Synchronization of Business Cycles in the EU: Time Series Clustering

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Abstract: - The enlargement of the European Union was the crucial factor of synchronization of business cycles. The main aim of the paper is to study macro variables co-movement within the EU and its underlying driving forces. The examined variables include GDP, export and employment. The choice of the similarity measure of time series depends mostly on the purpose of research. The authors have applied cluster analysis to identify the level of business activity convergence, based on an adaptive dissimilarity index covering both proximity on values and on behaviour, Euclidean distance and concordance measure. To distinguish homogenous groups of countries according to their business cycles dynamics two approaches were used: clustering based on matrix of dissimilarity measures calculated for a specific variable in time, and clustering based on average dissimilarity between countries. Authors presented also different methodological approaches to the identification of business cycles synchronisation (BCS) as well as current research. The results shows that there exists such phenomenon like "business cycles clubs". It means that we can observe quite high similarity of business cycles across EU countries, according to dynamics and values of analysed indicators, especially for export and GDP, but only within homogenous groups of countries. Received results can be compared with results obtained by other authors, but its most important application is possibility of create and apply the same anticyclical financial, monetary and fiscal policy to the group of some/several countries. An identification of BCS by means of two measures focused on proximity on values and on behaviour in a multidimensional environment, as well as an assessment of concordance of obtained classification for a particular indicators and for applied measures evidence some novelty of the research.

Key-Words: - business cycles, synchronisation, time series, dissimilarity measures, clustering, concordance, European Union.

1 Introduction

One of the main economic policy objectives is to reduce fluctuations in economic activity by stimulating and reducing demand, mainly domestic demand, in periods of economic downturn and recovery respectively. Determining the necessary strength and areas of state intervention requires not only knowledge of the economic cycle of a given country, but also the degree of its synchronisation with changes taking place in other economies [4]. Economic theory and practice provide many premises and evidence that the effectiveness of policies is higher, if there are less volatile and more synchronized business cycles [13]. Business cycle convergence and asymmetry is also an important criterion to judge the costs and feasibility of monetary and economic integration. Such integration can lead to regional concentration of industrial activities which, in turn, can lead to sector or region specific shocks, increasing the likelihood of diverging business cycles [32], as well as to better income insurance through greater capital integration, and in turn to more specialised production structure and an increase in trade and therefore less synchronized business cycles [27]. Production increase in a given country triggers a strong improvement of the foreign country's terms of trade, which raises foreign labour demand,

