sciendo

Synchronization of Business Cycles in European Union Countries

Robert-Adrian GRECU*
The Bucharest University of Economic Studies, Bucharest, Romania[1]
**Corresponding author, grecurobert16@stud.ase.ro*

Abstract. *The COVID-19 pandemic has affected economic activity worldwide. Despite the progress made by vaccination campaigns, important uncertainties still linger amid persistent global value chains disruptions and the ongoing energy crisis. A proper understanding of the behavior of the economy is therefore essential for future policy decisions. While there are plenty of studies regarding business cycles, using various methods from univariate filters to more complex methods, less papers focus on large scale comparisons. In this paper, we provide an overview of business cycles in European Union countries. We use the Hodrick-Prescott filter in order to measure the cyclical component of the gross domestic product and the Bry-Boschan-Quarterly algorithm for further analysis, namely the duration and the amplitude of the business cycles. Our results show that their size in European Union countries varies from 2.7 to 6 years and their amplitude is between 1.6 and 5.6 percentage points. We show that in developed economies, business cycles are more stable. Furthermore, strong correlations in terms of business cycles are found in the case of certain groups of countries, such as the Baltic ones or Belgium, Austria and France. In the case of Romania, its business cycle is more similar to the one of Bulgaria, Croatia and Slovenia. These results could provide useful information for policymakers in terms of future policy decisions conditional on both the current state of the economy and its structural characteristics. Under these circumstances, support measures should also take into consideration such properties of the economy.*

Keywords: business cycle, turning point, synchronization, European Union, amplitude, duration.

Introduction

After two years from its outbreak, the COVID-19 pandemic still represents an important source of uncertainty. It has already struck a hard blow on economies worldwide and the emergence of more contagious virus strains hinders economic recovery. Its rapid spread caused in 2020 severe contractions amid social distancing measures and even national lockdowns. At the current juncture, new risks have recently emerged amid persistent global value chains disruptions and the ongoing energy crisis.

A correct understanding of the behavior of the economy is essential for future decisions of policy makers. Moreover, it is necessary to be aware of the phase of the business cycle. Apart from determining its phase, a robust analysis could also show the position within the business cycle and other characteristics such as its amplitude and duration.

At the same time, understanding the linkages between economies could as well offer incentives regarding the future evolution of main macroeconomic indicators. The COVID-19 pandemic has shown a coordinated response of national authorities in terms of measures alleviating the adverse economic effects of the sanitary crisis. Yet, those measures have not accounted for specific economic structures and characteristics.

In this paper, we focus on business cycles in European Union (EU) countries. We use the Hodrick-Prescott filter to break down GDP into its trend and cyclical component. Firstly, we analyze the obtained results in case of the cycles of each member state. Secondly, in order to

[1] *This paper was co-financed by The Bucharest University of Economic Studies during the PhD program.*

DOI: 10.2478/picbe-2022-0021

provide a broader view on business cycles, we use the Bry-Boschan-Quarterly (BBQ) algorithm for determining turning points. This method facilitates the computation of the size of business cycles and also their amplitude. In the case of the latter one, this indicator can be used to assess the severity of a recession. The bigger the amplitude is, the stronger impact a recession is anticipated to have. Lastly, we evaluate the linkages between EU countries, thus highlighting possible strong spill-over effects at the current juncture.

Literature review

In modern macroeconomics the analysis of business cycles is essential for the understanding of the economic momentum and future evolutions. Formally, two institutions are in charge of maintaining a chronology of business cycles: National Bureau of Economic Research (NBER) in case of the USA and the Center for Economic Policy Research (CEPR) in case of Euro Area countries. This concept was first introduced at the NBER by Mitchell (1913) and a formal definition was provided by Burns and Mitchell (1946), according to which "business cycles are a type of fluctuation found in the aggregate economic activity of nations" (Grigoras, 2015).

In economic literature there are different approaches to measuring business cycles. Two of the most used are the classical one and the growth cycle view. In the case of the classic approach, it was pioneered by Burns and Mitchell and refined and extended by Zarnowitz (1996) and Moore and Zarnowitz (1982). This definition is still used by NBER (Mazzi, 2003). As regards the growth cycle perspective, it is assumed that the series measuring aggregate economic activity must be considered in terms of deviation from a trend, namely a potential level. Even though the above-mentioned approaches are the most frequently used in literature, Bortz (2021), following the work of Keynes on business cycles, identifies six different theories regarding business fluctuations.

