03	.62	.08	.22	.10	.08	.00	.01	.08	.00	.05	.01
Iceland	.04	.05	.51	.00	.04	.00	.00	.01	.00	.42	.00	.06	.00
Ireland	.00	.00	.11	.00	.69	.00	.00	.01	.00	.10	.00	.00	.00
Italy	.00	.00	.08	.00	.00	.00	.00	.00	.00	.23	.00	.00	.00
Latvia	.39	.11	.73	.57	.03	.81	.51	.05	.25	.00	.13	.16	.13
Lithuania	.11	.14	.04	.44	.07	.33	.40	.06	.20	.00	.10	.05	.25
Luxembourg	.26	.01	.24	.08	.23	.07	.04	.00	.01	.41	.02	.08	.00
Macedonia, FRY	.63	.16	.14	.00	.10	.12	.00	.03	.01	.60	.00	.27	.12
Malta	.39	.02	.00	.02	.14	.07	.00	.00	.01	.03	.00	.06	.06
Montenegro	.92	.58	.00	.86	.49	.84	.49	.85	.92	.29	.92	.88	.68
Netherlands	.00	.00	.26	.00	.18	.00	.00	.00	.00	.00	.00	.01	.00
Norway	.02	.01	.19	.05	.78	.24	.06	.06	.02	.11	.00	.00	.12
Poland	.01	.02	.24	.00	.16	.01	.29	.10	.03	.60	.09	.02	.00
Portugal	.01	.00	.01	.00	.13	.00	.00	.00	.00	.48	.00	.00	.01
Romania	.35	.97	.27	.39	.35	.95	.87	.78	.60	.21	.88	.60	.96
Serbia	.10	.51	.03	.03	.08	.21	.43	.64	.17	.24	.12	.10	.03
Slovakia	.04	.00	.02	.00	.01	.00	.00	.01	.00	.03	.00	.00	.16
Slovenia	.00	.00	.00	.00	.01	.00	.00	.00	.00	.07	.00	.00	.00
Spain	.04	.00	.02	.00	.02	.00	.00	.00	.00	.02	.00	.01	.13
Sweden	.00	.00	.01	.00	.21	.00	.00	.00	.00	.03	.00	.00	.01
Switzerland	.02	.01	.03	.03	.71	.22	.01	.00	.03	.04	.01	.00	.00
Turkey	.01	.07	.31	.21	.05	.50	.35	.00	.19	.46	.08	.00	.00
UK	.16	.03	.50	.67	.38	.37	.17	.00	.09	.00	.05	.07	.05

Note: Numbers above the main diagonal are concordance indices and numbers below main diagonal are their *p*-values.

Table 4 (continue). Concordance index, 2000q1-2016q3 (FD filter)

	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Macedonia, FRY	Malta	Montenegro	Netherlands
Austria	.85	.56	.58	.67	.76	.71	.53	.62	.59	.53	.59	.52	.77
Belgium	.79	.65	.67	.70	.76	.83	.62	.65	.68	.62	.68	.41	.80
B&H	.72	.67	.56	.58	.65	.65	.56	.72	.65	.65	.74	.78	.63
Bulgaria	.65	.64	.68	.74	.71	.76	.61	.61	.64	.73	.67	.52	.76
Croatia	.80	.67	.62	.68	.53	.70	.67	.73	.61	.67	.61	.56	.64
Cyprus	.83	.67	.62	.74	.74	.82	.52	.58	.64	.61	.67	.52	.85
Czech Republic	.74	.67	.65	.77	.80	.88	.58	.61	.67	.73	.76	.59	.85
Denmark	.68	.61	.80	.74	.71	.73	.64	.67	.73	.70	.73	.48	.79
EA19	.86	.73	.71	.77	.74	.88	.61	.64	.70	.70	.70	.48	.85
Estonia	.56	.48	.62	.59	.65	.61	.79	.76	.58	.45	.67	.37	.67
EU28	.82	.68	.76	.82	.79	.86	.65	.68	.68	.74	.74	.48	.89
Finland	.88	.59	.64	.70	.76	.80	.59	.68	.62	.59	.65	.52	.74
France	.82	.56	.70	.76	.73	.77	.59	.59	.71	.62	.65	.56	.74
Germany	1	.62	.64	.70	.64	.83	.56	.62	.65	.62	.59	.44	.74
Greece	.25	1	.62	.65	.62	.67	.58	.64	.70	.73	.67	.59	.64
Hungary	.07	.20	1	.67	.61	.68	.74	.65	.71	.71	.68	.37	.68
Iceland	.05	.04	.00	1	.70	.77	.68	.62	.65	.71	.59	.48	.74
Ireland	.08	.04	.05	.04	1	.71	.59	.56	.68	.65	.71	.70	.77
Italy	.00	.06	.03	.00	.00	1	.58	.55	.70	.70	.67	.44	.82
Latvia	.43	.49	.02	.03	.19	.58	1	.82	.67	.58	.64	.44	.58
Lithuania	.23	.24	.18	.32	.38	.87	.00	1	.61	.61	.67	.56	.61
Luxembourg	.05	.03	.00	.05	.01	.00	.04	.25	1	.70	.67	.56	.67
Macedonia, FRY	.13	.01	.01	.01	.04	.00	.58	.42	.01	1	.67	.59	.70
Malta	.35	.07	.00	.21	.01	.01	.02	.00	.05	.05	1	.63	.73
Montenegro	.66	.43	.06	.94	.05	.63	.30	.29	.61	.21	.34	1	.44
Netherlands	.01	.17	.02	.00	.00	.00	.26	.34	.03	.00	.00	.59	1
Norway	.05	.10	.09	.11	.13	.31	.00	.01	.37	.27	.10	.60	.18
Poland	.21	.28	.11	.17	.06	.32	.79	.34	.13	.88	.93	.52	.12
Portugal	.00	.00	.07	.10	.00	.00	.59	.50	.00	.00	.01	.37	.00
Romania	.85	.01	.00	.33	.42	.81	.44	.89	.52	.01	.84	.90	.73
Serbia	.02	.82	.46	.01	.71	.24	.68	.97	.90	.36	.91	.90	.39
Slovakia	.01	.06	.18	.15	.00	.01	.13	.01	.28	.00	.00	.89	.00
Slovenia	.00	.02	.01	.01	.00	.00	.20	.26	.01	.00	.00	.66	.00
Spain	.01	.12	.01	.03	.00	.00	.04	.09	.04	.00	.00	.72	.00
Sweden	.00	.01	.00	.00	.00	.00	.05	.10	.00	.00	.00	.66	.00
Switzerland	.02	.30	.00	.05	.03	.00	.04	.11	.00	.00	.01	.67	.00
Turkey	.03	.95	.00	.07	.02	.08	.33	.09	.05	.03	.76	.61	.63
UK	.57	.04	.05	.29	.02	.63	.00	.00	.01	.12	.00	.52	.08

A reason for this finding for Poland, some Western Balkan and Baltic countries may be related to the fact that some of these countries became EU members in 2004, when their synchronization with EU28 aggregate increased significantly. However, before becoming EU members their business cycles were almost all the time in the opposite phase with the EU cycle. Therefore in the whole period for these countries luck of or very weak synchronization was

detected. It would be interesting to calculate synchronization measures in sub-periods (before and after they came EU members). Instead of calculating the concordance index or average correlations in such sub-periods we have opted to use rolling cross-correlation coefficients to assess changes in a degree of synchronization.