transferred by labour wealth effect to foreign labour and GDP rise, i.e. domestic and foreign real activity commove positively [29]. Although we have to notice that the impact of financial integration on business cycles is ambiguous. On the one hand, financial markets work similarly to trade links. Thus, business cycles in one country are likely to affect investment decisions and asset prices in other countries via financial flows. Conversely, FDI allows countries to specialize such that a high degree of financial integration may reduce the extent of co-fluctuations [6]. The business cycle synchronisation testing has a multidimensional dimension. This is due not only to the relatively complex nature of the concept of "business cycle", but also to the need to answer questions about the nature of the links between sectoral, regional and international cycles [19]. There is the intuition behind multivariate analysis, which exploit more information, hence tracks co-movements in aggregate variables and offer richer interpretations in terms of underlying economic behaviour [16]. Since the economies are interconnected via trading, financial, and information flows, it is natural to look for connections among indicators and investigate regressive multivariate relationships. Grouping the series with similar features in the time domain (shape variation) and in the frequency domain (coherence) help to reveal co-movements of business cycles [38], [42]. At the same time, many authors point out that a correct analysis of the course and similarity of business cycles requires the definition of appropriate indicators characterising this phenomenon, allowing for accurate forecasting turning points, extract the cyclic component and distinguish short-run and long-run co-movements [28]. It does not seem sufficient to look to a single measure like a GDP, because the specific information can be drawn from other variables like private consumption, business investment, trade and changes in inventories [10], as well as employment, profit rate and technology [39]. Analysing cyclical fluctuations of GDP, labour and investment across advanced economies we can often observe that these indicators are highly positively correlated [29]. One of the indicators frequently used in the analysis of synchronisation determinants is trade characterised by exports and imports [7], [32], [3]. Inklaar et. al, re-examined the relationship between trade intensity and business cycle synchronization for 21 OECD countries during 1970-2003. Using a multivariate model including variables capturing specialisation, financial integration, and similarity of economic policies, they confirmed that trade intensity affects business cycle synchronization, although the effect is smaller than previously reported [25]. Some authors indicate that the level of similarity of business cycles increases as trade intensity increases and decreases as exports generated by new firms increase in response to productivity gains [40]. At the same time, works can be found showing that in the case of selected partners, for example ASEAN and China the export profile is increasingly dissimilar [45]. The main goals of the undertaken research are the identification of spatial patterns of business cycles synchronization within European Union and comparison the pattern of business cycles synchronization in the value (level) against the pattern of business cycles synchronization in behaviour (dynamics). Apart from stylised indicator GDP, we use export to consider trade intensity and employment. The latter indicator was incorporated, because we assume that there is a strong relation between effective anticyclical policy and reduction of the job loss [20]. There exist a broad range of measures to compare time series and the choice of the proper dissimilarity measure depends largely on the nature (purpose) of the clustering. In the specific context of time series data, the concept of dissimilarity is particularly complex due to the dynamic character of the series. Dissimilarities usually considered in conventional clustering could not work adequately with time dependent data because they ignore the interdependence relationship between values [22]. In order to eliminate the above limitations, the paper uses a cluster analysis (Ward method) using two measures of similarity of time series: the first order temporal correlation coefficient and Euclidean distance for standardized values. They allow to receive “homogenous” time series within a specific cluster that seems to be more synchronised to each other in comparison to the members of other clusters. In that case we can assume that they can become the objects of the same policy applied. The rest of the paper is organized as follows: the current research was reviewed to underline implications of results received by other authors (part 2), the business cycle synchronisation research methods were described (part 3), the data and received results were demonstrated (part 4) and the paper ends by discussing the main findings (part 5).

2 Current research

There is an extensive literature on business cycle synchronization in Europe. For instance, Artis et al. [2] and Janiga-Ćmiel [26] show strong improvement in cyclical correlations, report increasing convergence between the CEECs and the EU. The

main conclusions of the study conducted by Darvas and Szapáry [15] are that Hungary, Poland and Slovenia have achieved high degree of synchronization for GDP, industrial activity and exports, but not for consumption and service sector – see also a meta-analysis of 35 studies made by Fidrmuc and Korhonen [21]. Findings and discussions on a strong increase in synchronization of the euro-area states during the run-up to euro adoption, and a more stable level of business cycle synchronization thereafter can be found in Lee [33], and Bekiros et al. [8]. Batóg [4] using Economic Sentiment Indicator (ESI) and Theil's divergence ratio showed that the Member States of the European Union are characterised by a relatively diversified level of convergence with economic fluctuations – the same results received Gomez, Ortega, Torgler [23] and Savva et al. [41]. He also observed a strong increase in the correlation of economic fluctuations due to EU enlargement. In the pre-accession period, the impact on the convergence of business cycles of both the differences in average ESI levels and the differences in ESI trends was evident, while after EU enlargement, the first factor lost its importance. Similar conclusions, the existence of different synchronization levels and dynamics in output growth in single countries as well as in groups of countries, obtained Gomez et al., analysing old, new and potential members of EU. At the same time they demonstrated that the synchronization of the old EU countries remained stable until the current financial crisis. Di Gorgio [18] analysing the correlations between the cyclical fluctuations for CEECs and the Euro Area countries, and distinguishing between different regimes found that the indications of business cycle synchronization are quite high in the recession regime, but lower in the normal and high growth regimes. Similar conclusions were drawn by Stanisic [43]. Results received by Papageorgiou et al. [39] suggest a core–periphery distinction in Europe. They observed that European countries increased their synchronization in the time period 1992-1999, while the 2000-2009 time span is characterised by decreasing synchronization and an increase in the number of clusters. Stock and Watson [44] show that the volatility of economic activity in most G7 economies has moderated over the past 40 years, while in the same time, despite large increases in trade and openness, G7 business cycles have not become more synchronized. Economic and monetary integration is a frequently used argument in favour of increasing convergence of business cycles [24]. Bruzda et al. [9] examined cyclical synchronization of 20 European Union countries, and show that during the run-up to the euro both amplitude and phase synchronization increased, with the former tending to change more rapidly. Furthermore, for the new EU members an EU effect is identified in both types of cyclical synchronization with the euro area. There was found also strong cycle-return spillover effects between cross-country business cycles, cross-country stock market cycles and cross-country real estate market cycles across G7 from February 1990 to June 2014 [35]. Lukmanova and Tondl [36] using a quarterly data set covering the period 2002-2012 and estimate the direct and indirect effects of macroeconomic imbalances in the pre- and post-crisis period in a simultaneous equations model find that differences between Euro Area members in the current account, in government deficit and public debt, in private debt and unit labour cost developments have reduced business cycle synchronization, even more in the post-crisis period than before.