Given its importance in economic research, with implications also for policy recommendations, various methods of extracting business cycles have been used. In the case of the Romanian business cycle, Caraiani (2010) uses a Markov Switching AR approach on the monthly production index and obtains similar results in terms of turning points to the ones obtained through the classical dating procedure. Dumitru and Dumitru (2010) considers various approaches when modeling business cycles in Romania, namely univariate methods such as the Quadratic trend, the Hodrick-Prescott filter, Band-Pass filter, Beveridge-Nelson decomposition, Wavelet transformation and the principal component analysis. In the case of the Polish economy, Mazur (2017) is modeling the business cycle using a flexible Fourier form.

Apart from measuring the business cycle, the analysis of a possible synchronization between several countries in this regard also plays an important role in economic literature. Stock and Watson (2005) find that within Euro-zone countries international synchronization has increased, as well as for English speaking countries. Yet, across these two groups, correlations have decreased. Krupa (2012) studies the correlations between economic activity fluctuations and various Asian and Latin American emerging countries and concludes that there is no evidence to support the existence of a significant correlation regarding the business cycles of these countries.

Artis et al. (2004) investigate whether there is synchronization between European countries using a Markow-switching regime process. Except for the UK, the authors find a considerable synchronicity in terms of business cycles of European countries, especially in the case of Southern economies such as Spain and Portugal. Berger et al. (2021) also supports the presence of a global business cycle, regional cycles and development group cycles. Grigoras and Stanciu (2016) highlight that post-crisis developments show high heterogeneity in terms of synchronization of business cycles of EU member states.

At the current juncture, given the ongoing sanitary crisis, empirical evidence tries to capture specific effects of the health crisis. For instance, Kufel et al. (2021) use energy consumption when modeling business cycles and Cizmesija (2021) evaluates the relationship between the Economic Sentiment Indicator and GDP growth. Moreover, Gehringer and Mayer (2021) compile information from 20 macroeconomic indicators using the principal component analysis in order to obtain a business cycle indicator for Germany.

Methodology

Data

We used the real gross domestic product on a quarterly basis in order to determine business cycles. The series was seasonally and calendar adjusted, after which it was passed through the logarithmic operator and then differentiated. Data on real GDP for each of the EU member states were taken from the Eurostat database, the period analyzed in the article is between Q1 2001 and Q3 2021 and the econometric program used to obtain the results was Matlab 2020b.

Model

The main method used in the article to break down the data series into two main components, the trend and the cyclical component, is the Hodrick-Prescott filter. Thus, a time series of a variable is defined in the following way:

$$y_t = \tau_t + c_t \quad (1)$$

Where τ_t represents the trend of the variable and c_t represents the cyclical component. It should be noted that in addition to the two components in some data series, the seasonal component may also appear, but in this case the data series used were previously seasonally and calendar-adjusted.

To determine the trend of the data series, a loss function which is defined as in formula (2) is minimized:

$$\sum_{t=1}^{T}(y_t - \tau_t)^2 \ + \lambda \sum_{2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \quad (2)$$

Where λ represents the smoothing parameter. The first component of the function has the role to penalize very large residuals and the second component penalizes the dynamics of the series trend. The smoothing parameter (λ) is intended to illustrate the importance given to the two criteria in the loss function minimization process.

For the analysis of business cycles, Hodrick and Prescott (1980) used a smoothing parameter of 1,600 for quarterly data series. This value being calculated using the formula:

$$\lambda = \frac{\sigma^2(c_t)}{\sigma^2[(\tau_{t+1} - \tau_{t-1})]} \quad (3)$$

Following the calculation of the trend through the process of minimizing the loss function, the cyclical component was determined by deducting the trend component from the data series.