Table 4 (continue). Concordance index, 2000q1-2016q3 (FD filter)

	Norway	Poland	Portugal	Romania	Serbia	Slovakia	Slovenia	Spain	Sweden	Switzerland	Turkey	United Kingdom
Austria	.70	.75	.76	.39	.62	.65	.76	.70	.73	.71	.65	.59
Belgium	.70	.68	.88	.52	.56	.74	.85	.79	.82	.71	.65	.68
B&H	.65	.60	.74	.60	.70	.67	.74	.74	.72	.72	.58	.58
Bulgaria	.68	.68	.74	.62	.67	.76	.80	.77	.83	.70	.61	.58
Croatia	.53	.64	.62	.59	.64	.73	.71	.68	.62	.55	.67	.61
Cyprus	.59	.73	.80	.50	.61	.73	.86	.80	.80	.64	.55	.58
Czech Republic	.68	.59	.83	.53	.58	.82	.89	.89	.89	.79	.58	.64
Denmark	.65	.63	.74	.53	.55	.70	.77	.74	.80	.79	.73	.76
EA19	.68	.69	.89	.56	.61	.79	.92	.83	.89	.73	.61	.67
Estonia	.62	.54	.56	.41	.42	.67	.62	.65	.68	.67	.58	.79
EU28	.73	.64	.85	.55	.62	.83	.91	.88	.94	.77	.65	.71
Finland	.76	.69	.79	.45	.62	.71	.82	.73	.79	.77	.71	.65
France	.64	.75	.73	.48	.65	.62	.76	.67	.73	.80	.74	.65
Germany	.67	.64	.76	.48	.68	.71	.82	.73	.76	.71	.65	.56
Greece	.62	.61	.77	.68	.48	.70	.74	.68	.71	.61	.52	.70
Hungary	.64	.59	.61	.70	.56	.65	.70	.67	.73	.71	.71	.71
Iceland	.67	.63	.67	.64	.74	.65	.73	.70	.76	.71	.65	.62
Ireland	.67	.66	.79	.42	.47	.71	.76	.79	.85	.77	.65	.68
Italy	.59	.59	.83	.56	.61	.73	.89	.80	.83	.76	.64	.58
Latvia	.71	.51	.53	.62	.55	.64	.59	.62	.65	.61	.61	.79
Lithuania	.71	.58	.56	.56	.52	.73	.62	.65	.65	.64	.64	.82
Luxembourg	.59	.63	.74	.56	.52	.61	.71	.68	.74	.79	.67	.73
Macedonia, FRY	.59	.47	.71	.68	.58	.79	.74	.74	.74	.70	.70	.67
Malta	.62	.51	.74	.50	.48	.76	.77	.83	.74	.73	.52	.73
Montenegro	.44	.44	.67	.48	.48	.52	.56	.56	.56	.44	.56	.56
Netherlands	.65	.64	.77	.47	.58	.79	.89	.89	.86	.76	.55	.67
Norway	1	.63	.67	.58	.62	.71	.67	.67	.70	.68	.56	.71
Poland	.17	1	.61	.58	.58	.54	.63	.56	.61	.58	.61	.58
Portugal	.04	.24	1	.55	.53	.77	.88	.82	.85	.74	.56	.65
Romania	.42	.25	.46	1	.68	.56	.55	.48	.52	.47	.53	.59
Serbia	.11	.41	.72	.01	1	.52	.59	.53	.56	.58	.58	.42
Slovakia	.00	.57	.00	.59	.92	1	.83	.86	.80	.67	.61	.76
Slovenia	.10	.14	.00	.56	.27	.00	1	.91	.91	.74	.56	.65
Spain	.10	.61	.00	.96	.69	.00	.00	1	.88	.74	.53	.65
Sweden	.06	.11	.00	.92	.35	.00	.00	.00	1	.80	.65	.71
Switzerland	.12	.41	.01	.65	.23	.12	.03	.06	.00	1	.70	.70
Turkey	.41	.08	.36	.92	.30	.23	.37	.63	.09	.01	1	.67
UK	.00	.29	.04	.29	.35	.01	.14	.11	.08	.02	.07	1

Table 5. Concordance index, 2000q1-2016q3 (HP filter)

