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PAPER

Who will be the next in line to join the Euro Area? A business cycle synchronisation evidence

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Abstract This paper investigates business cycle synchronisation between seven-candidate countries to the Euro Area (EA) – Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, and Sweden – and the Euro Area (EA-12/EA-19), France, and Germany. The Hodrick-Prescott filter decomposes the real Gross Domestic Product into trend and cyclical components for the period 1995Q1-2019Q4. The results indicate the existence of a strong business cycle synchronisation between Sweden and the Euro Area, Germany, and France. The second highest correlation was observed for the Czech Republic, followed by Hungary, Poland, and Croatia. In contrast, Bulgaria and Romania show the weakest business cycle synchronisation with both the Euro Area and the core economies. We conclude that Sweden is the most prepared country to be the next passenger in the single currency train from business cycle synchronisation.

JEL Classification: E32, F15, F43, F44, F45.

Keywords: Euro Area, candidate countries, Hodrick-Prescott filter, business cycle synchronisation.

1. Introduction

According to Mundell (1961), there are four main criteria so that a monetary area can be considered an optimum currency area: i) high labour mobility throughout the area; ii) capital mobility and price and wage flexibility; iii) a currency risk-sharing or fiscal mechanism to share risk across countries in the

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area, and iv) similar business cycles. Mundell also defined other criteria as a high volume of trade between countries, more diversified production within economies, or homogeneous policy preferences across countries. In this work, we will focus the research on the study of the business cycle synchronisation between seven candidate countries to the Euro Area (EA) ─ Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, and Sweden ─ and the Euro Area (EA-12/EA-19) and between these seven candidate countries and the largest two European core economies, i.e., France and Germany.

The Hodrick-Prescott (H-P) filter is used to decompose the real Gross Domestic Product (GDP) into trend and cyclical components for the period between 1995Q1 and 2019Q4. Our empirical formulation encompasses four stages. We first analyse the stationary characteristics of the real GDP time series. Second, we proceed to select the most suitable ARIMA model for predictions to avoid the so-called end-points problem associated with using the H-P filter. Third, we use the H-P filter to identify and characterize similar business cycles from real GDP. Lastly, we obtain the correlation coefficients to measure business cycle synchronisation between countries. We aim to reveal which of the seven-candidate countries from the European Union are most prepared to ride along with their Euro Area partners.

Our contribution to the literature stems from the fact that this research strategy is conducted for a set of seven candidate countries to the Euro Area for approximately twenty-five years when most of the work developed so far has focused exclusively on the founding members of the Euro Area for a short period of time before the introduction of the euro. Some exceptions are, e.g., the works developed by Furceri and Karras (2008), Montoya and Haan (2008), Papageorgiu et al. (2010), Crespo-Cuaresma and Fernández-Amador (2013), Gächter and Ried (2014), Santos and Rodrígues (2016) and Borowiec (2020), that evaluate the patterns of cyclical convergence in European countries for relatively long periods before and after the adoption of the European single currency. One of the main findings of these researchers was that the adoption of the euro had significantly increased the correlation of business cycles. Nonetheless, results also suggest the existence of some divergence during the period of the financial crisis and economic recession that happened in 2008-2011.

Our empirical results point to a relatively strong business cycle correlation between Sweden and the Euro Area, Germany, and France, followed by the Czech Republic, Hungary, Poland, and Croatia. In contrast, Bulgaria and Romania show the weakest business cycle similarities with both the Euro Area and the core economies. From the perspective of business cycle synchronisation, everything indicates that Sweden is the most prepared country to be the next passenger in the single European currency train.
The paper is organized into five sections. Besides the introduction, section 2 sets the stage by briefly reviewing the business cycle synchronisation literature. In section 3, we describe the data and the methodology used. Section 4 studies the stationarity

characteristics of the series, selects the most suitable ARIMA model, applies the H-P filter, and analyses the business cycles and the correlation coefficients of the cyclical components of the real GDP. Finally, section 5 concludes.

2. Literature review

Dating business cycles and business cycles synchronisation is a relatively recent research topic in the economic literature, but of enormous importance, particularly for candidate countries to the Euro Area. If these countries wish to integrate a large currency area like the Euro Area, before doing so, they must share not only a common set of policies with their member countries but also a high degree of business cycle synchronisation.

Wesley Mitchell was the pioneer in developing empirical work for measuring business cycles by dating peaks and troughs for the United States economy. Together with Arthur Burns, in 1946, Wesley Mitchell defined business cycles as '*(...) a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; in duration, business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximately their own.*' (Burns and Mitchell, 1946, p. 3).

This definition has implicitly two types of business cycles, the so-called 'classic business cycle' and the 'growth cycle.' The classic cycle refers to alternating periods of contraction and expansion, while the growth cycle refers to interleaved periods of acceleration and deceleration of economic activity. Therefore, dating the peaks and troughs does not necessarily have to coincide in these two types of cycles (Rua, 2017). This work will study economic growth (recession) cycles using the H-P filter. This methodology is usually applied to the study of business cycles synchronisation between the Euro area member countries, although we can also find a few other ways of analysing the similarities of business cycles for other countries or regions. Several researchers also refer to a 'world business cycle' and, assuming from the beginning that this cycle exists, estimate it and calculate its importance in explaining country-specific movements. Some examples are the works of Cogley and Nason (1995), Gregory et al. (1997), Kaiser and Maravall (1999), Bonfim and Neves (2002), Lumsdaine and Prasad (2003), Mansour (2003), Canova et al. (2007), Aguiar-Conraria and Soares (2011), Bruzda (2011), Rua (2012), Tatomir and Popovic (2013), Miles and Vijverberg (2018), Umulisa and Habimana (2018), Si et al. (2019) and Duarte and Silva (2020), which in addition of using the filter approach, also use, e.g., VAR and Markov switching models or the wavelets methodology.

The vast majority of studies using the H-P filter were published after introducing the euro on 1 January 1999. The majority sought to examine retrospectively whether the member countries of the Euro Area are correlated with each other or whether their synchronisation has increased precisely because of the use of the euro. We can also find some works on business cycle synchronisation between the candidate countries and the member countries of the Euro Area. However, just a few have carried out their empirical analysis considering both the period before and after introducing the European single currency. Relevant literature also focused its attention on analysing the impact of the recent financial and sovereign debt crises on the increasing convergence process observed in the Euro Area, particularly after the most significant European Union (EU) enlargement to the East in 2004. In this line of research we find, e.g., Santos and Rodrígues (2016), Ertürk et al. (2017), and Kovačić and Vilotić (2017), which concluded that there was a weakening in the Euro Area business cycle correlation during the crisis and that the correlations also declined even during the post-crisis period.