After determining the economic cycle, materialized in the deviation from the trend of the data series, by means of the BBQ algorithm, proposed in a first phase by Bry and Boschan (1971) for monthly data and transformed for quarterly data by Harding and Pagan (2002) were calculated the turning points of business cycles.

$$\Delta_t = 1_{(\tau_t > \tau_{t \pm j}, 1 \le j \le 2)} \quad (4)$$

$$\nabla_t = 1_{(\tau_t < \tau_{t\pm j}, 1 \le j \le 2)} \quad (5)$$

Where Δ_t is the maximum point of the business cycle and ∇_t is the minimum point. The size of the business cycle D_c was calculated as the duration between two consecutive turning points of the same category, while the amplitude A_c was calculated as the difference between the value associated with the maximum point and one associated with the minimum point of the business cycle.

$$D_c = t_{\nabla_1} - t_{\nabla_0} \quad (6)$$

$$A_c = \tau_{\Delta_1} - \tau_{\nabla_1} \quad (7)$$

Finally, the correlation coefficient was calculated between the economic cycles of each state with those of the rest of EU member states, during the period analyzed.

Results and discussions

Identification of the business cycles in the EU Member States

The cyclical component of GDP growth for EU countries, grouped by geographical regions, is presented below (Figure 1-4).

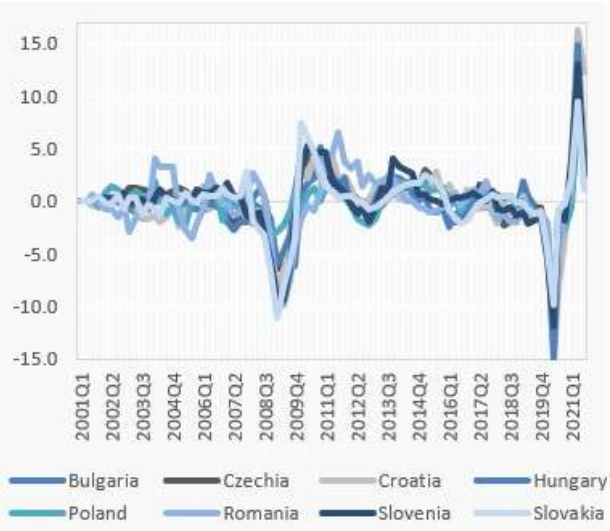

Figure 1. Cyclical component of GDP growth in Central and Eastern Europe countries

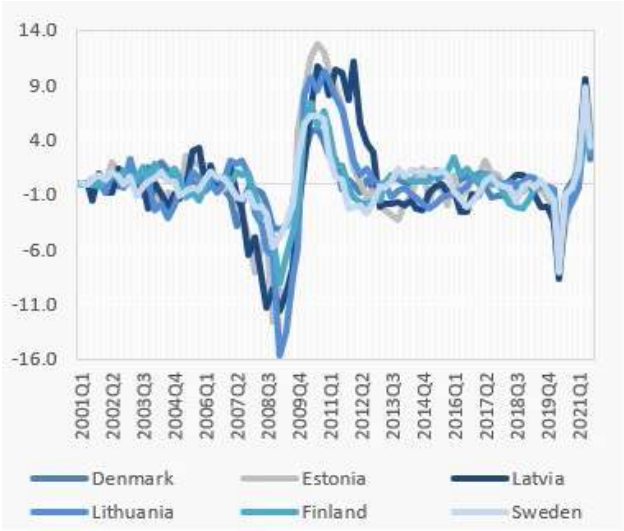

Figure 2. Cyclical component of GDP growth in Northern Europe countries

Source: authors' calculations based on data from the Eurostat database.