	Austria	Belgium	B&H	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	EA19	Estonia	EU28	Finland	France
Austria	1	.88	.74	.79	.74	.89	.86	.74	.86	.74	.86	.97	.89
Belgium	.00	1	.72	.79	.68	.86	.92	.86	.95	.62	.98	.88	.92
B&H	.00	.04	1	.70	.70	.77	.77	.60	.74	.47	.72	.74	.67
Bulgaria	.00	.00	.11	1	.74	.80	.83	.65	.80	.59	.80	.76	.77
Croatia	.01	.08	.05	.03	1	.76	.67	.55	.67	.58	.67	.71	.70
Cyprus	.00	.00	.01	.00	.01	1	.85	.73	.85	.64	.85	.86	.88
Czech Republic	.00	.00	.01	.00	.07	.00	1	.79	.97	.67	.94	.83	.85
Denmark	.04	.00	.33	.07	.65	.02	.00	1	.82	.70	.85	.74	.82
EA19	.00	.00	.01	.00	.04	.00	.00	.00	1	.64	.97	.83	.88
Estonia	.01	.20	.96	.15	.49	.10	.18	.07	.20	1	.64	.71	.67
EU28	.00	.00	.01	.00	.08	.00	.00	.00	.00	.09	1	.86	.91
Finland	.00	.00	.01	.00	.09	.00	.00	.05	.00	.01	.00	1	.92
France	.00	.00	.01	.00	.11	.00	.00	.01	.00	.05	.00	.00	1
Germany	.00	.00	.04	.00	.00	.00	.00	.02	.00	.05	.00	.00	.00
Greece	.98	.24	.16	1.00	.26	.49	.37	.68	.23	.27	.20	.81	.41
Hungary	.03	.00	.09	.17	.39	.01	.00	.00	.00	.22	.00	.03	.00
Iceland	.00	.01	.23	.18	.17	.00	.02	.02	.02	.03	.01	.00	.00
Ireland	.00	.00	.17	.01	.42	.00	.00	.00	.00	.15	.00	.00	.00
Italy	.00	.00	.01	.00	.21	.00	.00	.00	.00	.18	.00	.00	.00
Latvia	.25	.73	.73	.89	.26	.86	.84	.07	.84	.00	.81	.38	.71
Lithuania	.70	.56	.71	.95	.70	.26	.66	.73	.50	.01	.59	.78	.43
Luxembourg	.12	.00	.05	.47	.36	.04	.00	.00	.00	.66	.00	.07	.01
Macedonia, FRY	.60	.02	.03	.89	.46	.34	.14	.05	.06	.05	.03	.28	.04
Malta	.20	.00	.03	.06	.28	.03	.00	.00	.00	.46	.00	.30	.08
Montenegro	.28	.12	.24	.25	.39	.33	.34	.28	.34	.03	.12	.28	.33
Netherlands	.00	.00	.01	.00	.01	.00	.00	.00	.00	.18	.00	.00	.00
Norway	.20	.02	.93	.53	.63	.16	.06	.00	.06	.09	.03	.18	.15
Poland	.05	.00	.13	.04	.02	.00	.01	.00	.01	.14	.00	.01	.00
Portugal	.00	.00	.02	.00	.53	.00	.00	.00	.00	.73	.00	.01	.00
Romania	.47	.32	.34	.17	.75	.13	.23	.62	.39	.99	.26	.40	.52
Serbia	.07	.57	.01	.04	.64	.19	.28	.94	.44	.53	.47	.13	.50
Slovakia	.03	.08	.18	.00	.00	.05	.05	.55	.11	.26	.16	.17	.13
Slovenia	.00	.00	.00	.01	.00	.00	.00	.02	.00	.49	.00	.01	.00
Spain	.00	.00	.01	.00	.00	.00	.00	.00	.00	.16	.00	.00	.00
Sweden	.00	.00	.04	.00	.13	.00	.00	.00	.00	.27	.00	.00	.00
Switzerland	.30	.00	.29	.20	.99	.12	.01	.00	.00	.07	.00	.25	.06
Turkey	.25	.56	.20	.86	.52	.91	.97	.02	.80	.05	.65	.14	.34
UK	.51	.20	.92	.68	.32	.74	.48	.00	.35	.01	.25	.39	.32

Note: Numbers above the main diagonal are concordance indices and numbers below main diagonal are their *p*-values.

Only a few countries had concordance index value above 90%. This is simply the fact that in the whole period there were significant changes in the level of synchronization with some drop in the level of concordance around 2004 and at the end of the period, i.e. after 2012. These changes caused the concordance index drop to or below 90%.

Table 5 (continue). Concordance index, 2000q1-2016q3 (HP filter)

	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Macedonia, FRY	Malta	Montenegro	Netherlands
Austria	.80	.50	.74	.80	.77	.82	.62	.44	.64	.53	.65	.33	.86
Belgium	.86	.62	.83	.80	.86	.94	.53	.44	.76	.65	.71	.33	.92
B&H	.70	.70	.67	.70	.63	.72	.53	.56	.72	.70	.72	.56	.79
Bulgaria	.77	.53	.65	.71	.68	.79	.50	.53	.55	.53	.65	.37	.80
Croatia	.76	.61	.61	.67	.58	.62	.64	.58	.59	.58	.61	.37	.73
Cyprus	.82	.58	.73	.79	.76	.80	.52	.33	.65	.58	.67	.37	.88
Czech Republic	.88	.61	.79	.76	.82	.95	.52	.45	.71	.61	.73	.37	.94
Denmark	.73	.55	.91	.73	.85	.83	.67	.55	.83	.64	.79	.41	.79
EA19	.88	.64	.79	.76	.85	.95	.52	.42	.74	.64	.73	.37	.94
Estonia	.70	.33	.64	.64	.64	.65	.82	.67	.56	.33	.61	.30	.64
EU28	.88	.64	.82	.79	.85	.95	.52	.45	.74	.64	.70	.33	.91
Finland	.77	.53	.77	.80	.80	.82	.59	.47	.67	.56	.62	.33	.83
France	.82	.58	.79	.79	.88	.89	.55	.39	.74	.61	.64	.37	.85
Germany	1	.64	.70	.67	.76	.86	.52	.48	.71	.52	.67	.30	.85
Greece	.12	1	.55	.61	.58	.62	.39	.45	.65	.67	.61	.70	.61
Hungary	.03	.70	1	.73	.82	.77	.67	.61	.83	.70	.79	.44	.79
Iceland	.12	.43	.01	1	.67	.74	.67	.52	.65	.55	.67	.59	.79
Ireland	.01	.34	.00	.13	1	.86	.52	.42	.80	.67	.73	.48	.82
Italy	.00	.23	.00	.04	.00	1	.50	.44	.76	.62	.68	.37	.89
Latvia	.90	.34	.09	.03	.91	.93	1	.79	.62	.45	.64	.48	.55
Lithuania	.88	.52	.37	.90	.48	.50	.00	1	.56	.45	.55	.41	.42
Luxembourg	.01	.05	.00	.01	.00	.00	.23	.47	1	.68	.71	.52	.71
Macedonia, FRY	.91	.08	.00	.72	.01	.09	.70	.41	.03	1	.67	.63	.64
Malta	.01	.36	.00	.06	.00	.00	.16	.64	.01	.06	1	.63	.79
Montenegro	.01	.01	.63	.01	.93	.34	.88	.49	.65	.19	.02	1	.37
Netherlands	.00	.43	.00	.01	.00	.00	.70	.58	.00	.09	.00	.33	1
Norway	.26	.77	.00	.00	.03	.09	.01	.18	.00	.33	.06	.94	.04
Poland	.00	.32	.00	.17	.00	.00	.86	.50	.00	.41	.03	.67	.00
Portugal	.00	.00	.01	.13	.00	.00	.42	.27	.00	.07	.01	1.00	.00
Romania	.12	.33	.44	.04	.83	.32	.86	.62	.36	.65	.61	.18	.36
Serbia	.79	.83	.95	.09	.40	.51	.41	.75	.38	.89	.76	.49	.46
Slovakia	.00	.86	.33	.45	.34	.11	.42	.49	.33	.83	.21	.13	.02
Slovenia	.00	.13	.00	.01	.00	.00	.44	.98	.00	.29	.00	.45	.00
Spain	.00	.15	.01	.02	.00	.00	.70	.83	.00	.30	.00	.50	.00
Sweden	.00	.25	.00	.04	.00	.00	.89	.51	.00	.00	.01	.06	.00
Switzerland	.09	.62	.00	.04	.00	.00	.03	.38	.00	.13	.00	.44	.01
Turkey	.76	.53	.02	.28	.37	.75	.00	.00	.08	.50	.22	.75	.95
UK	.41	.66	.00	.09	.06	.40	.00	.01	.02	.20	.01	.77	.26