However, as highlighted by Camacho et al. (2006), the standard paradigm used in the economic literature on business cycle synchronisation is the so-called core and periphery scheme, namely to describe the supposed existence of a 'European business cycle' (Darvas and Szapáry, 2004). Some countries that exhibit higher synchronisation are typically situated in the business cycle core, whose cycle is recognized as representing the 'European business cycle.' The 'peripheral' countries are situated around this core and represent economies with more idiosyncratic business cycles.

One of these works was developed by Ormerod (2002), which studied the business cycle synchronisation in the core economies of the EU (France, Germany, Italy, and the Netherlands), plus the large economy of Spain and the United Kingdom (UK). Using the annual rates of real GDP growth on a quarterly basis over the period 1978Q1-2000Q3, the author found that the business cycle synchronisation between the core countries was strong over the whole period. The correlations between the growth rates of France, Germany, Italy, and the Netherlands are stable over time and become even stronger after the signing of the Maastricht Treaty in 1992. There was a slight loosening at the time of German reunification, but these economies are even more closely correlated after this event. The Spanish economy also converged with the core countries regarding its movements over the business cycle.

In contrast, the UK economy did exhibit some correlation with those of the EU core countries. This result seemed to anticipate the recent decision of the UK to leave the EU, the so-called BREXIT. However, there is no clear evidence to suggest that the UK business cycle has moved more closely in line with that of suggesting that the UK business cycle has moved more closely in line with the core EU economies over the 1978-2000 period.

Aguiar-Conraria and Soares (2011) also divided European countries into core and 'peripheral' to investigate the existence of business cycle synchronisation using for this purpose the wavelets methodology. The database consists of twenty-seven EU member countries between July 1975 and May 2010. Surprisingly, the authors found out that it is the French business cycle, not the German business cycle, leading the European cycle. Also, the business cycles of Portugal, Greece, Ireland, and Finland do not show statistically relevant degrees of synchronisation with the EA-12. Among non-Euro Area members, Denmark is highly synchronised with the Euro Area. On the other hand, the Czech Republic is the most synchronised among the countries that accessed the EU in 2004, which seems the most promising candidate to join it according to this criterion. Also interesting is the finding that countries that have already adopted the euro – Cyprus and Slovakia – are not very aligned with the Euro Area.

Focusing the attention on the candidate countries and the Euro Area, Darvas and Szapáry (2004) use, in turn, the H-P filter and the Band-Pass filter to study the similarities of business cycles over the period 1993-2002 in eight new EU members from Central and Eastern European countries (CEECs), for which the next step to be considered in the integration process was the entry into the European Monetary Union (EMU). In contrast to the usually analysed GDP and industrial production data, Darvas and Szapáry (2004) extend their analysis to the major expenditure and sectoral components of GDP, concluding that Hungary, Poland, and Slovenia have achieved a high degree of synchronisation with the EMU for GDP, industrial production and exports, but not for consumption and services. The other CEECs have achieved less or no synchronisation, as was the case in the Baltic countries.

Following a similar line of research, Traistaru (2004) also investigated the degree of business cycles synchronisation between the candidate countries and the Euro Area, having also analysed the similarity of economic structures and bilateral trade intensity as main transmission channels. Considering the period from 1990 to 2003 and using Band-Pass filtered GDP data, the author found that business cycles between the Central European new EU countries (CE-EU-8) and current Euro Area members are less correlated than the current Euro Area members. In the group of the CE-EU-8 countries, Hungary, Poland and Slovenia were closer correlated with the economic activity fluctuations in the current Euro Area members. Traistaru's (2004) empirical analysis also indicates that the similarity of economic structures and bilateral trade intensity was positively and significantly associated with business cycles correlations, suggesting that a common monetary policy might have asymmetric effects in a rushed extended Euro Area to the new EU members. Similar results were found by Siedschlag (2010) analysing the bilateral correlation of business cycles between the eight countries which access to the EU in 2004 and the EA-10 over the period 1990-2003. New EU-8 countries and the EA-10 have significant asymmetries. Among these countries, average correlations of business cycles with the Euro Area were the highest in the cases of Poland, Slovenia, and Hungary. This result is also similar to the findings of Artis et al. (2003) and Darvas and Szapáry (2004). Authors argue that new EU-8 member countries had lower bilateral trade and less similar economic structure. Beck (2013) goes even further in the study of business cycles synchronisation in the Euro Area and the EU by introducing in his analysis a broader set of determinants, namely the international trade, the structure of the economy, specialization, convergence, and participation in the monetary union. The dataset covers the period from 1991 to 2011. The results suggest that business cycles synchronisation is tighter in the Euro Area than in the EU, but its changes exhibit the same tendencies over time. Due to the monetary integration and increases in international trade, business cycles synchronisation has been rising. However, in the case of structural similarities of the economy, European countries tend to be less and less similar over time. Moreover, real convergence positively impacts economies specialization and structure divergence, particularly in the Euro Area, and lack of trade barriers and the European single currency may positively impact business cycle synchronisation.

A broader cross-country research on business cycle co-movements was developed by Camacho et al. (2006), which investigated the existence of a business cycle attractor in the Euro Area. The sample of countries includes all member countries of the EU, Romania, Turkey, Canada, USA, Norway, and Japan. Using quarterly seasonally adjusted industrial production for the period 1962Q1-2003Q1, the authors show that there is no evidence of a 'European economy' that acts as an attractor to the other economies of the area. The establishment of the EMU has not significantly increased the degree of co-movements across Euro Area member countries. Nevertheless, Camacho et al. (2006) confirmed that the business cycles of the Euro Area countries are more closely linked than the business cycles of the new members.

Afonso and Furceri (2008) have also not concluded that the European single currency strengthens the synchronisation of the business cycles in the Euro Area as a whole. Analysing macroeconomic costs determinants of joining EMU for the new EU member states and comparing them with those of the EMU members, the authors investigate the business cycle correlation between the candidate countries and the Euro Area and the ability of insurance mechanisms fiscal policies to smooth income fluctuations. The dataset covers twenty-eight members of the EU for the period between 1980 and 2005. The results suggest that EMU membership would not be costly for Cyprus, Hungary, and Malta, but it could have relevant costs in the short run for other countries. For some of these countries (e.g., Estonia, Lithuania, and Slovakia), business cycles are not yet well synchronised with the Euro Area's business cycle, and risk-sharing mechanisms do not provide enough insurance against shocks. Negative correlations vis-à-vis the EMU-wide business cycle are also exhibited by two of the three prospective EU members (Romania and Turkey).

