Literature Review

The study of Sala-i-Martin (1996) is one of the first studies regarding business cycle synchronization. In this study, 73 NUTS2 (DE, UK, FR, IT, NE, BE, and SP), 47 US regions, 10 Canadian provinces, 47 Japanese prefectures were used and data for personal income (some years depending on the sample) were collected (the period covered: for Europe 1950-1990, for United States 1880-1990, for Canada 1961-1991 and for Japan 1955-1990). In the empirical part of the study, β convergence and σ convergence were used. The results show that there are both types of convergence across regions of the US, Japan, Europe, Spain, and Canada, at about the same rate.

In 2003, Barrios et al. examined the patterns and determinants of business cycle correlations among 11 UK regions and six Eurozone countries. They used data for GDP that covered the period 1966-1997. They introduced the Hodrick-Prescott filter and correlation in the empirical part of their study, and they found that UK regions are less correlated with the EA than other EU countries and divergence has increased 6 EA countries GMM correlations. Moreover, they found that sectoral similarity promotes cyclical symmetry OLS Regression (explanatory variables) and high correlations among UK regions. Furthermore, the study of Bergman (2004) is about how similar are European business cycles. The data set of this study consists of quarterly observations on industrial production for the EU– 14 countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and the United Kingdom) and five non–EU countries (Canada, Japan, Norway, Switzerland and the US) for the sample 1961:1 to 2001:4. Regarding the methodology used in this study, Baxter and King (1999) have developed a bandpass filter that isolates cyclical components of economic time series. This filter can be designed to isolate cyclical components of economic time series conforming to a certain definition of business cycles. Bergman isolates cyclical components of the data with durations conforming to the Burns–Mitchell definition of the business cycle. He used a 12–order two–sided filter following Baxter and King (1999) to extract all fluctuations at frequencies between 6 and 32 quarters (1.5 year and 8– eight years) from the logarithm of industrial production in each country. The main finding of this study is that European business cycles are highly synchronized, although synchronization was higher during periods with highly flexible exchange rates. In addition, a positive tradeoff wa found between timing and magnitude such that more synchronization coincides with larger relative

magnitude. These results raise a concern about the consequences of a common monetary policy within EMU.

Belke and Heine (2006) examined the degree of correlation in their study among EU regional employment cycles and tried to connect it to the changing patterns of specialization. They used data for employment for 1989-2006 for 30 NUTS1 (BE, FR, DE, IE, NET, SP) countries. They employed Hodrick-Prescott filter and correlation in the empirical part of their study, and they found that the decline in regional synchronization is due to differences in regional industry structure Pairwise correlation (Bravais-Pearson coefficient). Acedo-Montoya and de Haan (2008) analyzed regional business cycle synchronization in the Eurozone, and they focused on 53 NUTS1 (12 EMU countries). They used data for Gross Value Added for the period 1978-2005. They employed Hodrick-Prescott and Cristiano-Fitzgerald filters and correlation as synchronization measure. They found that correlation has increased during the period considered, except in the 80s and the beginning of the 90s. According to the findings of their study, they also show the existence of a national border effect.

Korse *et al.* (2008) examined the changes in world business cycles during the period 1960-2003 for the G-7 countries. They employ a Bayesian dynamic latent factor model to estimate common and country-specific components in the main macroeconomic aggregates (output, consumption, and investment). Then, they quantify the relative importance of the common and country components in explaining co-movement in each observable aggregate over three distinct time periods: the Bretton Woods (BW) period (1960:1-1972:2), the period of common shocks (1972:3-1986:2), and the globalization period (1986:3-2003:4). The results of their study indicate that the common (G-7) factor explains, on average, a larger fraction of output, consumption, and investment volatility in the globalization period than it does in the BW period.

Regarding the study of Artis *et al.* (2010), data for 41 EU regions and 48 US states are exploited and annual data on regional real GDP are available for the 1982-2007 period. They examine what drives the business cycles and also the role of common and spatial components. They use in the empirical part of their study panel models with spatial dependencies and spatial correlation, and the results obtained by a panel model with spatial effects indicate that the impact of national business cycles for the regional development has been rather stable over the past two decades, in particular across US states. A tendency for convergence in business cycles often detected in country data is not confirmed at the regional level. The pattern of synchronization across the euro area is similar to that across US states. Although cyclical

heterogeneity is detected, it does not indicate a serious impediment to a common monetary policy of the European Central Bank.

Dimitru and Dimitru (2010) examine the business cycle correlation of the new member states with Eurozone, and they focus on the case of Romania. They use quarterly GDP data from 1997q1 until 2009q2 for their study and the countries that are included in their study are EA and 11 countries that joined the EU in 2004 and 2007, and for Eurozone. They use Quadratic trend, Hodrick-Prescott, Band-Pass filter, Beveridge-Nelson decomposition and Wavelet transformation in order to find the appropriate results for their study. The results of their study indicate cross-correlations in different sub-periods and concordance index. Also, the correlation of Romania with Eurozone was the lowest, after Hungary. According to the results of this study, the correlation increased in time, the most in the case of Slovakia and Romania, and Slovenia was the most synchronized country.

Filis et al. (2010) examine whether EU and Bulgarian business cycles are synchronized. They use GDP data from 1997q1 until 2007q2 for their study and the countries that are included in their study are EA15 and Bulgaria. They use Hodrick-Prescott filter and spectral analysis and squared coherency, and they find that cycles are correlated at 17 and 34 quarters. But a negative phase shift implies that their phases are not coordinated.

Papageorgiou *et al.* (2010) use major annual macroeconomics series data from 1960 until 2009, and their study is about business cycles synchronization and clustering in Europe. The countries that are included in their study are major European countries, US and Japan. They use Hodrick-Prescott filter and correlations in different sub-periods and mean rolling correlations to find important results for their study that was about Business cycles synchronization and clustering in Europe. The results of their study indicate that there is a different degree of synchronization between core and peripheral European countries. Also, the results of their study show that European countries increased their synchronization in 1992–1999, but decreased in 2000–2009.

Aguiar-Conraria and Soares (2011) use industrial production data from 1975m7 to 2010m5 for EU15 and EA12 countries, and their study is about business cycles synchronization and the Euro with an application of wavelet analysis. The methodology that they employ in their study is the Wavelet power spectra between 1.5 and 8 years frequencies and a metric based on wavelet spectra. They find that France and Germany most synchronized countries with the rest of Europe and Portugal, Greece, Ireland, and Finland do not show statistically relevant degrees of synchronization.

Artis *et al.* (2011) focus on business cycles synchronization since 1880. They use annual GDP data for their study for 25 advanced and emerging economies. The data cover the period 1880-2006. They use Hodrick-Prescott filter and correlation in different sub-periods, and they find that synchronization increased during 1950–1973 and accelerated since 1973 within a group of European countries. Moreover, in other regions, country specific shocks were the dominant forces of business cycle dynamics.

The study of Benčík (2011) is about business cycle synchronization between the V4 countries and the euro area. He uses GDP data from 1995q1 until 2010q3. The countries that are included in the study are Czech Republic, Hungary, Poland, and Slovakia. He uses the Hodrick-Prescott filter and correlation as a synchronization measure in different sub-periods. The findings of his study indicate that 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 and for Slovakia, the first and third lag and third lead are significant.