This will be investigated in more details in the rolling cross-correlations section. The degree of concordance between 80% and 90% characterize countries, which almost entirely belong to the group of old EU members (Spain, Portugal, Germany, Finland, France, Denmark, Austria and Ireland,), with Bulgaria being the only exception.

Table 5 (continue). Concordance index, 2000q1-2016q3 (HP filter)

	Norway	Poland	Portugal	Romania	Serbia	Slovakia	Slovenia	Spain	Sweden	Switzerland	Turkey	United Kingdom
Austria	.67	.71	.73	.56	.67	.73	.76	.82	.83	.70	.62	.59
Belgium	.73	.78	.85	.62	.58	.70	.82	.88	.92	.79	.59	.68
B&H	.51	.65	.74	.70	.72	.70	.81	.79	.70	.65	.56	.56
Bulgaria	.58	.69	.70	.71	.76	.85	.70	.76	.74	.64	.50	.50
Croatia	.56	.69	.56	.55	.56	.86	.80	.71	.67	.50	.58	.61
Cyprus	.62	.76	.77	.64	.62	.71	.80	.80	.82	.68	.52	.55
Czech Republic	.68	.76	.86	.64	.62	.71	.83	.92	.88	.80	.52	.61
Denmark	.83	.73	.74	.55	.50	.56	.71	.74	.82	.89	.73	.79
EA19	.68	.75	.86	.61	.59	.68	.83	.92	.91	.80	.55	.64
Estonia	.65	.66	.53	.45	.53	.59	.59	.68	.61	.71	.67	.67
EU28	.71	.78	.86	.64	.59	.68	.80	.89	.91	.80	.58	.67
Finland	.70	.75	.73	.59	.64	.70	.73	.79	.86	.70	.65	.62
France	.68	.76	.77	.58	.56	.68	.74	.80	.94	.71	.64	.64
Germany	.59	.86	.80	.61	.53	.77	.86	.89	.82	.68	.45	.61
Greece	.53	.61	.74	.64	.50	.50	.65	.65	.61	.56	.45	.58
Hungary	.89	.80	.71	.58	.50	.62	.77	.74	.82	.86	.70	.79
Iceland	.77	.59	.68	.76	.71	.62	.71	.71	.73	.71	.61	.70
Ireland	.71	.80	.77	.52	.44	.59	.71	.80	.91	.77	.64	.67
Italy	.67	.75	.88	.62	.58	.67	.79	.88	.92	.79	.56	.62
Latvia	.71	.53	.41	.45	.56	.59	.59	.56	.52	.68	.79	.76
Lithuania	.65	.58	.38	.61	.56	.62	.50	.47	.42	.62	.73	.76
Luxembourg	.76	.75	.73	.56	.42	.58	.79	.73	.80	.79	.65	.71
Macedonia, FRY	.59	.56	.65	.48	.50	.53	.62	.59	.67	.59	.58	.64
Malta	.68	.66	.68	.55	.53	.62	.74	.77	.67	.80	.61	.70
Montenegro	.48	.41	.48	.56	.56	.30	.41	.41	.33	.41	.44	.44
Netherlands	.68	.76	.80	.61	.59	.74	.89	.92	.88	.77	.52	.64
Norway	1	.68	.61	.65	.48	.55	.67	.64	.71	.79	.65	.80
Poland	.02	1	.75	.64	.49	.75	.81	.80	.78	.69	.47	.64
Portugal	.34	.00	1	.65	.58	.58	.76	.82	.80	.73	.47	.56
Romania	.15	.02	.19	1	.74	.62	.59	.56	.58	.56	.45	.55
Serbia	.86	.97	.44	.00	1	.64	.52	.55	.50	.55	.56	.44
Slovakia	.66	.00	.52	.34	.24	1	.79	.73	.68	.52	.50	.56
Slovenia	.09	.00	.00	.12	.85	.00	1	.88	.80	.70	.47	.62
Spain	.18	.00	.00	.50	.64	.04	.00	1	.83	.76	.47	.62
Sweden	.04	.00	.00	.46	.88	.13	.00	.00	1	.74	.61	.67
Switzerland	.00	.06	.01	.42	.64	.93	.07	.02	.02	1	.71	.74
Turkey	.07	.91	.69	.31	.64	.92	.82	.81	.56	.01	1	.79
UK	.00	.05	.72	.77	.40	.80	.18	.28	.21	.01	.00	1

The lowest level of concordance (between 70% and 80%) with both EU28 and EA19 aggregates seems to be recorded mostly for new EU members such as Hungary, Slovakia, Malta and Poland, with exception of Luxembourg, and two non-EU countries: Bosnia & Herzegovina and Norway.

Old EU members are all European countries who joined EU before 2004, while new EU members joined EU after 2004 (the last was Croatia who joined EU in 2013). Non-EU members group consists of quite different countries, including on one hand Iceland, Norway and Switzerland all three synchronized with EU cycle to some extent and on the other hand a few Western Balkan countries which are mostly not synchronized with EU cycle.

Table 6. Average concordance index; Period 2000q1-2016q3

	Old EU members		New EU members		Non–EU members	
	FD	HP	FD	HP	FD	HP
EA19	0.82	0.85	0.73	0.71	0.66	0.64
EU28	0.82	0.85	0.75	0.72	0.69	0.65

Concordance indexes of 0.82 (FD filter) and 0.85 (HP filter) for old EU members in Table 6 suggest that their cycles were more than 80% of time in the same phase with Euro Area and European Union cycles. New EU members were also synchronized with EA19 and EU28 cycles but with lower degree of synchronization. Non-EU members were least synchronized confirming the same results from the other studies of business cycles synchronization. All these results are quire robust across the cycle extraction methods used.