To end this literature review, it is also essential to mention the exciting findings recently obtained by Adamec (2018), which investigates business cycle synchronisation between countries of the Visegrad group, Euro Area, and Germany as a core economy. Using quarterly GDP data, seasonally and calendar-adjusted for the period 1995Q1-

2016Q4, Adamec (2018) applied the H-P filter to break down GDP to trend and cyclical components to obtain the relative output gap. Results suggest that before 2004, the period previous to the biggest enlargement of the EU, a few business cycles were weakly correlated, many of them were not correlated, and some were even negatively correlated. After this EU enlargement, business cycles became closely synchronised between countries in the Visegrad group and between the Visegrad group and the Euro Area or Germany. The only exception was Hungary, which showed a lower degree of business cycle synchronisation with many other EU countries due essentially to prolonged economic havoc. Given these results, the author suggests that candidate countries should work consciously to establish a stable place in the Euro Area club.

3. Methodology and data description

For the analysis of business cycle synchronisation, we use the Hodrick-Prescott filter methodology (Hodrick and Prescott, 1997)[1]. With this method, we can determine the cyclical component of the GDP for each country under research. This filter enables us to decompose a time series, in our case the values of real GDP, into two-time series. The first time series is the so-called trend component of the GDP; the second one corresponds to the cyclical or random part of the original values, the so-called cyclical component of the GDP:

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

where y_t is the time series of original values of GDP, τ_t is the trend component and C_t refers to the cyclical component extracted through the H-P filter. The cyclical component is thus the difference between the original GDP and its trend component. For this purpose, we can extract the trend component by minimizing the following equation:

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

with $t = 1,2,...T$. The first term of equation (2) is the sum of the square of deviations between the values of the original series and the respective values of the trend series, thus representing a measure of the degree of adjustment. The second term is the sum of the square of the second difference between the trend component, indicating a degree of smoothing. The smoothing parameter, λ, controls the variations in the trend component's growth rate and should therefore assume positive values.

The value adopted for λ is the critical element associated with the use of this filter. Hodrick and Prescott (1997, p. 6) draw attention to the fact that any filter can change the serial correlation properties of the data, which should be interpreted with caution. The suggested values for the smoothing parameter λ

[1] In this section we follow closely Duarte and Silva (2021).

for annual, quarterly, and monthly data are, respectively, 400, 1600, and 6400. Canova (1998, p. 485) states that the value of λ is debatable, having investigated the issue for quarterly data with $\lambda=1600$. In our study, we have used $\lambda=1600$ as the value for the smoothing parameter, suggested by Gretl software, as appropriate to work with quarterly data.

The data were taken from the Eurostat database. We downloaded GDP at market prices – chain-linked volumes with the reference year 2015. The data are expressed in million euros, and they are seasonally and calendar-adjusted at the quarterly frequency. We used data for the most extended period available. The first observations are from the first quarter of 1995. Due to the strong disturbances in terms of GDP growth caused by the current Covid-19 pandemic, we decided to exclude observations for the available year 2020. According to that, our dataset ends with the fourth quarter of 2019. Table 1 presents the description of variables.

Table 1. Description of variables

Variable	Description of variable
GDP_ EA12	Euro Area consisting of 12 original member states - Gross Domestic Product, constant prices (2015)
GDP_ EA19	Euro Area consisting of 19 actual member states - Gross Domestic Product, constant prices (2015)
GDP_Bul	Bulgaria - Gross Domestic Product, constant prices (2015)
GDP_Cro	Croatia - Gross Domestic Product, constant prices (2015)
GDP_Cze	Czech Republic - Gross Domestic Product, constant prices (2015)
GDP_Fra	France - Gross Domestic Product, constant prices (2015)
GDP_Ger	Germany - Gross Domestic Product, constant prices (2015)
GDP_Hun	Hungary - Gross Domestic Product, constant prices (2015)
GDP_Pol	Poland - Gross Domestic Product, constant prices (2015)
GDP_Rom	Romania - Gross Domestic Product, constant prices (2015)
GDP_Swe	Sweden - Gross Domestic Product, constant prices (2015)

Source: Eurostat database.

4. Results

In this section, we first analyse the stationary characteristics of the real GDP time-series and select the most suitable ARIMA model. Then, we identify and characterize the business cycles in the seven-candidate countries, the two core economies, and the Euro Area (EU-12/EU-19) using the H-P filter. Finally, we obtain the correlation coefficients of the cyclical components of real GDP as a measure of business cycle synchronisation.

4.1 Stationarity characteristics of the series

For the analysis of the stationarity characteristics of the real GDP of the nine countries and the aggregate real GDP of the EA-12 and EA-19, we used the traditional unit root and stationarity tests, respectively, the Augmented Dickey-Fuller test, usually known as ADF test (Dickey-Fuller, 1979), and the Kwiatkowski-Phillips-Schmidt-Shin test, well-known as KPSS test (Kwiatkowski et al. 1992). Both the ADF and KPSS tests were implemented considering the logarithm of the variables. Moreover, since we use quarterly data, seasonal adjustments were included in the analysis. Table 2 presents the log-values and first differences of log-values of real GDP (logarithmic rates of change of real GDP) for the seven EU candidate countries to the Euro Area, the EA-12 and EA-19, and the two core economies.