3 Research methods

Some authors show that the business cycles of advanced economies are synchronized, but in the same time they underline that standard macro models fail to explain that fact [29]. This phenomenon is probably the reason for the wide variety of methods used to identify the degree of synchronisation of business cycles. Most popular methods of identification of business cycles convergence are correlation coefficients, wavelet analysis [37], [1], [9] and time series models (clustering). Among other methods we can find: bivariate VAR-GARCH specification with a smoothly time-varying correlation that allows for structural changes in the degree of co-movement between the cyclical components [41], non-linear parametric Markov-Switching Model [46], Markov switching autoregressive models and synchronization tests [18], GMM in case of small samples [11], Dynamic Time Warping [5] and HP filter method [43]. The most common measure of co-movement between time series is the classical correlation. Unfortunately this measure is associated with two drawbacks: first, it does not allow for a separation of idiosyncratic components and common co-movements. Second, it is basically a static analysis that fails to capture any dynamics in the co-movement [6]. More recently, the correlation coefficients are used jointly with other measures of dependence, such as the dynamic correlation coefficient of Croux, Forni, and Reichlin [14], the coherency coefficient, the maximum correlation coefficient, or the phase-adjusted correlation

coefficient of Koopman and Azevedo [30]. Fu [22] provides a complete and comprehensive overview on recent time series data mining directions, including a range of key problems such as representation, indexing and segmentation of series, measures of dissimilarity, clustering procedures and visualization tools. If the objective is to compare profiles of series, then conventional distances between raw data evaluating a one-to-one mapping of each pair of sequences can produce satisfactory results. An excellent survey on time series clustering can be found in Liao [34]. To apply time series clustering we should be aware that the dynamics of a time series may change over time, a time series might display patterns that may enable it to belong to one cluster over one period while over another period, its pattern may be more consistent with those in another cluster [37]. A separate issue is the correct determination of the number of clusters. For this purpose, it is possible to use various measures of the quality of the divisions obtained, including, for example several R libraries, like clValid, fpc or clv. To analyse the synchronisation of business activity of EU countries two measures were applied. The first one is the dissimilarity index D based on similarity measure in the behaviour (dynamics) of the specific indicator for two countries called first order temporal correlation coefficient CORT [12]:

$$CORT = \frac{\sum_{t=1}^{T-1}(u_{t+1}-u_t)(v_{t+1}-v_t)}{\sqrt{\sum_{t=1}^{T-1}(u_{t+1}-u_t)^2}\sqrt{\sum_{t=1}^{T-1}(v_{t+1}-v_t)^2}} \quad (1)$$

where:

u_t, u_{t+1} – values of the given indicator in the first country in periods *t*, *t*+1,

v_t, v_{t+1} – values of the given indicator in the second country in periods *t*, *t*+1.