Another way to assess robustness of these results across the cycle extraction methods used is to calculate rank correlation between rank list of concordance indexes calculated from cycles obtained after FD and HP filters were used. There is a high degree of agreement between rank lists of concordance indexes based on FD and HP filters. The Spearman's rank-order correlation coefficients for EU28 and EA19 rank lists between two filters results are 0.9 and 0.91 respectively.

Figures 2 and 3 show the relationships between business cycle volatility and concordance index for results based on FD and HP filters respectively. Negative slope of the scatterplot on both Figures 2 and 3 indicates that there is a tendency among European countries with more volatile business cycles to be less synchronized with the Euro Area cycle. Most of the old EU members are located in the right bottom corner of the scatterplot characterized by low volatility and high concordance index, i.e. high synchronization with EA19 cycle. Visual inspection of these two scatterplots suggests that the negative relationship between volatility and synchronization and position of individual countries on these scatterplots are not significantly influenced by the cycle extraction methods used.

Figure 2. Volatility vs. Concordance index (FD filter)

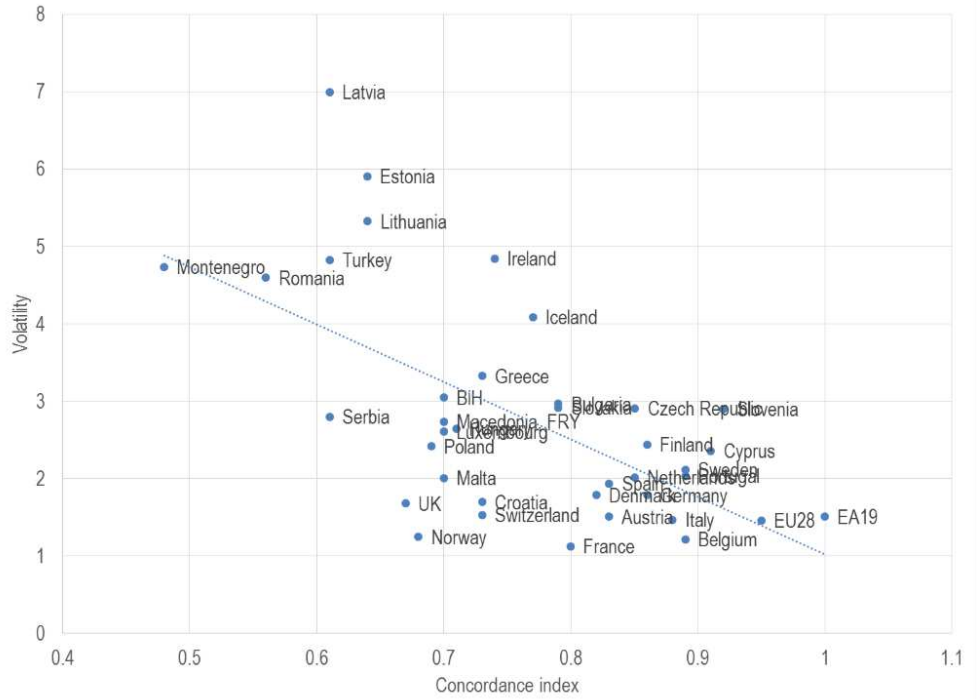
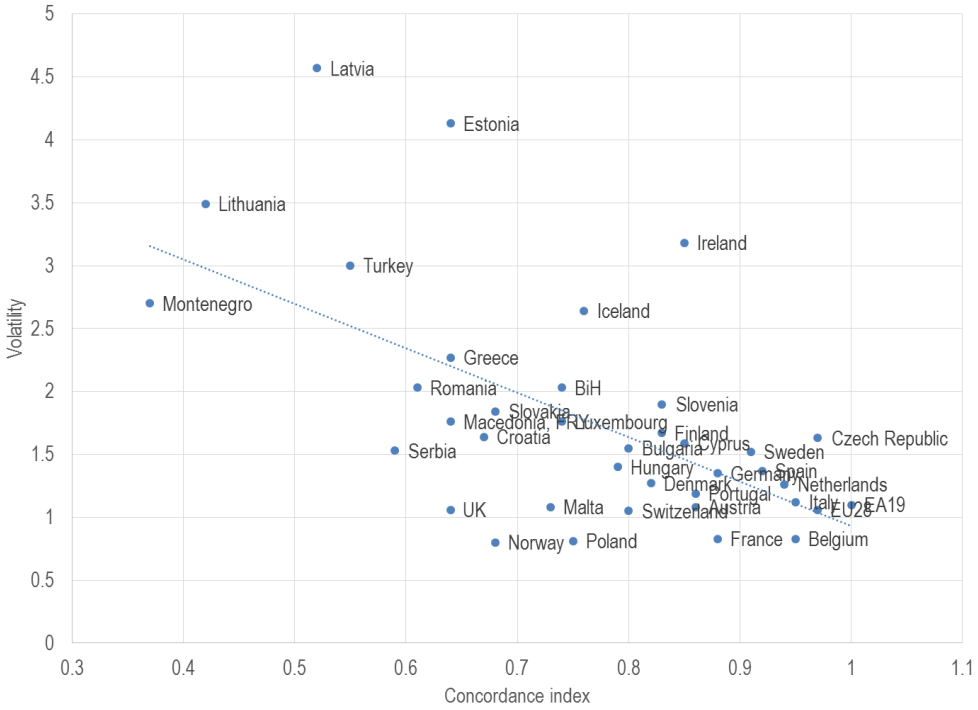


Figure 3. Volatility vs. Concordance index (HP filter)



4.3 CROSS-CORRELATIONS

From Table 7 we can see that most European countries, i.e. 60% of them, have the maximum value of the cross-correlation at zero lag indicating that their cycles are synchronized with the EU28 cycle (50% in Table 8).