Bergman and Jonung (2011) use annual GDP data from Sweden, Norway, Denmark, and selected OECD countries from 1834 to 2008. They focus on evidence from the Scandinavian currency union. The econometric methods that they employ in their study were Christiano-Fitzgerald filter and Rolling average crosscorrelations. The results of their study show that business cycles in the three Scandinavian countries are 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 is recorded.

Mink et al. (2011) use GDP data from 11 European countries from 1970q1 to 2006q4. They use Christiano-Fitzgerald, Hodrick-Prescott and Baxter-King filters and synchronicity and similarity as synchronization measure. The results of their study show that the EA output gaps are not more synchronous or similar at the end of our sample period than in the 1970s. They also find that 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. Lee (2012) reexamines the effect of the European Economic and Monetary Union (EMU) on the extent of business cycle synchronization across its member states. A dynamic latent factor model is used to identify the 'regional' effect of the euro area on output growth and inflation dynamics across European countries. The results of variance decomposition analysis confirm that both output growth and inflation tended to be more

synchronized among European countries during the run-up to the EMU, but there is no strong evidence to support the argument that the 'regional' effects prevailed after 1999.

Šergo et al. (2012) examine the business cycle synchronization in Croatia. They use data for 15 macroeconomic series from 1991m1 until 2010m3. They use the Hodrick-Prescott filter and concordance index as a measure of synchronization. The results of their study show that co-movement exists between unemployment and industrial production cycles. Also, the new job position on openings coincides with the growth of exports, construction and tourist arrivals. Furthermore, the findings of their study indicate that there is almost perfect synchronization between the construction industry and imports cycles, and slightly less with export cycles. Kolasa (2013) uses data for major economic series from 1996q1 until 2011q4, and investigates how and why the business cycles are different. The countries that are involved in the study are Czech Republic, Hungary, Poland, Slovenia, Slovakia. Hodrick-Prescott filter and correlations in different sub-periods are used in the empirical part of the study. The findings of the study indicate that the degree of synchronization increased for all countries after joining EU.

Marino (2013) uses GDP and employment data from 1977 until 1995 for 107 NUTS1 and some NUTS2 (BE, DE, EL, FR, IT, NL, PT, SP, and UK) countries. This study is about regional fluctuations and national cohesion in the EU12. This study employs dynamic factor model and correlation to measure synchronization. The findings of this study show that regions are more synchronized in terms of GDP than in terms of employment, and GDP dynamics are regional rather than national. Obradović and Mihajlović (2013) use GDP data for Bulgaria, Croatia, Hungary, Romania, Serbia and Slovenia from 2001q1 until 2009q4, and their study focus on the synchronization of business cycles in these countries. They use econometric methods in their study, such as Hodrick-Prescott and Baxter-King filters, correlations in different sub-periods and rolling cross-correlations. They find that Serbian cycle is not synchronized with cycles in other countries with Hungary as the only exception. They also find that there is a tendency of increasing a degree of synchronization.

The study of Park (2013) is about regional business synchronization in East Asian countries. He uses data for real GDP, real private consumption expenditure, and real investment that cover the period from 2000Q1 to 2011Q4. He uses the dynamic factor model to extract the regional common factor. The degree of business cycle synchronization is measured by time-varying dynamic conditional correlation for each country. Finally, the determinants of business cycle synchronization are examined by differentiating the monetary and fiscal policy variables

as well as the non-policy variables. The estimation of a dynamic two-factor model extracts the common factor and the nation-specific factor from both the macroeconomic aggregates and plausible driving forces of regional business cycles. According to the findings of the study, the evidence for regional business cycle synchronization is particularly strong for Korea, Malaysia and the Philippines, while Japan shows weak evidence of regional synchronization. On the other hand, Indonesia, Thailand, Singapore and China are decoupling from regional business cycles. The driver of monetary aggregate is the most significant determinant of regional fluctuations of macroeconomic aggregates, whereas oil price and productivity are on average important driving forces of nation-specific fluctuations of real economic activities.

Stanisic (2013) focus on the synchronization of business cycles among Central and Eastern European countries (CEECs) and the EA and quarterly, seasonally adjusted real GDP data series for the period 1995–2012, obtained from the Eurostat National Accounts database. Moreover, the Hodrick–Prescott filter method used to extract the business cycles from GDP data series, and the degree of co-movement of cycles is evaluated on the basis of various methods of rolling correlation. The results of the study show that there is no common CEE business cycle, although a synchronization trend is evident. Similarly, there is a strong trend of convergence of CEEC national business cycles toward that of the EA.

The study of Degiannakis *et al*. (2014) is about business cycle synchronization in EU-12 countries for the period 1980-2010 using Scalar-BEKK and multivariate Riskmetrics model frameworks. The results of the study provide evidence that changes in the business cycle synchronization correspond to major economic events that have taken place at a European level. In addition, they find that business cycle synchronization until 2007 had moved in a direction positive for the operation of a single currency, suggesting that the common monetary policy was less costly in terms of lost flexibility at the national level. However, as a result of the Great Recession of 2007 and the subsequent Eurozone Crisis, a number of periphery countries, most notably Greece, have experienced desynchronization of their business cycles with the EU12-wide cycle. Nevertheless, for most countries, any questions regarding the optimality and sustainability of the common currency area in Europe should not be attributed to a lack of cyclical synchronization.

Gouveia (2014) examines the business cycle correlation between the Euro area and the Balkan countries. She uses GDP data for these countries that cover the period from 2001q1 to 2011q4. The econometric methods that used in this study are Hodrick-Prescott and Baxter-King filters and Concordance index, rolling concordance index, Spearman’s rank-order

correlation coefficients, rolling correlation coefficients were used to measure synchronization. The findings of the study provide evidence that the degree of synchronization of Balkan countries (except Greece) tends to increase with slight degrease at the end of the period.

Konstantakopoulou and Tsionas (2014) concentrate on GDP data for main OECD countries for the period 1960q1-2010q4. They use Hodrick-Prescott, Christiano-Fitzgerald and Baxter-King filters and cross-correlations to measure synchronization. The results indicate that synchronization is stronger between the Euro-area's countries and cycles of Germany, France, Italy, Netherlands, Austria and Belgium are highly synchronized. Bekiros *et al*. (2015) employ cross-wavelet coherence measure to detect and identify the scale-dependent time-varying (de)synchronization effects amongst Eurozone and the broad Euro area business cycles before and after the financial crisis. The results suggest that the enforcement of an active monetary policy by the ECB during crisis periods could provide an effective stabilization instrument for the entire Euro area. However, as dynamic patterns in the lead-lag relationships of the European economies are revealed, (de)synchronization varies across different frequency bands and time horizons.