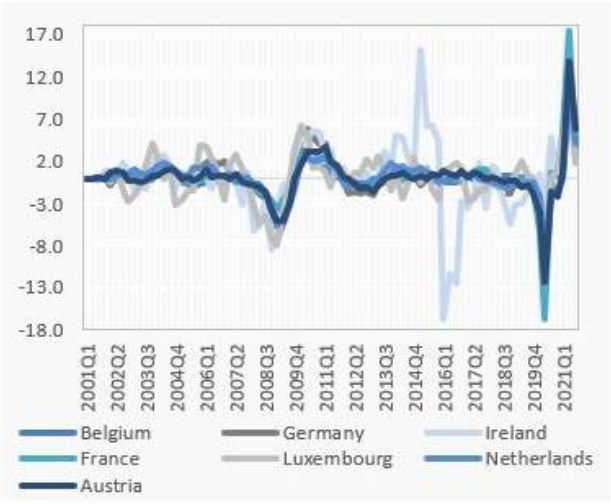

Figure 3. Cyclical component of GDP growth in Western Europe countries

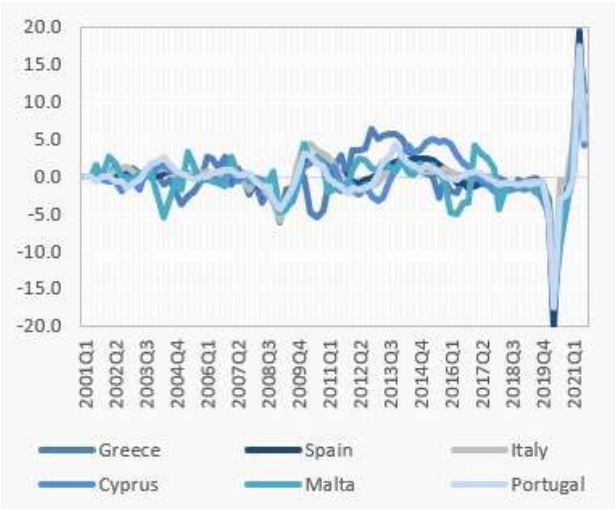

Figure 4. Cyclical component of GDP growth in Southern Europe countries

Source: authors' calculations based on data from the Eurostat database.

As regards CEE countries, one of the common elements of the business cycles is that they are relatively small. At the same time, it can be observed that the last financial crisis (2007-2009) generated a strong economic impact, representing for a part of these states one of the most pronounced minimum points of the business cycles from the last 20 years. Another minimum point, this time the global one in all CEE states relates to the COVID-19 pandemic.

In Poland, Romania and the Czech Republic, another common local minimum point was registered in the first part of the analysis interval (2002-2003), among others as a result of possible effects generated by the *dot-com bubble*. For Bulgaria, the Czech Republic and Poland another local minimum point of the business cycles appeared in the period (2012-2013) amid the effects of the sovereign debt crisis.

The BBQ algorithm for the numerical determination of turning points was also applied. Following this process, the length and average amplitude of a business cycle within each of the EU member states were determined (Table 1).

Table 1. The average size and amplitude of business cycles in the EU member states

Country	Average size of the business cycle (years)	Maximum size of the business cycle (years)	Average amplitude of the business cycle (percentage points)	Maximum amplitude of the business cycle (percentage points)
Austria	3.9	6.5	2.4	4.17
Belgium	3.08	4.25	2.07	4.29
Bulgaria	3.55	5.25	1.75	4.03
Czech Republic	4.62	7.25	3.88	6.19
Denmark	5.91	9	3.39	4.26
Germany	3.8	6.25	2.64	6.09
Estonia	3.16	4.75	4.24	16.52
Ireland	3.8	8	5.62	23.92
Greece	3.75	6	4.51	13.03

Country	Average size of the business cycle (years)	Maximum size of the business cycle (years)	Average amplitude of the business cycle (percentage points)	Maximum amplitude of the business cycle (percentage points)
Spain	4.56	8	2.92	7.01
France	3.12	4	1.61	5.4
Croatia	3.2	6	2.91	6.71
Italy	4.68	7.5	3.4	5.53
Cyprus	6	7.5	5	13.55
Latvia	3.16	4.75	4.3	17.39
Lithuania	3.85	6.75	4.13	14.45
Luxembourg	2.79	4.25	2.77	4.86
Hungary	3.2	4.25	2.5	5.1
Malta	3.25	5	3.46	7.6
Netherlands	5.91	8	3.41	4.54
Poland	3.9	5	2.6	5.07
Portugal	4.44	8.25	3.56	7.6
Romania	3.5	5.75	3.83	8.24
Slovenia	4.88	8	3.98	8.14
Slovakia	3.9	5.5	2.94	4.86
Finland	4.81	8	3.52	6.08
Sweden	3.25	4	2.48	6.29

Source: authors' calculations based on data from the Eurostat database

The results in Table 1 illustrate that the average size of a business cycle in the EU member states varies between 2.7 and 6 years. There are countries for which business cycles follow one another very quickly, such as Luxembourg or Belgium, on average once every 3 years, but there are also countries such as Cyprus, Denmark and the Netherlands for which on average a business cycle lasts up to 6 years. There is not a general trend in the size of the business cycles depending on the level of economic development of the states, the dimension of the cycle being largely determined by the characteristics of each national economy.