Table 7. Cross-correlations of EU28 and European countries cycles; Period: 2000q1 – 2016q3 (FD filter)

Lag *j*:	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
Austria	-.08	.10	.32	.54	.74	.86	**.88**	.77	.58	.34	.10	-.12	-.28
Belgium	-.19	-.05	.14	.38	.61	.80	**.90**	.86	.71	.49	.25	.02	-.16
B&H	.14	.23	.36	.47	.50	.43	.25	.02	-.23	-.45	-.60	-.67	**-.66**
Bulgaria	.03	.19	.35	.50	.60	**.64**	.60	.51	.39	.27	.17	.09	.05
Croatia	.14	.33	.53	.71	.85	**.90**	.85	.69	.46	.19	-.05	-.25	-.38
Cyprus	.26	.35	.43	.51	**.55**	.54	.46	.31	.12	-.08	-.26	-.39	-.49
Czech Repub.	-.07	.11	.31	.52	.69	.79	**.82**	.77	.65	.50	.35	.21	.09
Denmark	-.23	-.05	.17	.42	.66	.84	**.92**	.90	.78	.62	.45	.29	.15
Estonia	-.31	-.11	.11	.32	.51	.65	**.71**	.71	.65	.56	.44	.31	.19
Finland	-.11	.07	.29	.52	.72	.84	**.86**	.76	.56	.32	.08	-.13	-.29
France	-.20	-.03	.18	.42	.64	.80	**.86**	.80	.64	.42	.18	-.03	-.20
Germany	-.16	.02	.25	.50	.73	.88	**.91**	.81	.61	.35	.09	-.14	-.31
Greece	.35	.34	.34	.35	.38	.41	**.44**	.43	.38	.30	.20	.10	.01
Hungary	-.31	-.16	.03	.23	.42	.57	**.65**	.64	.59	.51	.43	.37	.32
Iceland	.21	.39	.56	.68	.77	**.80**	.78	.69	.56	.41	.25	.11	.00
Ireland	-.06	.05	.19	.34	.49	.61	.69	**.71**	.67	.58	.45	.31	.16
Italy	-.26	-.09	.14	.41	.66	.85	**.94**	.89	.73	.49	.24	.00	-.20
Latvia	-.10	.09	.28	.45	.58	.67	**.70**	.67	.61	.51	.40	.29	.19
Lithuania	-.14	.04	.23	.42	.56	.65	**.66**	.61	.50	.37	.24	.13	.06
Luxembourg	-.13	-.01	.15	.37	.60	.80	**.93**	.93	.81	.59	.33	.06	-.17
Macedonia	.06	.14	.24	.37	.49	.59	**.63**	.57	.46	.33	.20	.11	.05
Malta	.19	.27	.39	.52	.65	.72	**.72**	.64	.52	.37	.21	.05	-.09
Montenegro	-.05	-.21	-.28	**-.28**	-.21	-.09	.04	.15	.22	.24	.22	.16	.08
Netherlands	.20	.33	.48	.63	.74	.80	**.78**	.66	.46	.24	.01	-.19	-.35
Norway	.13	.27	.39	.51	.61	.68	**.71**	.68	.58	.45	.31	.19	.09
Poland	.22	.29	.37	.43	.47	**.49**	.48	.42	.31	.18	.03	-.11	-.22
Portugal	.19	.21	.28	.36	.46	.52	**.54**	.47	.33	.15	-.05	-.23	-.38
Romania	.09	.20	.31	.41	.49	**.52**	.49	.41	.30	.19	.12	.09	.09
Serbia	.03	.12	.21	.30	.38	**.42**	.40	.33	.23	.15	.10	.10	.12
Slovakia	.12	.26	.43	.60	.74	**.83**	.82	.73	.57	.36	.15	-.02	-.14
Slovenia	.10	.27	.46	.66	.82	**.91**	.90	.78	.59	.35	.13	-.07	-.21
Spain	.19	.32	.46	.61	.73	.80	**.80**	.71	.55	.36	.16	-.02	-.17
Sweden	-.45	-.28	-.03	.26	.56	.79	**.92**	.92	.81	.64	.43	.23	.06
Switzerland	.11	.25	.42	.60	.75	.86	**.87**	.79	.62	.41	.19	-.01	-.18
Turkey	-.50	-.37	-.20	.01	.23	.44	.60	.68	**.69**	.64	.56	.48	.41
UK	-.31	-.18	.00	.21	.43	.62	.75	**.79**	.73	.61	.46	.30	.18
EA19	-.08	.10	.32	.56	.78	.94	**.98**	.90	.71	.46	.20	-.04	-.23

Note: Cross-correlations are between current value of the EU28 business cycle and *j*-th lag of the selected countries cycles. Negative lag denotes leading. Bold font denotes maximum absolute values of the cross-correlation.

However, the degree of synchronization varies between -0.74 (Bosnia & Herzegovina) and 0.96 (Italy) with average value of 0.64. Old EU members'

cycles are without phase shift with EU28 cycle with two exceptions (Ireland and UK are lagging one quarter). Greece shows the lowest degree of synchronization measured by correlation of 0.44, Italy is the most synchronized country with correlation 0.94. Average correlation for the old EU members is 0.8, while for new EU members this correlation is slightly lower, i.e. 0.7, with least synchronized being Poland (0.49) while Slovenia is the most synchronized new EU member (0.9).

Table 8. Cross-correlations of EU28 and European countries cycles; Period: 2000q1 – 2016q3 (HP filter)