Ozyurt and Dees (2015) examine the regional dynamics of economic performance in the EU and to what extent spatial spillovers matter. They use data for real GDP for 253 NUTS2 EU for 2001-2008. They use moral index and Spatial Durbin ramdom-effect panel model. According to the findings of the study, social-economic environment and traditional determinants of economic performance are relevant and also there are high-income clusters (in Western Europe) with positive effects on development of neighbouring regions. Akar (2016) investigates the relationship between the financial and business cycles in Turkey. He analyzes financial and economic time series data for Turkey for 1998q1-2004q4 using Hodrick-Prescott filter, Concordance index, cross-correlations and dynamic conditional correlation (DCC). The results of the study provide evidence that financial and business cycles are highly synchronized and during the 2008 global crisis DCC dropped to statistically non-significant values.

Beck (2016) analyzes time series of real GDP for 24 EU countries, 82 NUTS 1, 242 NUTS 2 and 1264 NUTS 3 regions over the period between 1998 and 2010. The methods that used in the study about business cycle synchronization in European Union are Hodrick-Prescott, as well as Christiano and Fitzgerald filters. The results of the analysis support the 'European Commission' view and show a very high degree of BSC within EU countries. The country level analysis also reveals that within the EU there is a group of countries that could form an effectively working monetary union based on the BCS criterion.

Degiannakis et al. (2016) uses annual GDP and cyclically adjusted net lending (NLB) data from 10 EMU member-countries and the aggregate EMU12 from 1980 to 2012. Their study is about business cycle synchronization in EMU, and they examine whether fiscal policy can bring member-countries closer. In this study, a time-varying framework is used in order to obtain the results. The findings suggest that fiscal policy has important effects on business cycle synchronization for all 10 EMU countries. Hence, fiscal policy is shown to have the potential to be supportive of macroeconomic stabilization in the Eurozone. However, the evidence reveals that none of the countries under examination consistently uses fiscal policy to promote business cycle synchronization.

Gadea et al. (2017) investigate the evolution of regional economic interlinkages in Europe. They use GDP data for 213 NUTS2 (18 EU countries). The data cover the period from 1980-2011. They apply regime switching and dynamic model averaging in their study, and also correlation in order to measure synchronization. They find that the Great Recession synchronized Europe twice as much as the EU process in decades, Ile de France acts is the main channel of transmission of business cycle shocks, and increases in regional sectoral composition similarity have a positive effect on business cycle synchronization, only for regions that already experience high levels of similarity in their productive structure.

Grigoraş and Stanciu (2016) use GDP data for 30 European countries and for the United States for their study that is about new evidence on the (de)synchronization of business cycle. The data cover the period 1960/95q1-2014q3. They also use Classical definition of business cycles and concordance index and correlations. They find that a high level of 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.

The study of Monnet and Puy (2016) assesses the strength of business cycle synchronization between 1950 and 2014 in a sample of 21 countries using a new quarterly dataset (industrial production) based on IMF archival data. To enhance the comparability of the results with the previous literature, in particular Kose, Otrok and Whiteman (2003, 2008), they rely on the same econometric methodology to assess the importance of a world business cycle. The world business cycle was as strong during Bretton Woods (1950-1971) than during the Globalization period (1984-2006). Although globalization did not affect the average level of co-movement, trade and financial integration strongly affect the way countries co-move with the rest of the world. They find that financial integration de-synchronizes national outputs from the world cycle, although the magnitude of this effect depends crucially on the type of shocks

hitting the world economy. This de-synchronizing effect has offset the synchronizing impact of other forces, such as increased trade integration.

Bandrés et al. (2017) use European and regional level data for NUTS 2013 classification which lists 98 regions at NUTS1 level, 276 regions at NUTS2 level and 1,342 regions at NUTS 3 level. The data cover a period of 32 years, from 1980 to 2011. They use Finite Mixture Markov Models Clustering based on finite mixtures of dynamic regression models. The idea is to pool time series to obtain posterior inferences but without being necessary an overall pooling within clusters. The main findings of their study that is about regional business cycles across Europe are the following: (i) evidence of just one cluster amongst the European countries while, at the regional level, there is more heterogeneity and we identify five different groups of European regions; (ii) the groups are characterized as follows: the first contains most of the Greek regions; groups two and three include, in most cases, regions from Germany (plus a couple of regions from southern European countries in group two and some regions of the core countries in group three); group four is populated mainly by regions belonging to northern European countries; and group five is the largest and is composed of the rest of European regions; (iii) we notice that the degree of homogeneity of regional business cycles within countries is quite different; (iv) we also observe that spatial correlation increased during the convergence process towards the introduction of the euro and has taken a big leap with the Great Recession, both at country and regional level. In fact, co-movements among regions have mainly increased during the last decade. These results have important implications for policymakers in the design of convergence policies at the European level and also in the design of fiscal policies to reduce regional disparities at the country level.

Belke et al. (2017) use seasonally adjusted real gross domestic product (GDP) on a quarterly basis from the OECD. The data cover the period from 1970Q1 to 2015Q4. They use in their study Quarterly index for business cycle synchronization by Cerqueira (2013), and also correlation coefficients and nonparametric local polynomial regressions. The findings of their study about business cycle synchronization in the EMU show that the usual focus on co-movements and correlations might be misleading, however, since they also find large differences in the amplitude of national cycles. A strong common cycle can thus lead to large differences in cyclical positions, even if national cycles are strongly correlated.

Camacho et al. (2017) focus on 17 Spanish regions using total security system affiliation as the measure of economic activity and the data cover the period 1983.01-2017.05. Their study is about business cycles phases in Spain. They use Single-equation Markov-

switching model and concordance index. Based on a set of Markov-switching models, they find substantial synchronization of regional business cycles, which has increased since the Great Recession. They do however evidence a regional leading and lagging performance that repeats itself across the different recessions. Typically, earlier signals of national recessions appear in the Islands and Valencia, and are propagated from the periphery to the centre. Moreover, north-western regions tend to start the regional recoveries with a significant lag.

Duran and Ferreira-Lopez (2017) for their study in a Eurozone context use GDP and employment as the business cycle measures, and the determinants of business cycle synchronization identified in the literature were namely bilateral trade intensity, dissimilarity of labor market rigidity, dissimilarity in industrial structures, financial openness, and foreign direct investment relations. In order to investigate empirically the determinants of business cycle correlation, they employ simultaneous 4-equations model by Ordinary Least Squares (OLS) and three-stage least square. They find that bilateral trade relations present a positive influence on business cycle correlations, while the dissimilarity of labor market rigidity presents a negative influence. They also find that rest of the variables are non-significant. They also find that these results are robust to the use of the Hodrick–Prescott-filter and first differences as the de-trending methods, as well as the use of GDP as the business cycle measure, excluding the financial crisis years (2008 and 2009). They also find that results for employment as the business cycle measure are in contrast with the previous ones, and find industrial dissimilarity to be the relevant variable to determine business cycles synchronization. In what concerns the determinants of the lead and lag behavior, results show that the member states of the Eurozone that usually lead the cycle are the ones that are wealthier, with strict employment legislation, more specialized in construction and finance sectors, and more prone to international capital movements. Differences in the determinants between contemporaneous business cycles and lead and lag behavior of business cycles are especially important for policy-makers in the Eurozone to know about, in particular if asymmetric shocks between countries are set in place.