Table 2. Unit root and stationarity tests (1995Q1-2019Q4)

	ADF				KPSS			
	Level		Fist Difference		Level		First Difference	
	T	C	C	NC	T	C	T	C
l_GDP_EA12	-2.204	-1.597	-4.955***	-4.054***	0.366***	1.899***	0.105	0.265
l_GDP_EA19	-2.207	-1.572	-4.934***	-4.019***	0.366***	1.905***	0.104	0.259
l_GDP_Bul	-3.469**	-0.718	-2.049	-1.454	0.162**	1.956***	0.059***	0.060
Δ_l_GDP_Bul	-	-	-3.177**	-3.222***	-	-	0.053***	0.100
l_GDP_Cro	-2.041	-1.484	-2.597*	-2.244**	0.403***	1.692***	0.161**	0.442*
Δ_l_GDP_Cro	-	-	-8.77***	-8.82***	-	-	0.0208	0.021
l_GDP_Cze	-2.303	-0.018	-4.551***	-3.611***	0.183***	2.014***	0.134*	0.152
l_GDP_Fra	-2.321	-2.302	-3.93***	-2.614***	0.415***	1.955***	0.095	0.402*
l_GDP_Ger	-3.809**	-0.494	-7.845***	-4.583***	0.109	2.014***	0.032	0.032
l_GDP_Hun	-1.426	-0.525	-5.97***	-1.407	0.312***	1.86***	0.194***	0.189
l_GDP_Pol	-3.399*	-1.171	-12.78***	-1.95**	0.192***	2.097***	0.080	0.181
l_GDP_Rom	-3.034	0.173	-2.88**	-2.21**	0.140*	2.007***	0.115	0.182
l_GDP_Swe	-2.216	1.973	-5.41***	-1.29	0.337***	2.029***	0.042	0.155

Source: Authors, using the research database of Eurostat.

Notes: The number of lags included in the test regressions was chosen according to the AIC criterion. 'T' identifies tests ran with a constant and a trend. 'C' identifies tests ran with only a constant. 'NC' identifies tests ran without a deterministic term. 'Δ' identifies the first difference of the series. The null hypothesis of the ADF test is the existence of a unit root, while for KPSS under the null the series is (trend-) stationarity. Significance at the 1%, 5% and 10% levels is denoted by '***', '**' and '*', respectively.

According to this analysis, we can conclude that only the log-value of the real GDP of Bulgaria and Croatia need a second differentiation to become stationary. All other variables require only a single differentiation to be stationary. In other words, except for the series corresponding to Bulgaria and Croatia, which are I(2), all other series are I(1).

4.2 ARIMA model selection

The next step in our research is to eliminate the so-called end-points problem associated with using the H-P filter. This filter tends to underestimate the cyclical component of the variables, so it is necessary to correct this problem by adding observations to the original series, using forecast models for this purpose, as is the case with the Autoregressive Integrated Moving Average (ARIMA) model. Since we are using data with quarterly frequency, we forecast twelve values for each series, as suggested by Sorensen and Whitta-Jacobsen (2010).

In the previous section, we have identified the order of the integration (d) for all variables. We conclude that for Bulgaria and Croatia, the order was 2, and for the other economies (d) was 1. Hence, it is still necessary to determine the other two components of the ARIMA model – the autoregressive (AR) and the moving average (MA) model. To select the most appropriate ARIMA model, we will choose the minimum value of the Schwarz information criterion (BIC)[2]. The results of these selections are summarized in Table 3.

Table 3. ARIMA Model Selection – summary results

Variable	**ARIMA Model Selection (AR, d, MA) Schwarz information criterion (BIC)**								
I(1)	GDP_ EA12	GDP_ EA19	GDP_ Cze	GDP_ Fra	GDP_ Ger	GDP_ Hun	GDP_ Pol	GDP_ Rom	GDP_ Swe
	(1,1,0)	(1,1,0)	(1,1,0)	(1,1,0)	(1,1,0)	(1,1,0)	(0,1,1)	(2,1,2)	(2,1,2)
I(2)	GDP_ Bul	GDP_ Cro							
	(2,2,2)	(0,2,1)							

Source: Authors, using research database of Eurostat.

As can be seen, among the economies whose series are I(1), the analysis pointed to the choice of an ARIMA forecasting model (1,1,0) for the EA-12, EA-19, Czech Republic, France, Germany, and Hungary. On the other hand, we chose an ARIMA model (0,1,1) for Poland, and for Romania and Sweden, the most suitable model was an ARIMA model (2,1,2). Finally, for Bulgaria and Croatia, which real GDP series are I(2), it was

2 Similar to what was done in the analysis of stationarity, seasonal adjustments were also included in the selection of the most appropriate ARIMA model.

selected an ARIMA model (2,2,2) and an ARIMA model (0,2,1), respectively.

4.3 Dating business cycles

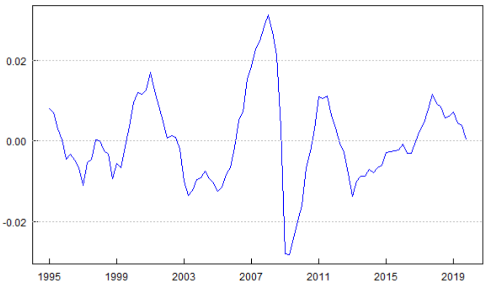
After choosing the most appropriate ARIMA forecasting model, our main goal was to measure the business cycle chronology. In order to proceed with the business cycle identification and characterization, the cyclical components of real GDP were then determined by applying the H-P filter methodology to the added series (original series plus the twelve observations estimated by the ARIMA model). Figure 1 shows the cyclical components of real GDP for the eleven economies considered in this study – graphs (a) to (l) –, as well as for all the series – graph (m).

On the other hand, Table 4 gives a more accurate account of the dating of the business cycles identified in EA-12, EA-19, Bulgaria, Croatia, Czech Republic, France, Germany, Hungary, Poland, Romania, and Sweden in the period from 1995Q1 to 2019Q4, as well as their duration and different phases (expansion vs. recession). We refer specifically to identifying peaks and troughs in the cyclical component of the real GDP.

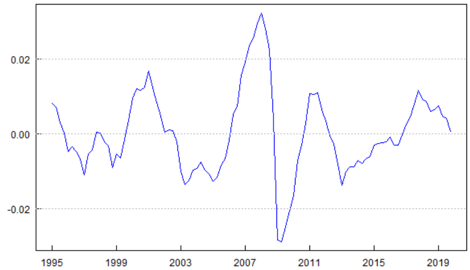
Following Burns and Mitchell (1946), business cycles were defined from trough to trough. We can thus identify six economies with four cycles (EA-12, EA-19, France, Germany, Poland, and Sweden), three economies with five cycles (Croatia, Czech Republic, and Hungary), and two countries (Bulgaria and Romania) with only three cycles. The most extended cycle was precisely detected in one of these countries – Bulgaria – with a duration of forty quarters, divided into an expansion phase of thirty-five quarters, from 1999Q4 to 2008Q3, and a recession of five quarters, which was observed after the financial crisis of 2008, specifically between 2008Q3 and 2009Q4. In turn, the shortest cycle was detected for the Czech Republic between 2014Q1 and 2016Q4, thus having a duration of only eleven quarters. This situation is similar to what happened in other countries. In fact, everything seems to indicate that the international financial crisis of 2008 has affected all economies in a similar way, including the core economies, so in this perspective, we expect some business cycle synchronisation between the candidate countries and the Euro Area, as well as with France and Germany.