Lag *j*:	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
Austria	-.11	.13	.38	.62	.81	.92	**.94**	.86	.69	.46	.21	-.03	-.24
Belgium	-.31	-.09	.16	.43	.67	.85	**.94**	.93	.81	.62	.38	.14	-.09
B&H	.31	.42	.53	.61	.64	.59	.46	.24	-.03	-.29	-.51	-.67	**-.74**
Bulgaria	.23	.41	.57	.68	**.73**	.71	.62	.48	.30	.11	-.05	-.19	-.27
Croatia	.20	.39	.57	.72	.82	**.85**	.81	.68	.50	.30	.09	-.10	-.24
Cyprus	.12	.26	.39	.50	.57	**.58**	.53	.40	.24	.06	-.12	-.27	-.39
Czech Repub.	-.04	.18	.41	.63	.80	.91	**.93**	.86	.72	.54	.33	.12	-.07
Denmark	-.24	-.03	.21	.46	.67	.83	**.92**	.92	.84	.70	.52	.32	.12
Estonia	-.21	.01	.24	.45	.62	.73	**.77**	.74	.66	.52	.36	.19	.03
Finland	-.16	.09	.36	.61	.81	.93	**.95**	.86	.68	.45	.20	-.04	-.24
France	-.25	-.01	.25	.51	.73	.88	**.94**	.90	.76	.57	.33	.09	-.12
Germany	-.18	.06	.32	.56	.77	.90	**.93**	.85	.68	.45	.18	-.08	-.32
Greece	**.35**	.33	.31	.30	.30	.30	.30	.27	.23	.17	.11	.03	-.04
Hungary	-.27	-.08	.14	.37	.56	.71	**.79**	.79	.73	.63	.49	.35	.22
Iceland	.28	.48	.64	.77	.83	**.84**	.78	.65	.49	.31	.14	.00	-.11
Ireland	-.17	-.03	.13	.31	.48	.62	.71	**.74**	.70	.61	.48	.31	.14
Italy	-.32	-.10	.17	.44	.68	.87	**.96**	.93	.81	.62	.37	.12	-.13
Latvia	.00	.21	.41	.58	.69	.75	**.75**	.69	.58	.43	.27	.12	-.01
Lithuania	.01	.21	.39	.55	.65	**.69**	.66	.56	.42	.26	.09	-.05	-.15
Luxembourg	-.18	-.01	.21	.44	.66	.83	**.93**	.93	.82	.63	.38	.12	-.13
Macedonia	.03	.10	.18	.27	.35	.42	**.47**	.44	.38	.30	.22	.14	.08
Malta	.10	.20	.31	.43	.53	.60	**.62**	.59	.51	.39	.24	.09	-.04
Montenegro	.12	-.12	-.30	-.39	**-.39**	-.30	-.15	.01	.16	.26	.32	.32	.28
Netherlands	.08	.28	.49	.68	.83	.91	**.91**	.80	.63	.41	.16	-.07	-.28
Norway	.10	.29	.47	.61	.70	**.75**	.74	.68	.57	.45	.31	.18	.07
Poland	.08	.26	.45	.62	.74	**.78**	.74	.60	.38	.10	-.19	-.46	-.68
Portugal	.01	.09	.22	.36	.49	.60	**.65**	.61	.51	.35	.16	-.04	-.23
Romania	.40	.54	.65	.71	**.71**	.65	.53	.37	.19	.01	-.13	-.23	-.27
Serbia	.22	.32	.39	**.42**	.41	.36	.25	.13	.01	-.10	-.16	-.19	-.16
Slovakia	.15	.33	.51	.66	.76	**.79**	.75	.63	.45	.24	.02	-.18	-.33
Slovenia	.10	.30	.51	.69	.83	**.90**	.89	.77	.59	.36	.11	-.12	-.31
Spain	.13	.28	.44	.58	.70	.76	**.77**	.69	.55	.37	.18	-.02	-.19
Sweden	-.47	-.25	.02	.30	.57	.79	.93	**.95**	.87	.71	.50	.26	.03
Switzerland	.06	.24	.43	.61	.76	.85	**.86**	.79	.66	.47	.26	.04	-.15
Turkey	-.55	-.39	-.20	.02	.23	.42	.56	.65	**.67**	.63	.55	.45	.34
UK	-.26	-.07	.15	.38	.58	.74	.83	**.84**	.77	.63	.46	.27	.09
EA19	-.16	.07	.33	.58	.80	.94	**1.00**	.94	.80	.58	.33	.07	-.16

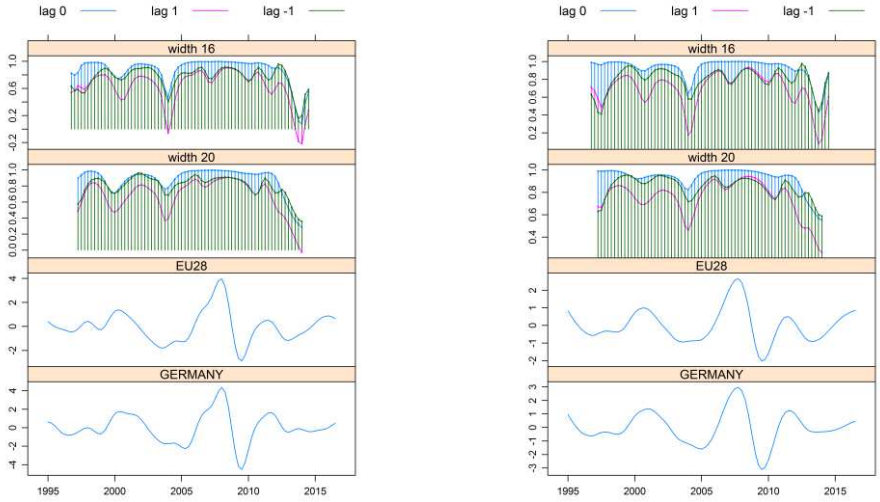
Note: Cross-correlations are between current value of the EU28 business cycle and *j*-th lag of the selected countries cycles. Negative lag denotes leading. Bold font denotes maximum absolute values of the cross-correlation.

As expected, non-EU countries are with the lowest average maximal correlation of 0.4. Most contributions to such a lower correlation were made by the Western Balkan countries, while Switzerland and Norway are well synchronized with EU28 cycle. Most of new EU countries cycles are lagging one or two quarters behind the EU28 cycle, while the Western Balkan countries are leading or lagging for three or more quarters. These findings are quite robust across the filters used.

4.4 ROLLING CROSS-CORRELATIONS

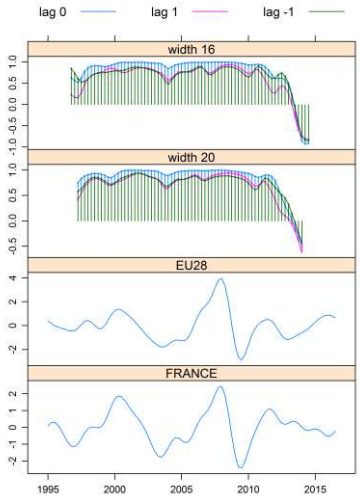
To estimate the delay time between two cycles, we look at the cross-correlation function.

Figure 4. Rolling cross-correlations for EU28 and Germany (a) FD filter and b) HP filter) and France (c) FD filter and d) HP filter)

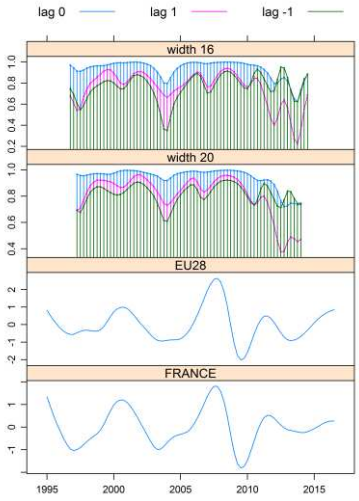


a)

b)