The study of Karadimitropoulou (2018) is about on 5 developed economies (G5) and 19 emerging economies for the 1972-2009 period value added growth in a multi-sector dynamic factor model. The empirical part of this study includes methods such as multi-factor dynamic model to a multi-sector setting. It is augmented with a region-specific factor to capture sectoral synchronization at a regional level. Also, in the empirical part of the study, Correlations – Variance Decomposition are included. The results suggest that, while there

exists a common 'regional business cycle' in the G5, fluctuations in sectoral value added growth are dominated by country specific factors in the emerging markets. Despite that, the international factor (the sum of world and sector factors) is more important than the region factor, suggesting that the emerging markets are more synchronized with the G5. A simple regression shows that (i) the world factor would be more important the larger the share of agriculture in output; (ii) in more open economies the sector factor is more important in explaining sectoral VA growth fluctuations; (iii) the region factors is more important the richer and the less volatile the economy. Finally, a comparison of the variance of sectoral value added growth accounted for by each factor from the pre- to the post-globalization period shows convergence of the business cycles within the G5 and EM, respectively. The changes in the contribution of the world, sector and region factor are due to changes in the importance of those factors within sectors. However, for the emerging markets, the fall in the importance of the country factors is dominated by changes in the structural composition of the economies. Therefore, the evolution of the structural composition in the emerging markets could be an important driver for more synchronised business cycles at the regional and international level.

The study of Kovacic and Vilotic (2017) assesses European business cycle synchronization. They used quarterly GDP data from Eurostat database covering period 2000q1-2016q3. The data are for the European countries. The econometric methods they use in their research are Corbae-Ouliaris ideal band filter and double Hodrick-Prescott filter. They also use Concordance index and cross-correlation function. Rolling cross-correlations at three lags were also used to assess evolution of synchronization over time. The findings of the study provide evidence that business cycles of most old EU members are synchronized with EU cycle. However, rolling crosscorrelations 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.

Lange (2017) uses data for total employment for both sexes, 15 years and over. The estimation period is from 1976:5 to 2010:6. He uses Markov switching methodology to capture the asymmetric nature of provincial business cycles in Canada, and also used Concordance indices and cross-correlations. The results of the study show that the estimations identify two- and three-regime provincial business cycles, as well as some provincial economies that do not experience explicit cycle phases. Despite the asychronicity of provincial business cycles,

concordance indices identify a very close cyclical pattern between most provinces and Canada as the reference economy, and maximum correlation coefficients indicate that recessions in Ontario, which has a relatively large concentration of manufacturing, lead overall recessions in Canada and in some of the other provinces.

Leiva-Leon (2017) uses Data on U.S. states coincident indexes were provided by the Federal Reserve Bank of Philadelphia. The sample spans from August 1979 until February 2016. The Chicago Fed National Activity Index (CFNAI) is used as a monthly measure of the U.S. national business cycle. All these indexes of real economic activity, for each state and for the entire United States, have been constructed based on the principle of co-movement among industrial production, employment, sales and income measures. Leiva-Leon (2017) based the methodology they will apply in their research on Markov-switching framework to endogenously identify periods where economies are more likely to (i) synchronously enter recessionary and expansionary phases, and (ii) follow independent business cycles. The reliability of the framework is validated with simulated data in Monte Carlo experiments. The main results report substantial changes over time in the cyclical affiliation patterns of US states, and show that the more similar the economic structures of states, the higher the correlation between their business cycles. A synchronization-based network analysis discloses a change in the propagation pattern of aggregate contractionary shocks across states, suggesting that the US has become more internally synchronized since the early 1990s.

Gomez-Losko et al. (2019) use annual real GDP data for NUTS2 regions corresponding to 16 European countries. The series are available from 1980 to 2011. They also apply econometric methods in their research, such as Finite Mixture Markov models that allow to deal with technical difficulties that arise in capturing business cycles with short samples and heterogeneous data. The aim of this paper was threefold. First, they analyze the comovements of the business cycles of European regions. Second, they date these business cycles, for the first time in the literature, and identify clusters of regions with similar business cycle behavior, using Finite Mixture Markov models. Third, they develop a new index to measure within-country homogeneity. They find that comovement among regions is, on average, quite low, although it increased during the convergence process prior to the euro cash changeover and after the onset of the Great Recession. They identify five different groups of European regions. They also find heterogeneity in the size of border effects.

The study of Jarko et al. (2018) is about 3,000 business cycles synchronisation coefficients and their design and estimation characteristics, and they use meta-regression

analysis. They 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); (3) there is evidence of country-specific publication bias; (4) their differences-in-differences estimates suggest the euro accounted for approximately half of the observed increase in synchronisation.

The study of Camacho et al. (2019) is about all the members of the EA using a large panel of cross-country data. They use macroeconomic series of production, consumption and investment for each country. In particular, they use the demeaned growth rates of GDP, Household and NPISH Final Consumption Expenditure, and Gross Fixed Capital Formation. The seasonally adjusted series were downloaded from the Eurostat database at a quarterly frequency. Effective sample spans the period between the first quarter of 2000 to the last quarter of 2015 for all the nineteen countries of the EA but Cyprus. They take advantage of the dimension reduction properties of dynamic factor models to summarize a large dataset of macroeconomic indicators for the Euro Area countries. Then, they estimate latent state variables based on Markov-switching methodologies to obtain a time-varying measure of business cycle synchronization. The combination of the techniques allows them to describe the evolution in the degree of coincidence of the business cycle phases along time for this set of countries. Their results suggest that there was a general decline in the degree of business cycle synchronization across the Euro Area countries following the financial and the sovereign debt crises. Although they have recovered the levels of business cycle synchronization exhibited before these events, there are significant differences across countries in the required time to recover those levels.

Guerini et al. (2019) extract data for their study from Eurostat database of manufacturing industrial production time-series in the European Union (EU) over the 2000-2017 period. Moreover, the approach they use exploits Random Matrix Theory and extracts the latent information contained in a balanced panel data by cleaning it from possible spurious correlation. They employ this method to study the synchronization among different countries over time. Also, the empirical exercise tracks the evolution of the European synchronization patterns and identifies the emergence of synchronization clusters among different EU economies. They find that synchronization in the Euro Area increased during the first decade of the century and that it reached a peak during the Great Recession period. It then decreased in the aftermath of the crisis, reverting to the levels observable at the beginning of the 21st century. Second, they show that the asynchronous business cycle dynamics at the beginning of

the century was structured along an East-West axis, with eastern European countries having a diverging business cycle dynamics with respect to their western partners. The recession brought about a structural transformation of business cycles co-movements in Europe. Nowadays, the divide can be identified along the North vs. South axis. This recent surge in asynchronization might be harmful for the European Union because it implies countries' heterogeneous responses to common policies.

Hou and Knaze (2019) use yearly or quarterly GDP data for 21 OECD countries and the data cover the period from 1973 to 2016. They apply Baxter-King filter and correlation in order to measure synchronization. Using the Extreme Bound Analysis (EBA) methodology, they find that the exchange rate regime is a robust determinant of business cycle synchronization. Compared to country pairs with freely floating arrangements, they find that: (i) the correlation coefficient measuring business cycle synchronization is higher by around 0.12 points in countries with no separate legal tenders; (ii) other hard pegs such as currency board arrangements and de-facto pegs have also significantly more synchronised business cycles, but the size of the correlation coefficient is halved compared to countries with no separate legal tenders; (iii) the effect is not always linearly decreasing with the increasing exchange rate regime flexibility, since crawling pegs and crawling bands turn out to be insignificant, whereas the effect of moving bands as a more flexible type of exchange rate regimes is positive and significant; (iv) the effect is stronger for countries with high degree of financial openness and good institutional quality.