The highest growth cycles happened in Poland (between 2013Q1 and 2019Q4), Bulgaria (from 1999Q4 to 2009Q4), and Hungary (between 2005Q1 and 2009Q1). On the other hand, the most significant slowdown in economic activity occurred in Croatia (between 2014Q3 and 2019Q4) and Romania (from 1999Q2 to 2003Q4). Sweden is a curious case, with expansion phases of relatively similar duration as the recession phases, something that also happened in the EA-12 and EA-19, especially in the first part of the sample, a situation that may indicate a resilient business cycles synchronisation between these economies.

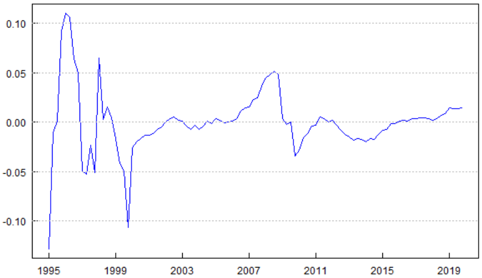
(a) hp_GDP_EA12



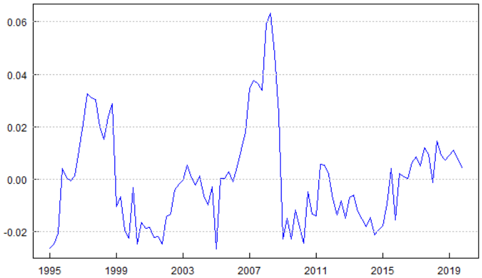
(b) hp_GDP_EA19



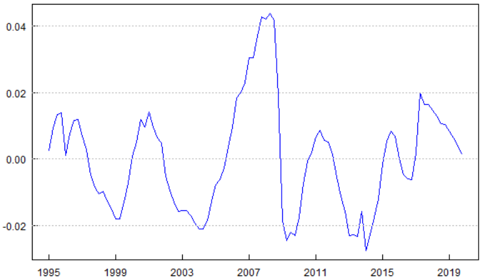
(c) hp_GDP_Bul



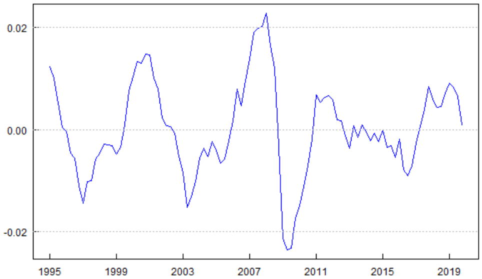
(d) hp_GDP_Cro



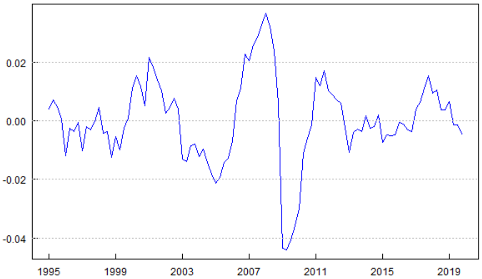
(e) hp_GDP_Cze



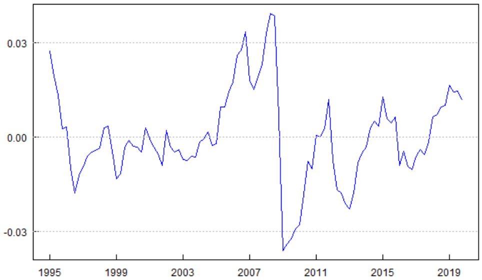
(f) hp_GDP_Fra



(g) hp_GDP_Ger



(h) hp_GDP_Hun



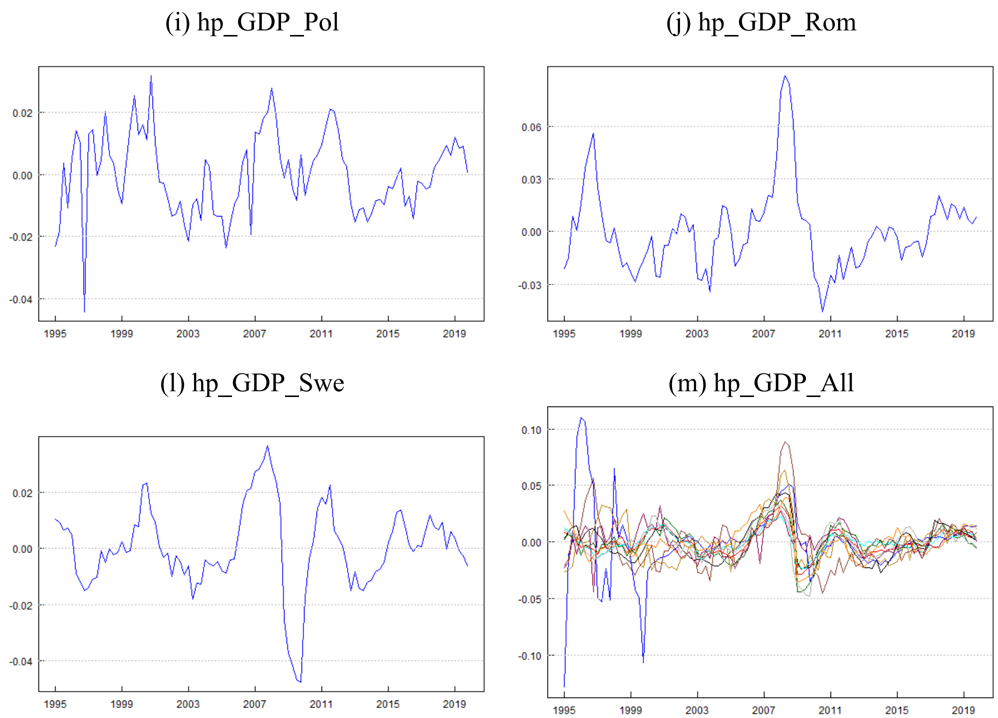


Figure 1. Cyclical components of the real GDP

Source: Authors, using research database of Eurostat.