Another important characteristic is the maximum size of the business cycles in the EU member states during the analyzed period. Thus, the longest business cycle was recorded in Denmark and lasted for about 9 years. Large cycles were also recorded in Ireland, Spain, the Netherlands, Slovenia and Finland, in all these cases the business cycle lasting for a period of approximately 8 years. However, there are also countries for which the maximum size of the business cycle is relatively small. For instance, in countries like Sweden, France, Hungary and Belgium, the longest cycle lasted for about 4 years. A common feature for most Member States is that the maximum size of business cycles was recorded in the second half of the analysis period, after the last financial crisis, most of which ended as a result of the health crisis.

In addition to size, another important characteristic of the business cycle is the amplitude. Amplitude is measured as the difference between the level of the analyzed variable, namely the real annualized GDP growth rate with quarterly frequency, at the peak of the business cycle compared to its value at the trough of the same cycle. It is desirable that the amplitude of business cycles is reduced, in order to avoid severe episodes of recession.

The average amplitude of the business cycles, recorded in the EU member states, during the analyzed period is between 1.61 and 5.62 percentage points. The country with the lowest amplitude of the business cycles is France, followed by Bulgaria, for which the average value of this indicator is below 2 percentage points. On the other hand, the group of states with the highest average value of the amplitude is composed of Ireland and Cyprus, for which the value of this indicator is above 5 percentage points. One important thing to note is that the most developed countries in the EU (such as France, Germany, Austria, Belgium) have a lower average amplitude of business cycles than the average of the EU member states. This result illustrates that in developed countries, economic dynamics are more stable, with less pronounced movements than in less developed countries.

Similar to the analysis of the dimension of business cycles, also for the amplitude indicator the maximum values during the analyzed period were determined. Thus, the country for which the largest difference in quarterly GDP dynamics was recorded at the peak and trough of a business cycle is Ireland. Other countries that have seen strong changes during the business cycle are Latvia, Estonia, Lithuania, Cyprus and Greece for which the maximum amplitude exceeded the threshold of 10 percentage points. Most of them recorded this maximum amplitude following the last financial crisis or the shock generated by the COVID-19 pandemic. On the other hand, there are countries for which even the maximum value of the amplitude has been very low. Austria, Belgium, Denmark, Luxembourg and the Netherlands fall into this category, for which the maximum amplitude was below the 5-percentage point threshold.

Identification of the correlation between business cycles in the EU member states

Table 2 shows the level of correlation between the business cycles of different EU countries.

Table 2. Correlation matrix of business cycles in EU member states – part 1

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV
BE		0.70	0.84	0.69	0.68	0.64	0.30	0.45	0.77	0.91	0.67	0.86	0.46	0.62
BG	0.70		0.83	0.48	0.24	0.64	0.22	0.78	0.81	0.57	0.88	0.63	0.73	0.74
CZ	0.84	0.83		0.79	0.59	0.67	0.50	0.69	0.89	0.75	0.80	0.84	0.69	0.71
DK	0.69	0.48	0.79		0.67	0.78	0.75	0.45	0.66	0.66	0.64	0.75	0.46	0.71
DE	0.68	0.24	0.59	0.67		0.44	0.27	0.00	0.49	0.79	0.27	0.74	0.20	0.37
EE	0.64	0.64	0.67	0.78	0.44		0.54	0.54	0.58	0.61	0.77	0.61	0.35	0.94
IE	0.30	0.22	0.50	0.75	0.27	0.54		0.51	0.51	0.30	0.51	0.48	0.33	0.50
EL	0.45	0.78	0.69	0.45	0.00	0.54	0.51		0.78	0.38	0.87	0.53	0.67	0.66
ES	0.77	0.81	0.89	0.66	0.49	0.58	0.51	0.78		0.77	0.86	0.88	0.74	0.63
FR	0.91	0.57	0.75	0.66	0.79	0.61	0.30	0.38	0.77		0.61	0.91	0.42	0.58
HR	0.67	0.88	0.80	0.64	0.27	0.77	0.51	0.87	0.86	0.61		0.71	0.73	0.82
IT	0.86	0.63	0.84	0.75	0.74	0.61	0.48	0.53	0.88	0.91	0.71		0.63	0.55
CY	0.46	0.73	0.69	0.46	0.20	0.35	0.33	0.67	0.74	0.42	0.73	0.63		0.35
LV	0.62	0.74	0.71	0.71	0.37	0.94	0.50	0.66	0.63	0.58	0.82	0.55	0.35	
LT	0.58	0.72	0.64	0.65	0.34	0.94	0.44	0.62	0.57	0.53	0.81	0.52	0.34	0.96
LU	0.71	0.67	0.74	0.72	0.55	0.74	0.48	0.61	0.68	0.65	0.72	0.66	0.42	0.79
HU	0.60	0.60	0.70	0.80	0.37	0.83	0.75	0.71	0.76	0.64	0.84	0.71	0.51	0.79