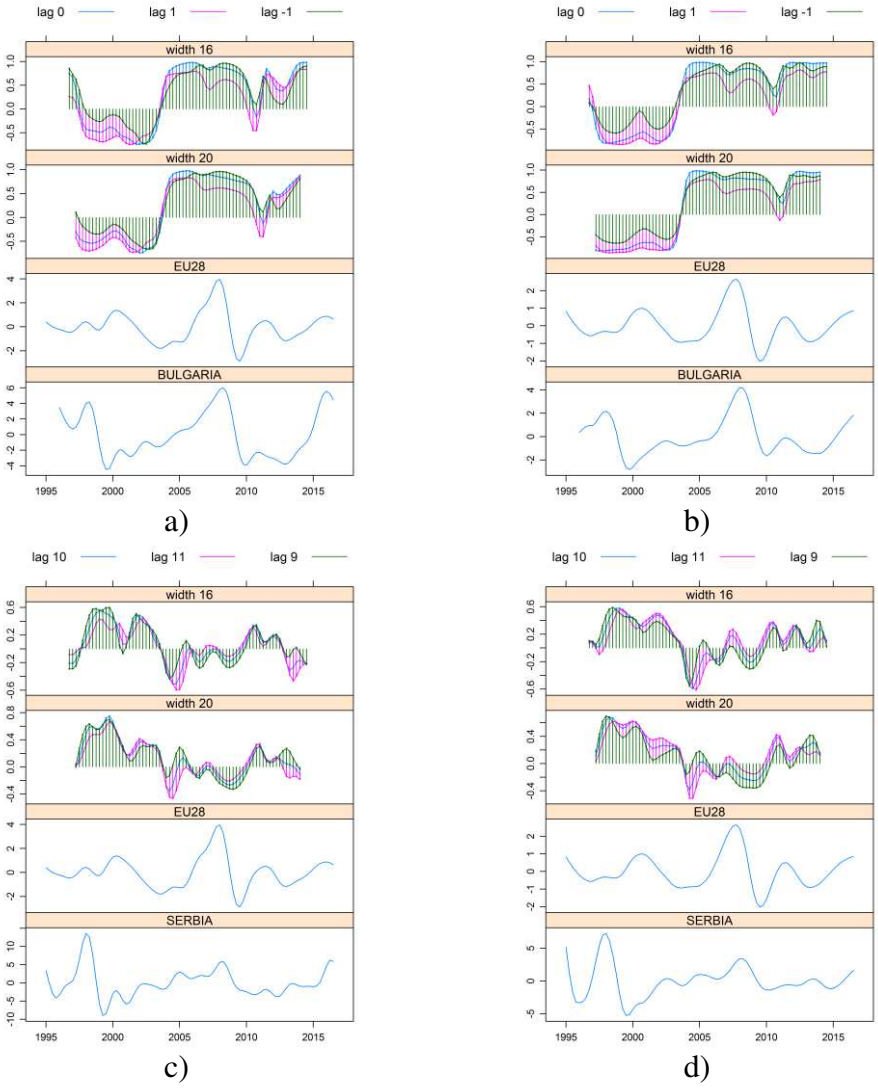
c)



d)

We picked out the lag time corresponding to the maximal correlation between two cycles. For most European countries this is 0 quarters. Then the correlations on one lead and one lag around the selected lag time are calculated. The rolling cross-correlation coefficients for two largest economies and EU founding members, Germany and France are shown in Figure 4. In Figure 5 rolling cross-correlations are shown for Bulgaria (joined EU in 2007) and Serbia (started the process of joining EU) as representatives of new EU members and Western Balkan countries who are in the process of joining EU.

Figure 5. Rolling cross-correlations for EU28 and Bulgaria (a) FD filter and b) HP filter) and Serbia (c) FD filter and d) HP filter)



Visual inspection of the rolling cross-correlations in Figure 4 suggests that Germany and France are highly synchronized with EU28 cycle in period from 1997 until 2011 with small drop in the value of correlation on lag 0 to 0.5

around 2004. After 2011 a sharp drop in the correlation to almost zero (Germany) and even to negative correlation in case of France suggests lack of synchronization in the recent period. These results are quite robust across the cycle extraction methods used with an exception in the most recent period where the results from HP filter do not match the results from FD filter. This could be partly contributed to the fact that the HP filter performs poorly are the end of the series.

Negative correlations on the first two graphs in Figure 5 tell us that the Bulgarian business cycle was initially, before 2004, most of the time in opposite phases to EU28 cycle. In addition, the largest correlation was on lag 1 which means that the Bulgarian cycle was following changes in EU28 cycle after one quarter. However, after 2004, when Bulgaria was in preparation to join EU in 2007, synchronization rapidly increased to reach almost the maximum value until 2010, when two cycles were synchronized in the same quarter. Similarly to Germany and France sudden sharp drop in the level of synchronization occurred in 2011 with Bulgarian cycle. Luckily this drop didn't last long and the synchronization returned to its previous level.

Serbian business cycle and its level of synchronization is a specific case, nothing similar to other countries. The highest correlation value was identified at lag 10 suggesting that the Serbian cycles are lagging for about two and a half years behind EU28 cycle. The maximum level of synchronization was varying between 0 and 0.6 in period before 2004. Even at this maximal value the correlation was not statistically significant leading us into conclusion that the Serbian cycle was not synchronized with EU28 cycle. The situation didn't change significantly after 2004. Moreover, the Serbian cycle after 2004 was most of the time in opposite phases to the EU28 cycle and lagging even more that before 2004.

All above results for both old EU members (Germany and France), new EU member (Bulgaria) and non-EU member (Serbia) are quite robust to changes both in the cycle extraction methods used (FD and HP filters) and selected width of rolling windows (16 and 20 quarters).

5. CONCLUSIONS

This paper analyzes the prospects for a monetary union among European countries by assessing synchronization of business cycles. Analysis was undertaken using two different cycle extraction methods (Corbae-Ouliaris and Hodrick-Prescott filters) and three different synchronization measures (concordance index, cross-correlations and rolling cross-correlations). The overall finding provide the following conclusion: both concordance index and cross-correlations indicated that business cycles of most old EU members are synchronized with EU cycle in period 2000q1-2016q3. Degree of synchronization

within the new EU members is not in general as large as that between the old EU countries. Non-EU countries are even less synchronized with European Union and Euro Area aggregates than new EU members.

However, analysis based on the rolling cross-correlations indicted that the degree of synchronization has been varying in the observed period. Majority of new EU members' cycles were weakly or not at all synchronized with EU cycle until 2004/5. After 2004 most of them were synchronized in the same quarter but with greater variations between countries. For most of these countries the degree of synchronization dropped significantly after 2010/12. These results are quite robust across the cycle's extraction methods and synchronization measures used.

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