A joint comparative analysis of the cyclical components of the real GDP of all countries is shown in Table 4. The results point to the existence of a strong business cycle synchronisation between Sweden and the Euro Area (EA-12 and EA-19), Germany and France, followed by the Czech Republic, Hungary, Poland, and Croatia. In the opposite direction, we find Bulgaria and Romania, which seem to have the weakest business cycle synchronisation with both the Euro Area and the core economies.

Table 4. Business cycles identification using Hodrick-Prescott filter

Country	Trough	Peak	Trough	Expansion (A)	Recession (B)	Cycle (A+B)	A/B
EA_12	1997 Q1	2001 Q1	2005 Q1	16	16	32	1
	2005 Q1	2008 Q1	2009 Q1	12	4	16	3
	2009 Q1	2011 Q3	2013 Q1	10	6	16	1,66
	2013 Q1	2017 Q4	2019 Q4	19	8	27	2,375
EA_19	1997 Q1	2001 Q1	2005 Q1	16	16	32	1
	2005 Q1	2008 Q1	2009 Q1	12	4	16	3

Country	Trough	Peak	Trough	Expansion (A)	Recession (B)	Cycle (A+B)	A/B
	2009 Q1	2011 Q3	2013 Q1	10	6	16	1,66
	2013 Q1	2017 Q4	2019 Q4	19	8	27	2,375
Bulgaria	1997 Q2	1998 Q1	1999 Q4	3	7	10	0,428
	1999 Q4	2008 Q3	2009 Q4	35	5	40	7
	2009 Q4	2011 Q2	2014 Q1	6	11	17	0,545
Croatia	1995 Q2	1998 Q4	1999 Q4	14	4	18	3,5
	1999 Q4	2003 Q2	2005 Q1	14	7	21	2
	2005 Q1	2008 Q2	2009 Q1	13	3	16	4,33
	2009 Q1	2011 Q3	2014 Q3	10	12	22	0,833
	2014 Q3	2015 Q3	2019 Q4	4	17	21	0,235
Czech Republic	1999 Q2	2001 Q1	2004 Q2	7	13	20	0,534
	2004 Q2	2008 Q2	2009 Q2	16	4	20	4
	2009 Q2	2011 Q2	2014 Q1	8	11	19	0,727
	2014 Q1	2015 Q3	2016 Q4	6	5	11	1,2
	2016 Q4	2017 Q2	2019 Q4	2	10	12	0,2
France	1997 Q1	2001 Q1	2003 Q2	16	9	25	1,78
	2003 Q2	2008 Q1	2009 Q2	19	5	24	3,8
	2009 Q2	2011 Q1	2016 Q3	7	22	29	0,318
	2016 Q3	2017 Q4	2019 Q4	5	8	13	0,625
Germany	1998 Q4	2001 Q1	2005 Q1	9	16	25	0,563
	2005 Q1	2008 Q1	2009 Q1	12	4	16	3
	2009 Q1	2011 Q3	2013 Q1	10	6	16	1,67
	2013 Q1	2017 Q4	2019 Q4	19	8	27	2,375
Hungary	1996 Q3	1998 Q3	2005 Q1	8	26	34	0,307
	2005 Q1	2008 Q3	2009 Q1	14	2	16	7
	2009 Q1	2011 Q4	2013 Q1	11	9	20	1,222
	2013 Q1	2015 Q1	2016 Q4	8	7	15	1,143
	2016 Q3	2019 Q1	2019 Q4	10	3	13	3,333
Poland	1996 Q4	2000 Q4	2005 Q2	16	18	34	0,889
	2005 Q2	2008 Q1	2009 Q3	11	6	17	1,833
	2009 Q3	2011 Q3	2013 Q1	8	6	14	1,333
	2013 Q1	2019 Q1	2019 Q4	24	3	27	8

Country	Trough	Peak	Trough	Expansion (A)	Recession (B)	Cycle (A+B)	A/B
Romania	1999 Q2	2000 Q2	2003 Q4	4	14	18	0,286
	2003 Q4	2008 Q2	2010 Q3	18	9	27	2
	2010 Q3	2013 Q4	2016 Q3	13	11	24	1,181
Sweden	1996 Q4	2000 Q3	2003 Q2	15	11	26	1,363
	2003 Q2	2007 Q4	2009 Q4	18	8	26	2,25
	2009 Q4	2011 Q3	2013 Q3	7	8	15	0,875
	2013 Q3	2015 Q4	2019 Q4	9	16	25	0,562

Source: authors, using the research database.

Although this analysis allows us to have a first glance at the joint movements between the cyclical components of real GDP, the analysis can, however, be complemented with a more particular examination of the values of the correlation coefficients of the cyclical components of real GDP. We develop this task in the following section.

4.4 Business cycles synchronisation

The business cycles synchronisation was carried out by calculating the correlation coefficients between the cyclical components of real GDP between the seven-candidate countries and the Euro Area (EA-12/EA-19) and between France and Germany, as shown in Table 5.

Table 5. Correlation coefficients between cyclical components of the real GDP

	EA_12	EA_19	France	Germany
Bulgaria	0.1945*	0.1995**	0.0942	0.1839*
Czech Republic	0.8473***	0.8499***	0.7051***	0.7433***
Croatia	0.4644***	0.4768***	0.2686***	0.4340***
Hungary	0.7075***	0.7145***	0.7012***	0.6359***
Poland	0.5038***	0.5033***	0.4452***	0.3947***
Romania	0.3539***	0.3629***	0.2503**	0.3309***
Sweden	0.8642***	0.8637***	0.8274***	0.8108***

Source: authors, using the research database.

Notes: As usual, '*', '**' and '***' are the 10%, 5% and 1% significance levels of the correlation coefficients, respectively.

As can be seen, the strongest relationship measured is between Sweden and EA-12, with a correlation coefficient of 0.8642 for a significance level of 1%. Sweden also shows high business cycle synchronisation with EA-19, with a similar value for the correlation coefficient (0.8637), a situation observed similarly for all the other candidate countries since the results point to minor differences between the EA-12 and the EA-19. This last result is interesting and could also be interpreted as an indicator of great synchronisation within the Euro Area, an aspect that did not guide our primary research objective but our results still seem to suggest. Regarding the core countries, it appears that Sweden also has a strong business cycle correlation with both of these economies, although somewhat less pronounced with Germany, with a correlation coefficient of 0.8108, while with France, it is 0.8274. In this context, everything seems to suggest that Sweden is the most prepared candidate country to be the next passenger in the European single currency train.