Nkwatoh (2019) analyses the degree of business cycles' synchronization of ECOWAS economies and uses annual GDP growth rate data that cover the period from 1975 to 2015. Nkwatoh(2019) uses Hodrick-Prescott filter and country correlations in order to find the results of the study. The result from the transitory component shows that the business cycles of WAEMU sub-economies are similar. But on a general note, the correlation coefficients of both components show that the business cycles of ECOWAS economies differ significantly, suggesting that, a broader monetary union involving both WAEMU and WAMZ economies will not be beneficial to the entire ECOWAS region. However, ECOWAS governments can take the risk of forming a monetary union in 2020 since a high probability of addressing a wide range of macroeconomic differentials across the region is incumbent on ex-post conditions, rather than on ex-ante prerequisite conditions that only focuses on the cost of relinquishing monetary autonomy.

Abdallah (2020) uses trade intensity data for Tunisia. The data cover the period 1980-2018. Regarding the empirical part of the study and the methodology used, the synchronization of economic cycles is measured by calculating the correlations between the cyclical components of certain macroeconomic variables. In their work, they use GDP in real terms to calculate the cyclical correlations between Tunisia and each partner country of the European Union (France, Italy, Germany, Spain, and Belgium). The cyclical components are extracted by the HP filter. Following the crisis of 2008, Tunisia experienced an economic recession characterized by a high unemployment rate consequence by the decline in these exports after the decline in demand of the European Union, which is the main trading partner for the Tunisian economy. France, Italy, Spain, Germany, and Belgium absorb more than 67.89% of Tunisian exports. To absorb the negative effects of this economic dependence in the existence of a crisis, other new markets must be explored. The most important market in the last decade is the African market, which is distinguished by an average real gross domestic product growth, approximately 5%. In this sense, we will study, in this research, the correlation of the Tunisian economic cycle as well as the degree of commercial intensity with that of the main European partner countries.

Gießler et al. (2020) use Real GDP, unemployment rates and survey data as business cycle indicators. They distinguish between two regions-East Germany and West Germany. They use quarterly, seasonally adjusted GDP growth for the period 1991-2017. In order to extract results for their study, they construct a coincident index determined by an inverse standard deviation weighting for all indicators. Furthermore, they estimate a factor model of the indicators where the indicators are represented by two unobservable components: the common component (factor) F and the idiosyncratic component. They also use correlations of quarterly GDP growth, output gap, first differences of unemployment rates, the cyclical component of unemployment rates and first differences of survey data for the time period between 1991 and 2017. They employ a cycle synchronisation index (CSI) to assess the degree of business cycle synchronisation. The CSI counts the sum of sign concordances of two indicators and relates this sum to the number of observations of the time series. Overall, according to the application of the econometric methods, they find that the regional business cycles have synchronised over time. GDP-based indicators and survey data show a higher degree of synchronization than the indicators based on unemployment rates. However, synchronization among East and West German business cycles seems to have become weaker again recently.

Bunyan et al. (2020) examine the pairwise synchronization for 14 EU countries. They use annual GDP data for the period 1981-2014. The determinants of synchronization are the countries' pairwise differentials of cyclically adjusted net lending, government expenditure, gross exports, total factor productivity, labour productivity, capital productivity, inflation, industrial structure, private and national savings rates. They use in their study Diag-BEKK time-varying pairwise correlation of the GDP cyclical component, which have been extracted using HP filter as a measure of synchronization, and they applied a dynamic panel model with GMM. They find that countries with similarly sized public sectors, and fiscal divergence, have more synchronized business cycles. They also find that trade intensity, inflation differentials and differences in capital productivity growth rates matter for synchronization. They also find that country-pairs that trade more intensely and have similar productivity growth rates have more synchronized business cycles, while differences in inflation rates (i.e. higher inflation differentials) across country-pairs lead to increased business cycle synchronization.

Furceri and Karras (2008) use quarterly GDP data for 12 EMU countries for the period 1993 to 2004. The cyclical component of economic activity is extracted using: simple differencing, the Hodrick–Prescott filter, and the Band–Pass filter. They find the correlation between the cyclical output of each individual country with the EMU-wide cyclical output. They also apply a Panel IV regression to examine the effect of trade and fiscal policy on synchronization. The findings of the study show that all countries in the sample were better synchronized with the EMU-wide economy in the period 1999 to 2004 than during 199. They also find that the increase in overall synchronization is more due to trade factors and less (if at all) to fiscal policy coordination.

Darvas and Szapáry (2008) use quarterly GDP data for 10 EMU countries and 8 CEEC countries for the period 1983 to 2002. According to their study, the determinants of synchronization are trade, industrial production, gdp components. Furthermore, they employed a Dynamic factor model using various measures of synchronization (correlations, leads and lags in the cycles, volatility of business cycles, and persistence of the business cycle). The results of the study reveal that countries have become more synchronized over time, and trade is a major driver of synchronization.

Altavilla (2004) examines whether the EMU members share the same business cycle, and uses quarterly GDP data for 6 EU countries and the US for the period 1980 to 2002. The study uses the phase, steepness of phase, cumulative movements between phases, amplitude and concordance of the countries' cycles. Also, in their research they aim to extract the cyclical

component and they used HP and Band-pass filters. They also use Markov switching models, and they also compute the mean corrected index of concordance. The results suggest that, although during the main recessionary periods the euro area economies shared a similar output dynamic, some differences still remain in the size and timing of the business cycle features. The results also suggest that adhesion to the new currency area is likely to lead to stronger synchronization of EMU members' business cycles.

Montoya and De Haan (2008) use GVA per capita data for each of the 53 EU Nuts 1 regions. The data cover the period from 1975 to 2005. They find the regional business cycle synchronization using rolling-window correlation coefficient. Furthermore, the cyclical components are extracted using HP and CF band-pass filter. They also employ multidimensional scaling techniques to the cyclical component of GVA of the 53 NUTS 1 regions. They find that synchronization has increased for the period considered, with exceptions during the eighties and the beginning of the nineties. Still, the correlation of the business cycle in some regions with the benchmark remained low or even decreased. Their findings also support the hypothesis of the existence of a 'national border' effect.

Crespo-Cuaresma and Fernández-Amador (2013) use quarterly real GDP data for all EU countries and 11 OECD countries for the period 1960-2008. They use business cycle convergence/divergence test and business cycle dispersion measure for the proxy of synchronization. Furthermore, they identify significant business cycle divergence taking place in the mid-eighties, followed by a persistent convergence period spanning most of the nineties. This convergent episode finishes roughly with the birth of the European Monetary Union.