	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV
MT	0.47	0.10	0.46	0.54	0.51	0.18	0.50	0.19	0.47	0.48	0.28	0.49	0.17	0.17
NL	0.71	0.59	0.86	0.74	0.75	0.46	0.46	0.53	0.78	0.73	0.59	0.84	0.66	0.48
AT	0.92	0.72	0.85	0.69	0.78	0.64	0.23	0.42	0.79	0.92	0.68	0.87	0.54	0.63
PL	0.70	0.58	0.72	0.40	0.48	0.19	0.04	0.33	0.55	0.55	0.41	0.60	0.60	0.22
PT	0.60	0.55	0.74	0.61	0.53	0.31	0.50	0.61	0.86	0.66	0.64	0.81	0.78	0.32
RO	0.61	0.84	0.82	0.65	0.34	0.64	0.45	0.82	0.79	0.58	0.84	0.60	0.63	0.78
SI	0.70	0.83	0.89	0.75	0.48	0.70	0.56	0.80	0.86	0.66	0.88	0.79	0.79	0.73
SK	0.80	0.92	0.85	0.49	0.46	0.59	0.16	0.62	0.76	0.65	0.76	0.66	0.59	0.69
FI	0.79	0.80	0.87	0.78	0.60	0.80	0.44	0.61	0.76	0.73	0.80	0.83	0.69	0.77
SE	0.88	0.60	0.79	0.82	0.70	0.77	0.52	0.38	0.69	0.79	0.65	0.81	0.40	0.68

Source: authors' calculations based on data from the Eurostat database.

Table 2. Correlation matrix of business cycles in EU member states – part 2

	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
BE	0.58	0.71	0.60	0.47	0.71	0.92	0.70	0.60	0.61	0.70	0.80	0.79	0.88
BG	0.72	0.67	0.60	0.10	0.59	0.72	0.58	0.55	0.84	0.83	0.92	0.80	0.60
CZ	0.64	0.74	0.70	0.46	0.86	0.85	0.72	0.74	0.82	0.89	0.85	0.87	0.79
DK	0.65	0.72	0.80	0.54	0.74	0.69	0.40	0.61	0.65	0.75	0.49	0.78	0.82
DE	0.34	0.55	0.37	0.51	0.75	0.78	0.48	0.53	0.34	0.48	0.46	0.60	0.70
EE	0.94	0.74	0.83	0.18	0.46	0.64	0.19	0.31	0.64	0.70	0.59	0.80	0.77
IE	0.44	0.48	0.75	0.50	0.46	0.23	0.04	0.50	0.45	0.56	0.16	0.44	0.52
EL	0.62	0.61	0.71	0.19	0.53	0.42	0.33	0.61	0.82	0.80	0.62	0.61	0.38
ES	0.57	0.68	0.76	0.47	0.78	0.79	0.55	0.86	0.79	0.86	0.76	0.76	0.69
FR	0.53	0.65	0.64	0.48	0.73	0.92	0.55	0.66	0.58	0.66	0.65	0.73	0.79
HR	0.81	0.72	0.84	0.28	0.59	0.68	0.41	0.64	0.84	0.88	0.76	0.80	0.65
IT	0.52	0.66	0.71	0.49	0.84	0.87	0.60	0.81	0.60	0.79	0.66	0.83	0.81
CY	0.34	0.42	0.51	0.17	0.66	0.54	0.60	0.78	0.63	0.79	0.59	0.69	0.40
LV	0.96	0.79	0.79	0.17	0.48	0.63	0.22	0.32	0.78	0.73	0.69	0.77	0.68
LT		0.75	0.77	0.11	0.43	0.60	0.19	0.27	0.72	0.72	0.67	0.78	0.66
LU	0.75		0.63	0.26	0.65	0.68	0.38	0.53	0.74	0.76	0.75	0.77	0.73
HU	0.77	0.63		0.43	0.54	0.59	0.19	0.62	0.71	0.76	0.48	0.71	0.70
MT	0.11	0.26	0.43		0.47	0.48	0.43	0.52	0.32	0.35	0.22	0.21	0.48
NL	0.43	0.65	0.54	0.47		0.79	0.71	0.83	0.70	0.85	0.67	0.79	0.63
AT	0.60	0.68	0.59	0.48	0.79		0.72	0.66	0.68	0.76	0.81	0.82	0.81
PL	0.19	0.38	0.19	0.43	0.71	0.72		0.56	0.45	0.60	0.69	0.58	0.53
PT	0.27	0.53	0.62	0.52	0.83	0.66	0.56		0.65	0.78	0.53	0.63	0.51
RO	0.72	0.74	0.71	0.32	0.70	0.68	0.45	0.65		0.86	0.76	0.74	0.52
SI	0.72	0.76	0.76	0.35	0.85	0.76	0.60	0.78	0.86		0.79	0.90	0.68
SK	0.67	0.75	0.48	0.22	0.67	0.81	0.69	0.53	0.76	0.79		0.79	0.70