Still showing a strong correlation of their cyclical components of the real GDP and, therefore, an eventually high business cycle synchronisation with both the Euro Area and the core economies, we also find the Czech Republic and Hungary. Indeed, the second-highest correlation with the Euro Area (EA-12/EA-19), France, and Germany is observed for the Czech Republic followed by Hungary, Poland, and Croatia. However, in the case of these last two countries, the degree of synchronisation can already be considered relatively moderate.

On the other hand, Bulgaria and Romania show the weakest business cycle synchronisation with both the Euro Area and the core economies. This finding suggests that these two candidate countries will have to run even a little further to get into the carriage of the single European currency in the coming years. Nonetheless, Romania appears to be better positioned when compared to Bulgaria, with a correlation coefficient of 0.3629 with the EA-19 and a correlation coefficient of 0.2503 and 0.3309 with France and Germany, respectively. The weakest relationship can be seen in the case of Bulgaria, particularly against France, with a correlation coefficient of only 0.0942, although not statistically significant. In addition to its low synchronisation with the other economies, Bulgaria is also the only country for which the degree of business cycle correlation with the Euro Area and Germany is just verified for a significance level of 10%.

A more thorough analysis of Table 5 allows us to observe that the cyclical components of the real GDP of three of the seven-candidate countries (Hungary, Poland, and Sweden) are more synchronised with France than with Germany as a core economy. This result is very intriguing if we consider the fact that the German economy is usually considered the major ‘locomotive’ of economic growth in the European Union. It is also evident that all the candidate countries are relatively more synchronised with the aggregate EA-12 and EA-19 than with either of the two core economies, France or Germany, considered in this study. These results are thus very similar to those found by Ormerod (2002), Darvas and Szapáry (2004), Traistaru (2004), Aguiar-Conraria and Soares (2011), and Adamec (2018), although in some of these works, other methodologies of analysis of the business cycle synchronisation between countries were used.

5. Conclusion

This study aimed to analyse business cycle synchronisation between seven candidate countries to the Euro Area – Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, and Sweden – and the Euro Area aggregate (EA-12/EA-19) and between these seven candidate countries and the most prominent two European core economies – France and Germany – for the period between 1995Q1 and 2019Q4.

We used the H-P filter methodology to obtain the cyclical component of real GDP of all countries, components from which we dated the business cycles and investigated the existence of synchronisation in their behaviour.

Our empirical results point out the existence of a relatively strong business cycle correlation between Sweden and the Euro Area, Germany, and France, followed by the Czech Republic, Hungary, Poland, and Croatia. The strongest relationship measured in our analysis was between Sweden and EA-12, with a correlation coefficient of 0.8642 for a 1% significance level. Also, Sweden shows high business cycle synchronisation with the core countries, although somewhat less pronounced with Germany. From the perspective of business cycle synchronisation, everything seems to indicate that Sweden is the most prepared of the candidate countries to be the next country to join the Euro Area.

In contrast, Bulgaria and Romania showed the weakest business cycle similarities with the Euro Area and the core economies. The weakest co-movement in the cyclical component of real GDP was observed in the case of Bulgaria, especially between Bulgaria and France, with a correlation coefficient value of only 0.0942, although not statistically significant.

The empirical results also prove that Hungary, Poland, and Sweden are more synchronised with France than with Germany, which could suggest that during the period under analysis, the German economy has not exclusively played the role of the European integration process 'locomotive.' Moreover, candidate countries to the Euro Area seem to be more synchronised with the aggregates EA-12 and EA-19 than with core economies, which could be a good sign that a broader European business cycle could be achieved in the near future.

References

Adamec, V. (2018). Synchronization of Economic Cycles in Countries of the Visegrad Group, Germany and Eurozone. *Acta Universitatis Agriculturae et Silviculturae Mendelianae*

Brunensis, *66*(3), 719-728. https://doi.org/10.11118/actaun201866030719

Afonso, A., & Furceri, D. (2008). EMU enlargement, stabilization costs and insurance mechanisms. *Journal of International Money and Finance*, *27*(2), 169-187. https://doi.org/10.1016/j.jimonfin.2007.12.010

Aguiar-Conraria, L., & Soares, M. J. (2011). Business cycle synchronization and the Euro: A wavelet analysis. *Journal of Macroeconomics*, *33*(3), 477-489. https://doi.org/10.1016/j.jmacro.2011.02.005

Artis, M., Marcellino, M., & Proietti, T. (2003). Characterising the Business Cycle for the Accession Countries. *European Forecasting Network*, Autumn 2003 Report.

Beck, K. (2013). Determinants of Business Cycles Synchronization in the European Union and the Euro Area. *Quarterly Journal of Economics and Economic Policy*, *8*(4), 25-48. https://doi.org/10.12775/EQUIL.2013.025

Bonfim, D., & Neves, P. D. (2002). Comportamento cíclico da economia portuguesa: 1953-1995. *Banco de Portugal, Boletim Económico*, *6*, 23-40. https://www.bportugal.pt/paper/comportamento-ciclico-da-economia-portuguesa-1953-1995

Borowiec, J. (2020). The convergence and synchronization of business cycles in the European Union and the European Monetary Union. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, *64*(3), 7-20. https://doi.org/10.15611/pn.2020.3.01

Bruzda, J. (2011). Business Cycles Synchronization According to Wavelets - The Case of Poland and the Euro Zone Member Countries. *Bank I Kredyt*, *42*(3), 5-32. https://bazekon.uek.krakow.pl/gospodarka/171193429

Burns, A. F., & Mitchell, W. C. (1946). Measuring business cycles. *National Bureau of Economic Research*.