Di Giorgio (2016) use quarterly seasonally adjusted real GDP growth rates for the period 1993-2014 for CEEC and EA countries. They apply MSI(H)-AR (Markov switching intercept heteroscedastic) and MSI(H)-VAR models in this study. The results indicate that CEEC countries share the same business cycle features with EA cycles when they are in a recession regime; however, this is less evident when they are in an economic expansion phase. They also reject the hypothesis of the independence of CEEC cycles from the EA cycle.

Savva et al. (2010) use monthly seasonally adjusted industrial production index for existing EMU, 9 enlargement countries and 3 candidate countries for the period Jan-1980 to Jun-2006. They use Bivariate VAR-GARCH and Double Smooth Transition Conditional Correlation GARCH model. They also use HP filter for the cyclical component. They find that all new EU members and negotiating countries have at least doubled their business cycle

synchronization with the euro area or changed from negative to positive correlations, since the early 1990s.

Jiménez-Rodríguez et al. (2013) use quarterly data on real output growth, real consumption growth, and real investment growth of selected euro area and CEE countries for the period 1995 –2011. They also use Markov switching models and concordance indices for the empirical part of the study. The results show that an increase in business cycle synchronization, with the degree of concordance between country-specific and European business cycles being high.

Barrios and De Lucio (2003) use quarterly employment data from 1988-1998 for Spanish and Portuguese regions, and they also use data for direct investment flows, exports, bilateral trade, and distance between regions' capital. The econometric methods that they apply in their study are Cross-Correlation coefficient between HP filtered series and fourth difference and dissimilarity index for sectoral employment. They show that the so-called border effect (i.e. the difference of between- and within-country business cycles correlations) has notably decreased in Iberian regions in the aftermath of the accession of Spain and Portugal to the European Community. In testing the determinant of economic co-fluctuations, they show that the relative size and industrial structures of regions were the most significant variables.

Rodríguez-Pose and Fratesi (2007) use NUTS II data for GDP, Employment (overall, in services and non-services industries), industrial structure covering the period 1980-2000 for 5 EU countries. They test the pro-cyclicality of regional growth vis-à-vis national growth (sheltered economy hypothesis). Also, the regional growth differentials are with respect to the national growth rate. They apply an OLS regression to test the effects of macro-variables on changes in sheltered economies. The results of the analysis support the hypothesis of a change towards a pro-cyclical evolution of regional disparities in the cases of Italy, Portugal, and Spain, but not in those of Greece and France. A relationship between these pro-cyclical patterns and the emergence of less dynamic sheltered economies is also detected in peripheral regions. This lack of dynamism is related to the fact that numerous peripheral areas in southern Europe have become increasingly dependent on factors such as transfers or public investment and employment, and therefore are less exposed to changes in market conditions.

The paper of Bandrés, E., et al. (2017) is a review about regional-level approach. They mention in their paper that most of these studies focus on examining synchronization among short-term fluctuations in regional real economic activity. They also mention that there are four types of methodologies that are considered and are pairwise correlations, dynamic factor

models, regime switching approaches and clustering techniques. Most of the regional literature focuses on simple pairwise correlations. Specifically, in most papers, the series are transformed by using, mainly, the Hodrick-Prescott filter17 and then pairwise correlations are computed based on the filtered data. Different measures of economic activity are used; for example, Fatas (1997), Barrios and De Lucio (2003) and Belke and Heine (2006) use employment data while Acedo-Montoya and de Haan (2008) use gross value added (GVA) and Barrios et al. (2003) work with GDP series. Finally, Clark and van Wincoop (2001) work with GVA and employment measures of real activity to compare synchronization patterns among European countries and US Census regions. Regarding dynamic factor models, Marino (2013) analyzes regional fluctuations of GDP and employment. With respect to the regime-switching approach, in a recent paper, Gadea et al. (2016) combine regime-switching models and dynamic model averaging to measure time-varying synchronization for GDP.

They also refer that many papers deal with a short number of European regions, which are quite aggregated. The nomenclature of territorial units for statistics (NUTS) 2013 classification lists 98 regions at NUTS1 level, 276 regions at NUTS2 level and 1,342 regions at NUTS 3 level in the European Union. Almost all of the regional studies work with the NUTS1 aggregation level.

They also mention that some of the papers identify a border effect, regions belonging to the same country are more synchronized than regions belonging to different countries. Some papers also identify a role of the productive structure in accounting for synchronization, although results differ across papers, which could be due to differences in the definition of sectors, in the specialization measures, in the database and/or in the techniques.

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Appendix

Table 1. Summary of Literature

	Authors	Geography and Data Used	Methodology- Synchronization Measure
	Sala-i-Martin (1996)	73 NUTS2 (DE, UK, FR, IT, NE, BE and SP), 47 US regions, 10 Canadian provinces, 47 Japanese prefectures. Personal income (some years depending on the sample) EU: 1950-1990 US: 1880-1990 CA: 1961-1991 JA: 1955-1990	β convergence and σ convergence
	Barrios *et al.* (2003)	11 UK regions GDP 1966-1997	Hodrick-Prescott filter Correlation
	Bergman (2004)	The data set consists of quarterly observations on industrial production for the EU– 14 countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and the United Kingdom) and five non–EU countries (Canada, Japan, Norway, Switzerland and the US) for the sample 1961:1 to 2001:4.	Baxter and King (1999) have developed a bandpass filter that isolates cyclical components of economic time series. This filter can be designed to isolate cyclical components of economic time series conforming to a certain definition of business cycles. In particular, he isolates cyclical components of the data with durations conforming to the Burns–Mitchell definition of the business cycle. He use a 12–order two–sided filter following Baxter and King (1999) to extract all fluctuations at frequencies between 6 and 32 quarters (1.5 year and 8– eight

			years) from the logarithm of industrial production in each country.
	Belke and Heine (2006)	30 NUTS1 (BE, FR, DE, IE, NET, SP) Employment 1989-1996	Hodrick-Prescott filter Correlation
	Acedo-Montoya and de Haan (2008)	53 NUTS1 (12 EMU countries) Gross Value Added 1978-2005	Hodrick-Prescott and Cristiano-Fitzgerald filters Correlation
	Korse *et al.* (2008)	This paper studies the changes in world business cycles during *the period 1960-2003 for the G-7 countries.	They employ a Bayesian dynamic latent factor model to estimate common and country-specific components in the main macroeconomic aggregates (output, consumption, and investment). Then, they quantify the relative importance of the common and country components in explaining co-movement in each observable aggregate over three distinct time periods: the Bretton Woods (BW) period (1960:1-1972:2), the period of common shocks (1972:3-1986:2), and the globalization period (1986:3-2003:4).
	Artis *et al.* (2010)	Data for 41 EU regions and 48 US states are exploited: Annual data on regional real GDP are available for the 1982-2007 period.	Panel models with spatial dependencies Spatial correlation
	Dimitru and 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
	Filis *et al.* (2010)	Period: 1999q1-	Hodrick-Prescott filter and spectral analysis