	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
FI	0.78	0.77	0.71	0.21	0.79	0.82	0.58	0.63	0.74	0.90	0.79		0.80
SE	0.66	0.73	0.70	0.48	0.63	0.81	0.53	0.51	0.52	0.68	0.70	0.80	

Source: authors' calculations based on data from the Eurostat database.

On the one hand, table 2 shows that the strongest linear link between business cycles in two different member states is between Lithuania and Latvia. In this case, the correlation coefficient reached 0.96 during the analyzed period (2001-2021). At the same time, Estonia also has a correlation coefficient of business cycles above 0.94 with each of the above-mentioned countries. Thus, the economies of the three states, namely Lithuania, Latvia and Estonia, seem to follow a very similar dynamic. Another group of countries for which a very strong business cycle link has been discovered are Belgium, Austria and France, with the correlation coefficient of business cycles exceeding 0.9.

On the other hand, the countries with the lowest correlation of business cycles are Germany and Greece. In the case of these states, the correlation coefficient is 0.0067. This result illustrates the different structure of the economies of the two states but also very different dynamics during the analyzed period. Two other countries with a very low level of correlation of the business cycles are Poland and Ireland, in which case it is 0.04. These results support the conclusions of Grigoras and Stanciu (2016) regarding synchronization of the business cycles in the EU countries.

Romania's economy had a similar dynamic during the period studied with that of Bulgaria, Croatia and Slovenia. In all three cases, the correlation coefficients were above 0.8 illustrating a strong link between Romania's business cycles bilaterally with each of them. In the opposite corner, the countries with the lowest correlation of business cycles with Romania are Germany, Malta and Ireland.

Conclusion

The COVID-19 pandemic has affected significantly economic activity worldwide. In 2020, it caused severe contractions. Yet, starting 2021, the economic outlook has begun to brighten amid the progress made by vaccination campaigns.

The Hodrick-Prescott filter, used in order to compute the cyclical component of GDP, confirmed the economic recovery in 2021. The filter also showed a different profile of the pandemic in terms of duration of economic effects as compared to the financial crisis. While in the case of the 2007-2009 financial crisis the recovery is evaluated to be a long-lasting one, U-shaped, in case of the sanitary crisis the recovery is evaluated to be V-shaped.

Using the BBQ algorithm, empirical evidence shows that business cycles in EU countries vary from 2.7 years to 6 years. We highlighted small business cycles in countries from Central and Eastern Europe (CEE). For instance, in Romania, an average business cycle is evaluated to last 3.5 years. Similar results are obtained in the case of Bulgaria, Hungary and Cyprus. The country having the longest cycle is Denmark, with 9 years, significantly above CEE countries. In terms of amplitude, our results indicate that in developed countries, economic dynamics are more stable. The lowest amplitude was recorded in France (below 2 percentage points), while in Romania it is evaluated at 3.83 percentage points.