Camacho, M., Perez-Quiros, G., & Saiz, L. (2006). Are European business cycles close enough to be just one?. *Journal of Economic Dynamics and Control*, *30*(9-10), 1687-1706. https://doi.org/10.1016/j.jedc.2005.08.012

Canova, F. (1998). Detrending and business cycle facts. *Journal of Monetary Economics*, 41(3), 475-512. https://doi.org/10.1016/S0304-3932(98)00006-3

Canova, F., Ciccarelli, M., & Ortega, E. (2007). Similarities and convergence in G7 cycles. *Journal of Monetary Economics*, *54*(3), 850-878. https://doi.org/10.1016/j.jmoneco.2005.10.022

Cogley, T., & Nason, J. M. (1995). Effects of the Hodrick-Prescott Fillter on trend and difference stationary time series Implications for business cycle research. *Journal of Economic Dynamics and Control*, *19*(1-2), 253-278. https://doi.org/10.1016/0165-1889(93)00781-X

Crespo-Cuaresma, J., & Fernández-Amador, O. (2013). Business cycle convergence in EMU: A first look at the second moment, *Journal of Macroeconomics*. 37(C), 265-284. https://doi.org/10.1016/j.jmacro.2013.02.001

Darvas, Z., & Szapáry, G. (2004). Business Cycle Synchronization in the Enlarged EU: Comovements in the (Soon-To-Be) New and Old Members, *Magyar Nemzeti Bank Working Paper, No. 2004-1, SSRN Electronic Journal*. http://doi.org/10.2139/ssrn.508564

Darvas, Z., & Szapáry, G. (2008). Business Cycles Synchronization in the Enlarged EU. *Open Economies Review*, *19*(1), 1-19. https://doi.org/10.1007/s11079-007-9027-7

Dickey, D., & Fuller, D. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366), 427-431. https://doi.org/10.2307/2286348

Duarte, A. P. & Silva, N. B. (2020). Sincronização dos ciclos económicos em alguns países da União Europeia: Uma análise de onduletas. *In* A. P. Duarte, M. Simões, P. Bação, and R. Martins (Eds.), *Estudos de Homenagem a João Sousa Andrade*. Almedina, 149-172.

Duarte, A. P. & Silva, N. B. (2021). Exchange Rate Synchronization for a set of Currencies from Different Monetary Areas, presented at the *Slovak Economic Association Meeting (SEAM 2021)*. Online, Nitra, Slovakia, September 2, 2021.

Ertürk, E., Yılmaz, D., & Çetin, I. (2017). Business Cycle Synchronization in European Economic and Monetary Union (EMU): Testing the OCA during Financial Crisis. *Ankara Üniversitesi SBF Dergisi*, *4*(72), 1157-1183. https://doi.org/10.1501/SBFder_0000002481

Furceri, D., & Karras, G. (2008). Business-cycle synchronization in the EMU. *Applied Economics*, *40*(12), 1491-1501. https://doi.org/10.1080/00036840600843954

Gächter, M., & Riedl, A. (2014). One money, one cycle? The EMU experience. *Journal of Macroeconomics*, *42*(C), 141-155. https://doi.org/10.1016/j.jmacro.2014.07.006

Gregory, A., Head, A., & Raynauld, J. (1997). Measuring world business cycles. *International Economic Review*, *38*(3), 677-701. https://doi.org/10.2307/2527287

Hodrick, R., & Prescott, E. (1997). Postwar U. S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking*, *29*(1), 1-16. https://doi.org/10.2307/2953682

Kaiser, R., & Maravall, A. (1999). Estimation of the business cycle: A modified Hodrick-Prescott filter. *Spanish Economic Review*, *1*(2), 175-206. https://doi.org/10.1007/s101080050008

Kovačić, Z., & Vilotić, M. (2017). Assessing European business cycles synchronization. *MPRA Paper*, No. 79990, May. https://mpra.ub.uni-muenchen.de/79990/

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics*, *54*(1-3), 159-178. https://doi.org/10.1016/0304-4076(92)90104-Y

Lumsdaine, R., & Prasad, E. (2003). Identifying the common component of international economic fluctuations: a new approach. *Economic Journal*, *113*(484), 101–127. https://doi.org/10.1111/1468-0297.00093

Mansour, J. (2003). Do national business cycles have an international origin?. *Empirical Economics*, *28*(2), 223–247. https://doi.org/10.1007/s001810200128

Miles, W., & Vijverberg, C-P. C. (2018). Did the Euro Common Currency Increase or Decrease Business Cycle Synchronization for its Member Countries?. *Economica*, *85*(339), 558-580. https://doi.org/10.1111/ecca.12201

Montoya, L. A., & de Haan, J. (2008). Regional Business Cycle Synchronization in Europe?. *International Economics and Economic Policy*, *5*(1-2), 123-137. https://doi.org/10.1007/s10368-008-0106-z

Mundell, R. (1961). A theory of optimum currency areas. *The American Economic Review*, *51*(4), 657-665. https://www.jstor.org/stable/1812792

Ormerod, P., & Mounfield, C. (2002). The Convergence of European Business Cycles 1978-2000. *Physica A: Statistical Mechanics and its Applications*, *307*(3-4), 494-504. https://doi.org/10.1016/S0378-4371(01)00609-4

Papageorgiou, T., Michaelides, P. G., & Milios, J. G. (2010). Business cycles synchronization and clustering in Europe (1960-2009). *Journal of Economics and Business*, *62*(5), 419-470. https://doi.org/10.1016/j.jeconbus.2010.05.004

Rua, A. (2012). Wavelets in Economics. *Banco de Portugal, Boletim Económico*, *6*, 71-79. https://www.bportugal.pt/en/paper/wavelets-economics

Rua, A. (2017). Datação dos ciclos económicos em Portugal. *Banco de Portugal*. https://www.bportugal.pt/paper/datacao-dos-ciclos-economicos-em-portugal

Santos, S., & Rodríguez, M. (2016). Core-Periphery Business Cycle Synchronization in Europe and the Great Recession. *Eastern European Economies*, *54*(6), 521-546. https://doi.org/10.1080/00128775.2016.1238767

Siedschlag, I. (2010). Patterns and determinants of business cycle synchronization in the enlarged European Economic and Monetary Union. *Eastern Journal of European Studies*, *1*(1), 21-44. https://ejes.uaic.ro/articles/EJES2010_0101_SIE.pdf

Sorensen, P. B., & Whitta-Jacobsen, H. J. (2010). *Introducing Advanced Macroeconomics: Growth & Business Cycles*, McGraw-Hill Education, UK, 2nd edition.

Tatomir, C-F., & Popovic, O. C. (2013). Business cycles synchronization in the European Union: truth or challenge?. *Theoretical and Applied Economics*, *20*(7), 33-42. http://store.ectap.ro/articole/878.pdf

Traistaru, I. (2004). Transmission channels of business cycles synchronization in an enlarged EMU. *ZEI Working Paper*, No. B 18-2004. https://www.econstor.eu/handle/10419/39537

Umulisa, Y., & Habimana, O. (2018). Business cycle synchronization and core-periphery patterns in the East African community: A wavelet approach. *Journal of Economic Integration*, *33*(4), 629-658. https://doi.org/10.11130/jei.2018.33.4.629