		2007q2 Countries: Bulgaria and EA15 Series: GDP	Squared coherency
	Papageorgiou *et al.* (2010)	Period: 1960-2009 Countries: major European countries, US and Japan Series: Major annual macroeconomics series	Hodrick-Prescott filter Correlations in different sub-periods and mean rolling correlations
	Aguiar-Conraria and Soares (2011)	Period: 1975m7-2010m5 Countries: EU15 and EA12 Series: Industrial production.	Wavelet power spectra between 1.5 and 8 years frequencies. Metric based on wavelet spectra
	Artis *et al.* (2011)	Period: 1880-2006 Countries: 25 advanced and emerging economies Series: Annual GDP.	Hodrick-Prescott filter Correlations in different sub-periods
	Benčík (2011)	Period: 1995q1- 2010q3 Countries: Czech Republic, Hungary, Poland, Slovakia and EA15 Series: GDP	Hodrick-Prescott filter Cross-correlations in different sub-periods
	Bergman and Jonung (2011)	Period: 1834-2008 Countries: Sweden, Norway, Denmark and selected OECD countries Series: annual GDP.	Christiano-Fitzgerald filter Rolling average crosscorrelations
	Mink *et al.* (2011)	Period: 1970q1-2006q4 Countries: 11 European countries Series: GDP	Christiano-Fitzgerald, Hodrick-Prescott and Baxter-King filters Synchronicity and similarity

	Lee (2012)	European Economic and Monetary Union (EMU) on the extent of business cycle synchronization across its member states.	A dynamic latent factor model is used to identify the 'regional' effect of the euro area on output growth and inflation dynamics across European countries.
	Šergo *et al.* (2012)	Period: 1991m1 and 2010m3 Countries: Croatia Series: 15 macroeconomic series	Hodrick-Prescott filter Concordance index
	Kolasa (2013)	Period: 1996q1- 2011q4 Countries: Czech Republic, Hungary, Poland, Slovenia, Slovakia Series: major economic series.	Hodrick-Prescott filter Correlations in different sub-periods
	Marino (2013)	107 NUTS1 and some NUTS2 (BE, DE, EL, FR, IT, NL, PT, SP and UK) GDP and employment 1977-1995	Dynamic factor model Correlation
	Obradović and 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
	Park (2013)	East Asian countries in the period of 2000:Q1-2011:Q4. Real GDP, real private consumption expenditure, and real investment	Dynamic factor model to extract the regional common factor. The degree of business cycle synchronization is measured by time-varying dynamic conditional correlation for each country. Finally, the determinants of business cycle synchronization are examined by differentiating the monetary and fiscal policy variables as well as the non-policy variables

	Stanisic (2013)	This paper focuses on the synchronization of business cycles among Central and Eastern European countries (CEECs) and the EA. Data: quarterly, seasonally adjusted real GDP data series for the period 1995–2012, obtained from the Eurostat National Accounts database.	Business cycles are extracted from GDP data series using a double Hodrick–Prescott filter method. The degree of co-movement of cycles is evaluated on the basis of various methods of rolling correlation
	Degiannakis *et al.* (2014)	EU-12 Period: 1980-2012	Scalar-BEKK and multivariate Riskmetrics model frameworks.
	Gouveia (2014)	Period: 2000q1- 2011q4 Countries: 8 countries in Southeastern Europe Series: GDP	Hodrick-Prescott and Baxter-King filters Concordance index, rolling concordance index, Spearman's rank-order correlation coefficients, rolling correlation coefficients
	Konstantakopoulou and Tsionas (2014)	Period: 1960q1-2010q4 Countries: main OECD countries Series: GDP	Hodrick-Prescott, Christiano-Fitzgerald and Baxter-King filters Cross-correlations
	Bekiros *et al.* (2015)	Eurozone Countries	Cross-wavelet coherence measure to detect and identify the scale-dependent time-varying (de)synchronization effects amongst Eurozone and the broad Euro area business cycles before and after the financial crisis.
	Ozyurt and Dees (2015)	253 NUTS2 EU Real GDP pc 2001-2008	Moran index Spatial Durbin ramdom-effect panel model
	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)

	Beck (2016)	Time series of real GDP for 24 EU countries, 82 NUTS 1, 242 NUTS 2 and 1264 NUTS 3 regions over the period between 1998 and 2010.	Hodrick-Prescott, as well as Christiano and Fitzgerald filters.
	Degiannakis *et al.* (2016)	Annual GDP and cyclically adjusted net lending (NLB) data from 10 EMU member-countries and the aggregate EMU12. The data cover the period from 1980 to 2012.	Time-varying framework.
	Gadea *et al*. (2017)	213 NUTS2 (18 EU countries) GDP 1980-2011	Regime switching and Dynamic model averaging Correlation
	Grigoraş and Stanciu (2016)	Period: 1960/95q1- 2014q3 Countries: 30 European and US Series: GDP	Classical definition of business cycles Concordance index and correlations
	Monnet and Puy (2016)	This paper assesses the strength of business cycle synchronization between 1950 and 2014 in a sample of 21 countries using a new quarterly dataset (industrial production) based on IMF archival data.	To enhance the comparability of the results with the previous literature, in particular Kose, Otrok and Whiteman (2003, 2008), they rely on the same econometric methodology to assess the importance of a world business cycle.
	Bandrés *et al.* (2017)	NUTS 2013 classification28 which lists 98 regions at NUTS1 level, 276 regions at NUTS2 level and 1,342 regions at NUTS 3 level. The series cover a period of 32 years, from 1980 to 2011. European and regional level growth of the GDP	Finite Mixture Markov Models Clustering based on finite mixtures of dynamic regression models. The idea is to pool time series to obtain posterior inferences but without being necessary an overall pooling within clusters.

	Belke *et al.* (2017)	Seasonally adjusted real gross domestic product (GDP) on a quarterly basis from the OECD. Data ranging from 1970Q1 to 2015Q4.	Quarterly index for business cycle synchronization by Cerqueira (2013) Correlation coefficients and nonparametric local polynomial regressions
	Camacho *et al.* (2017)	Sample period is 1983.01-2017.05. 17 Spanish regions using total security system affiliation as the measure of economic activity.	Single-equation Markov-switching model Concordance index
	Duran and Ferreira-Lopez (2017)	Eurozone context, using GDP and employment as the business cycle measures, of the determinants of business cycle synchronization identified in the literature, namely bilateral trade intensity, dissimilarity of labor market rigidity, dissimilarity in industrial structures, financial openness, and foreign direct investment relations.	Simultaneous 4-equations model by Ordinary Least Squares (OLS) and three-stage least square to investigate empirically the determinants of business cycle correlation.
	Karadimitropoulou (2018)	5 developed economies (G5) and 19 emerging economies for the 1972-2009 period value added growth in a multi-sector dynamic factor model.	Multi-factor dynamic model to a multi-sector setting. It is augmented with a region-specific factor to capture sectoral synchronization at a regional level. Correlations – Variance Decomposition
	Kovacic and Vilotic (2017)	Period: Quarterly GDP series from Eurostat database covering period 2000q1-2016q3 Countries: Europe	Corbae-Ouliaris ideal band filter and double Hodrick-Prescott filter Concordance index and cross-correlation function. Rolling cross-correlations at three lags were used to assess evolution of synchronization over time.
	Lange (2017)	Total employment for both sexes, 15 years and over.3 The estimation period is from 1976:5 to 2010:6	Markov-switching methodology Concordance indices and cross-correlations
	Leiva-Leon (2017)	Data on U.S. states coincident indexes were provided by the Federal Reserve Bank of Philadelphia. The sample spans from August 1979 until February 2016 The Chicago Fed	Markov-switching framework to endogenously identify periods where economies are more likely to (i) synchronously enter recessionary and