As regards connections between countries, Baltic ones are the most linked in terms of business cycle synchronization. Belgium, Austria and France also have a strong linear link between

business cycles, while in the case of Romania, a higher correlation is registered with Bulgaria, Croatia and Slovenia.

To sum up, these results could have been used by policy makers when introducing support measures during the pandemic. Should they have been aware of the connections between countries, they could personalize more the support packages, accounting for structural characteristics. Furthermore, countries having a higher amplitude of the business cycle could have introduced more consistent measures in anticipation of a more severe contraction.

The study has its limitations. Future research could imply computing business cycles using more macroeconomic variables or even other econometric tools, such as multivariate filters. As recommended by NBER, the co-movement of various indicators could be used as a proxy to determine business cycles. Furthermore, in order to facilitate fast policy decisions, the analysis of data with a higher frequency could also enrich the current results.

References

Artis, M., Krolzig, H.M., & Toro, J. (2004). The European Business Cycle. *Oxford Economic Papers*, 56(1), 1-44.

Berger, T., Evaraert, G., & Pozzi, L. (2021). Testing for international business cycles: A multilevel factor model with stochastic factor selection. *Journal of Economic Dynamics & Control*, 128(3), 104134.

Bortz, P. (2021). Keynes's theories of the business cycle: evolution and contemporary relevance. *Levy Economics Institute*, Working Paper no. 986.

Bry, G., & Boschan, C. (1971). Programmed Selection of Cyclical Turning Points. *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*, 7-63.

Burns. A., & Mitchell, W. (1946). Measuring business cycles. *New York: National Bureau of Economic Research.*

Caraiani, P. (2010). Modeling business cycles in the Romanian economy using the Markov Switching approach. *Romanian Journal of Economic Forecasting,* 13(1), 130-136.

Cizmesija, M., & Skrinjaric, T. (2021). Economic sentiment and business cycles: A spillover methodology approach. *Economic Systems*, 45(1), 100770.

Dumitru, I., & Dumitru, I. (2010). Business cycle correlation of the new member states with Eurozone – the case of Romania. *Romanian Journal of Economic Forecasting*, 13(4), 16-31.

Gehringer, A., & Mayer, T. (2021). Measuring the business cycle chronology with a novel business cycle indicator for Germany. *Journal of Business Cycle Research*, 17, 71-89.

Grigoraș, V., & Stanciu, I. (2015). Business cycle dating and properties. *National Bank of Romania,* Occasional Papers no. 14.

Grigoraș, V., & Stanciu, I. (2016). New evidence on the (de)synchronization of business cycles: Reshaping the European business cycle. *International Economics*, 147, 27-52.

Harding, D., & Pagan, A. (2002). Dissecting the Cycle: A Methodological Investigation. *Journal of Monetary Economics*, 49(2), 365-381.

Hodrick, R., & Prescott, E. (1981). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking*, 29, 1-16.

Krupa, P., & Skrzypczynski, P. (2012). Are business cycles in the US and emerging economies synchronized? *National Bank of Poland*, Working paper no. 111.

Kufel, T., Kufel, P., & Błazejowski, M. (2021). Do COVID-19 lock-downs affect business cycles? Analysis using energy consumption cycle clock for selected European countries. *Energies*, 15(1), 340.

Mazur, B. (2017). Probabilistic predictive analysis of business cycle fluctuations in Polish economy. *Equilibrium, Quarterly Journal of Economics and Economic Policy*, 12(3), 435-452.

Mazzi, G., & Scocco, M. (2003). Business cycles analysis and related software applications. *Office for Official Publications of the European Communities*, European Commission.

Mitchell, W. (1913): Business cycles. *Memoirs of the University of California*, vol. 3.

Moore, G., & Zarnowitz, V. (1982). Sequential signals of recession and recovery. *Journal of Business*, 55(1), 57-85.

Stock, J., & Watson, M. (2005). Understanding changes in international business cycle dynamics. *Journal of the European Economic Association*, 3(5), 968-1006.

Zarnowitz, V. (1996). Business cycles: theory, history, indicators and forecasting. *The Economic Journal*, 27(418).

Eurostat database. Quarterly national accounts. Retrieved from https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=namq_10_gdp&lang=en