The correlation coefficient CORT is transformed to the dissimilarity index D, based on an automatic adaptive exponential tuning function:

$$D = \frac{2}{1+\exp(k \cdot CORT)} \quad (2)$$

where: *k* – tuning parameter (we use *k* = 3).

The second measure responsible for measurement of the similarity in the paths of levels (values) of indicator for two countries is Euclidean distance for values standardized separately for individual country:

$$dE = \sqrt{\sum_{t=1}^{T}\left(\frac{u_t-\bar{u}}{s_u}-\frac{v_t-\bar{v}}{s_v}\right)^2} \quad (3)$$

where:

u_t, v_t – values of the given indicator in the first and second country in period *t*,

$\bar{u}, s_u$ – mean and standard deviation of the given indicator in the first country,

$\bar{v}, s_v$ – mean and standard deviation of the given indicator in the second country.

Additionally we assess the consistency of clustering results based on two applied measures D and dE using the concordance index similar to Sokal-Michener dissimilarity index:

$$concordance = \frac{\sum_{i=1}^{n}\sum_{j=i+1}^{n} c_{ij}}{\frac{n(n-1)}{2}} \quad (4)$$

where:

c_{ij} is equal 1 if countries *i* and *j* are in the same group in two classifications or countries *i* and *j* are not in the same group in two classifications, and 0 otherwise.

4 Empirical results

The data (annual observations of GDP, export and employment in 2002-2017) was extracted from Eurostat Database. The grouping of countries, based on the values of the measure of dissimilarity (D) and Euclidean distance (dE), was carried out using the STATISTICA 12.0 statistical package. First of all, the matrices of distance between countries were determined on the basis of D and dE measures for the analysed indicators. The distance matrices were then the basis for the grouping of countries using the Ward method. In addition, objects were grouped based on the average distance taking into account all the considered indices. Next, the obtained classifications were compared using a measure of concordance in two profiles: the concordance of classifications obtained according to different measures for the same index and the concordance of classifications obtained for pairs of indicators for the same measure.

In Figures 1 and 2 structure of groups of countries received for index D and distance dE according to export is presented. We can observe very high level of consistency of clusters derived using both measures. Only a few countries changed their membership. For example Finland is similar to Denmark, France, Sweden, Greece, Germany, Austria and Belgium if we consider similarity in export dynamics, while its level run is analogical to such countries like United Kingdom, Luxembourg, Malta and Ireland.

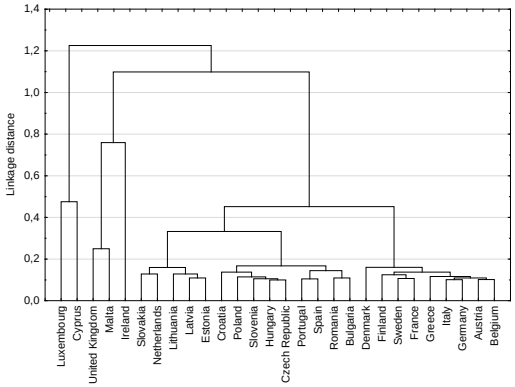

Fig. 1. Dendrogram in case of index D for export

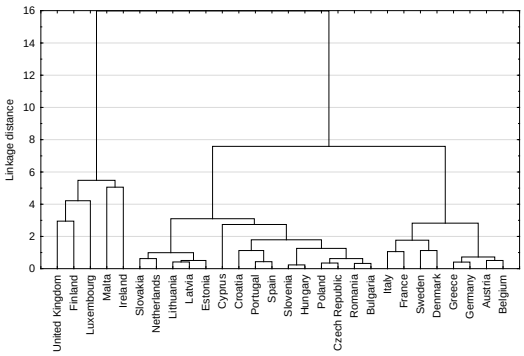

Fig. 2. Dendrogram in case of distance dE for export

Figures 3 and 4 present dendrograms for measures D and dE when distances between countries were computed as average of distances between countries calculated separately for three indicators: GDP, export and employment.