		National Activity Index (CFNAI) is used as a monthly measure of the U.S. national business cycle. All these indexes of real economic activity, for each state and for the entire United States, have been constructed based on the principle of co-movement among industrial production, employment, sales and income measures.	expansionary phases, and (ii) follow independent business cycles. The reliability of the framework is validated with simulated data in Monte Carlo experiments.
	Gomez-Losko *et al.* (2019)	Annual real GDP data. NUTS2 regions corresponding to 16 European countries. The series were available from 1980 to 2011.	Finite Mixture Markov models that allow to deal with technical difficulties that arise in capturing business cycles with short samples and heterogeneous data.
	Jarko *et al.* (2018)	About 3,000 business cycles synchronisation coefficients and their design and estimation characteristics	Meta-regression analysis
	Camacho *et al.* (2019)	All the members of the EA using a large panel of cross-country data. Macroeconomic series of production, consumption and investment for each country. In particular, they use the demeaned growth rates of GDP, Household **and** NPISH Final Consumption Expenditure, and Gross Fixed Capital Formation. The seasonally adjusted series were downloaded from the Eurostat database at a quarterly frequency. Effective sample spans the period between the first quarter of 2000 to the last quarter of 2015 for all the nineteen countries of the EA but Cyprus.	They take advantage of the dimension reduction properties of dynamic factor models to summarize a large dataset of macroeconomic indicators for the Euro Area countries. Then, they estimate latent state variables based on Markov-switching methodologies to obtain a time-varying measure of business cycle synchronization.
	Guerini *et al.* (2019)	Eurostat database of manufacturing industrial production time-series in the European Union (EU) over the 2000-2017 period.	The approach exploits Random Matrix Theory and extracts the latent information contained in a balanced panel data by cleaning it from possible

			spurious correlation. We employ this method to study the synchronization among different countries over time.
	Hou and Knaze (2019)	Period: 1973-2016 Yearly or Quarterly GDP 21 OECD Countries	Baxter-King filter Correlation
	Nkwatoh (2019)	ECOWAS economies Annual real GDP growth rate from 1975 to 2015	Hodrick-Prescott filter Country correlations
	Abdallah (2020)	Tunisia, 1980-2018 Trade intensity	The synchronization of economic cycles is measured by calculating the correlations between the cyclical components of certain macroeconomic variables. In their work, they use GDP in real terms to calculate the cyclical correlations between Tunisia and each partner country of the European Union (France, Italy, Germany, Spain, and Belgium). The cyclical components are extracted by the HP filter.
	Gießler *et al.* (2020)	Real GDP, unemployment rates and survey data as business cycle indicators. They distinguish between two regions—East Germany and West Germany. They use quarterly, seasonally adjusted GDP growth for the period 1991-2017.	They construct a coincident index determined by an inverse standard deviation weighting for all indicators Furthermore, they estimate a factor model of the indicators where the indicators are represented by two unobservable components: the common component (factor) F and the idiosyncratic component Correlations of quarterly GDP growth, output gap, first differences of unemployment rates, the cyclical component of unemployment rates and first

			differences of survey data for the time period between 1991 and 2017. They employ a cycle synchronisation index (CSI) to assess the degree of business cycle synchronisation. The CSI counts the sum of sign concordances of two indicators and relates this sum to the number of observations of the time series.
	Bunyan *et al.* (2020)	14 EU countries' pairwise synchronization. Annual data for the period 1981-2014. Annual GDP. Determinants of synchronization were the countries' pairwise differentials of: Cyclically adjusted net lending, government expenditure, gross exports, total factor productivity, labour productivity, capital productivity, inflation, industrial structure, private and national savings rates.	Measure of synchronization: Diag-BEKK time-varying pairwise correlation of the GDP cyclical component, which have been extracted using HP filter. Dynamic panel model with GMM.
	Furceri and Karras (2008)	Quarterly GDP data for 12 EMU countries for the period 1993 to 2004. The cyclical component of economic activity is extracted using: simple differencing, the Hodrick–Prescott filter, and the Band–Pass filter.	Correlation between the cyclical output of each individual country with the EMU-wide cyclical output. Panel IV regression to examine the effect of trade and fiscal policy on synchronization.
	Darvas and Szapáry (2008)	Quarterly GDP data for 10 EMU countries and 8 CEEC countries for the period 1983 to 2002. Determinants of synchronization: trade, industrial production, gdp components.	Dynamic factor model using various measures of synchronization (correlations, leads and lags in the cycles, volatility of business cycles, persistence of the busines cycle).
	Altavilla (2004)	Quarterly GDP data for 6 EU countries and the US for the period 1980 to 2002. The study uses the phase, steepness of phase, cumulative movements between phases, amplitude and concordance of the countries' cycles.	HP, Band-pass filters for the extraction of the cyclical component. Markov-Switching models. They also compute the mean corrected index of concordance.

	Montoya and De Haan (2008).	53 EU NUTS 1 regions for the period 1975-2005. GVA per capita for each NUTS I region.	Regional business cycle synchronization using rolling-window correlation coefficient. Cyclical components are extracted using HP and CF band-pass filter. Multidimensional Scaling techniques to the cyclical component of GVA of the 53 NUTS 1 regions
	Crespo-Cuaresma and Fernández-Amador (2013)	Quarterly real GDP data for all EU countries and 11 OECD countries for the period 1960-2008	Business cycle convergence/divergence test and business cycle dispersion measure for the proxy of synchronization.
	Di Giorgio (2016)	Quarterly seasonally adjusted real GDP growth rates for the period 1993-2014 for CEEC and EA countries.	MSI(H)-AR (Markov switching intercept heteroscedastic) and MSI(H)-VAR models.
	Savva et al. (2010)	Monthly seasonally adjusted industrial production index for the period Jan-1980 to Jun-2006. Countries: existing EMU, 9 enlargement countries and 3 candidate countries	Bivariate VAR-GARCH and Double Smooth Transition Conditional Correlation GARCH model. HP filter for the cyclical component.
	Jiménez-Rodríguez et al. (2013)	Quarterly data on real output growth, real consumption growth, and real investment growth of selected euro area and CEE countries for the period 1995 –2011	Markov switching models and concordance indices.
	Barrios and De Lucio (2003)	Quarterly employment data from 1988-1998 for Spanish and Portuguese regions. Direct investment flows, exports, bilateral trade, and distance between regions' capital	Cross-Correlation coefficient between HP filtered series and fourth difference. Dissimilarity index for sectoral employment.
	Rodríguez-Pose and Fratesi (2007)	NUTS II data for period 1980-2000 for 5 EU countries. GDP, Employment (overall, in services and non-services industries), industrial structure,	Test the pro-cyclicality of regional growth vis-à-vis national growth (sheltered economy hypothesis). Regional growth differentials with respect to the national growth rate. OLS regression to test the effects of macro-variables on changes in sheltered economies.