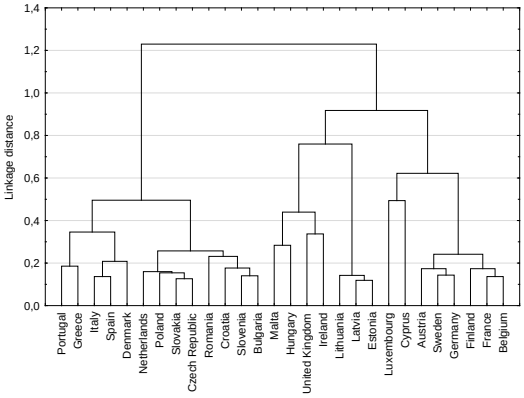

Fig. 1. Dendrogram in case of measure D and average distance between countries

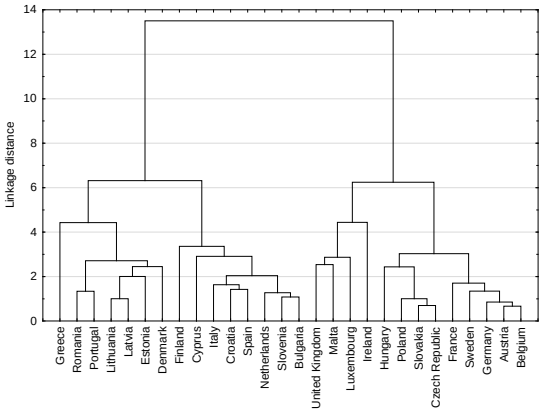

Fig. 2. Dendrogram in case of measure dE and average distance between countries

In both cases it seems that the most eligible partition relates to four clusters. Based on above dendrograms there could be drawn the conclusion that quite high overall homogeneity of received clusters occurs.

Table 1 presents values of the measure of concordance of two classifications of examined countries – first classification is based on the measure D and the second one – on the measure dE.

Table 1. Concordance of countries classifications according to D and dE on the base of specific indicator

Indicator	Concordance
GDP	0.804
Export	0.934
Employment	0.635
Average	0.688

Table 2 shows values of the measure of concordance of classifications based on two indicators in case of two measures D and dE.

Table 2. Concordance of countries classifications according to D and dE for the pairs of indicators

Indicators	Concordance for D	Concordance for dE
GDP – export	0.723	0.693
GDP – employment	0.609	0.577
Export – employment	0.616	0.571

It turned out that there is very strong concordance between classifications obtained with use of D and dE for export and GDP. The strong concordance of classifications refers also to the

same pair of indicators when we use only one measure. The level of concordance is always higher when we apply measure D.

5 Conclusion

The results of the cluster analysis carried out with the use of macroeconomic indicators characterizing the level of production, trade intensity represented by export and employment indicate the occurrence of a relatively strong synchronization of business cycles across the European Union countries in 2002-2017, because of high values of concordance of received classifications. In most cases, the classifications suggest the division of the countries examined into four groups, the so-called "business cycle clubs". A detailed analysis of the agglomeration's results shows that the most common in the same cluster appear Southern European countries (Greece, Portugal, Spain, Italy, Croatia and Cyprus), Central and Eastern European countries (Czech Republic, Slovakia, Poland, Bulgaria and Romania), Baltic countries (Estonia, Lithuania, Latvia), highly developed countries (Austria, Belgium, France, Germany, Sweden) and Great Britain with Ireland. It corresponds to core-periphery hypothesis of Papageorgiou et al. [39]. In the future research the robustness of the level of business cycles synchronisation can be assessed within time subperiods to decide whether the regime switches occur during economic crisis. Additional indicators like public debt or Economic Sentiment Indicator can also enrich conducted analysis.

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